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Fayetteville, AR 72703

May 1, 2023

Ms. Jennifer Ivory
Secretary of the Commission
Arkansas Public Service Commission
1000 Center Street
Little Rock, AR 72203

Re: ASPC Docket No. 07-078-TF
*IN THE MATTER OF THE APPLICATION FOR APPROVAL OF ARKANSAS
WESTERN GAS COMPANY'S INITIAL ENERGY EFFICIENCY PROGRAM
PLAN*

Dear Ms. Ivory:

Enclosed for filing in the above-referenced docket is Black Hills Energy Arkansas, Inc.'s Energy Efficiency Program Portfolio Annual Report for the program year 2022. The report is comprised of both a narrative report and an electronic spreadsheet.

Please contact me at Jeff.Dangeau@blackhillscorp.com or at (479) 601-8174 if you have any questions.

Respectfully,

Jeff Dangeau
Associate General Counsel
Black Hills Energy Arkansas, Inc.

Comprehensive Energy Efficiency Plan Annual Report



May 1, 2023

Table of Contents

1.0 EXECUTIVE SUMMARY	4
1.1 Historical Summary of the Comprehensive Energy Efficiency Plan.....	4
1.2 Program Year 2022 Results	6
1.2.1 Major Accomplishments	6
1.2.2 Goals and Objectives for EE Portfolio:.....	7
1.2.3 Progress Achieved vs. Target and Objectives:	8
1.2.4 High Level Recap of Portfolio Savings, Participation Levels, and Prior Year Comparisons	8
1.2.5 Highlights of Well-Performing Programs:	10
1.2.6 What’s Working and What’s Not	11
1.2.7 Planned Changes to Programs or Budgets.....	11
1.2.8 Estimation of EE Resource Potential	11
1.2.9 Training	12
1.2.10 Conclusion	12
2.0 PORTFOLIO PROGRAMS	13
2.1 Residential Solution Program - Equipment Rebate Pathway.....	13
2.1.1 Program Description	13
2.1.2 Pathway Highlights	13
2.1.3 Description of Participants	14
2.1.4 Challenges & Opportunities	14
2.1.5 Planned or Proposed Changes to Program & Budget	14
2.1.6 BHEA’s Response to Evaluators’ Recommendations.....	14
2.2 Residential Solution Program - Home Energy Savings Pathway.....	16
2.2.1 Program Description	16
2.2.2 Pathway Highlights	16
2.2.3 Description of Participants	18
2.2.4 Challenges & Opportunities	18
2.2.5 Planned or Proposed Changes to Program & Budget	18
2.2.6 BHEA’s Response to Evaluators’ Recommendations.....	18
2.3 Residential Solution Program Conclusion	19

- 2.3.1 Pathway Highlights 19
- 2.3.2 Residential Solution Budget, Savings, and Participants 19
- 2.4 Commercial & Industrial Solutions Program.....20
 - 2.4.1 Program Description 20
 - 2.4.2 Program Highlights 20
 - 2.4.3 Program Budget, Savings, and Participants 23
 - 2.4.4 Description of Participants 24
 - 2.4.5 Challenges & Opportunities 24
 - 2.4.6 Planned or Proposed Changes to Program & Budget 24
 - 2.4.7 BHEA’s Response to Evaluators’ Recommendations..... 24
- 2.5 Low Income Pilot Program24
 - 2.5.1 Program Description 24
 - 2.5.2 Program Highlights 25
 - 2.5.3 Program Budget, Savings, and Participants 26
 - 2.5.4 Description of Participants 26
 - 2.5.5 Challenges & Opportunities 26
 - 2.5.6 Planned or Proposed Changes to Program & Budget 26
 - 2.5.7 BHEA’s Response to Evaluator’s Recommendations..... 26
- 2.6 Energy Efficiency Arkansas28
 - 2.6.1 Program Description 28
 - 2.6.2 Program Highlights 28
 - 2.6.3 Program Budget, Savings, and Participants 28
 - 2.6.4 Description of Participants 28
 - 2.6.5 Challenges & Opportunities 29
 - 2.6.6 Planned or Proposed Changes to Program & Budget 29
- 3.0 SUPPLEMENTAL REQUIREMENTS30
 - 3.1 Staffing30
 - 3.2 Stakeholder Activities30
 - 3.3 Information Provided to Consumers to Promote EE.....31

1.0 EXECUTIVE SUMMARY

1.1 Historical Summary of the Comprehensive Energy Efficiency Plan

This annual report is provided to the Arkansas Public Service Commission (“APSC” or the “Commission”) as a review of Black Hills Energy Arkansas, Inc.’s (f/k/a SourceGas Arkansas, Inc., f/k/a Arkansas Western Gas Company), (“BHEA” or the “Company”) Comprehensive Energy Efficiency Plan (“CEEP”) for Program Year (“PY”)2022 and plan results pursuant to Section 9 of the “Rules for Conservation and Energy Efficiency Programs (“C&EE Rules”). These rules require that each operating utility within the jurisdiction of the Commission file an Annual Report by May 1st of each year. The report should address “the performance of each conservation and energy efficiency program operated by the utility.”¹

In March of 2019, Black Hills Energy Arkansas filed its 2020–2022 Energy Efficiency Plan (“EE Plan”) in response to Commission Order No. 25 in Docket No. 13-002-U. The Arkansas Public Service Commission (“APSC”) approved the 2020–2022 programs, which builds upon BHEA’s Quick Start Energy Efficiency programs that were implemented from late 2007 through early 2011 and the Comprehensive Programs that have been implemented in Arkansas since mid-2011. The EE Plan was filed in compliance with Order No. 43 of Docket No. 13-002-U, which required investor-owned natural gas utilities in Arkansas to capture energy savings equivalent to 0.5% of their 2018 energy sales reduced by those customers choosing to self-direct their energy efficiency efforts.

This report covers activities for the BHEA CEEP that commenced on January 1, 2022, through December 31, 2022. The BHEA CEEP consists of three separate programs with individual pathways for each.

- **Residential Solutions Program (“RSP”) Section 2.1-2.3**
 - **Equipment Rebate Pathway:** The Equipment Rebate Pathway offers residential customers rebates for purchasing energy efficient furnaces, tankless water heaters, and smart thermostats. The Equipment Rebates Pathway is designed to help provide customers assistance in identifying potential measures that are eligible for rebate and installation in qualifying residential homes.
 - **Home Energy Solutions Pathway (“HES Pathway”):** The HES Pathway offers residential customers no cost assessments and energy efficient improvements. The Consistent Weatherization Approach (“CWA”) is delivered through this program. The HES Pathway is designed to help customers achieve savings by consulting with a qualified contractor who will analyze their energy use, identify, and install core energy efficiency improvements at no cost to the customer.

¹ Section 9, Page 11 of the APSC Rules for Conservation and Energy Efficiency

- **Commercial & Industrial Solutions Program (“CISP”): Section 2.4**
 - **Custom:** CISP offers technical assistance to support Commercial and Industrial customers in identifying and implementing energy savings opportunities. In its custom program offering, the CISP offers on-site technical assistance, trade ally incentives for steam system surveys, and incentives based on verified performance of custom measures that are outside of the scope of the TRM V8.1.
 - **Prescriptive:** CISP offers prescriptive incentives for measures that have deemed savings established in the TRM, including commercial furnaces, water heaters, boilers, boiler controls, and food service equipment.
 - **Direct Install:** The direct install component provides installation of high-saving, low-cost measures at no cost to the participant. Direct Install measures include low flow showerheads, faucet aerators, pre-rinse spray valves, and weather stripping for exterior doors.
- **Low Income Pilot Program (“LIPP”): Section 2.5**
 - **LIPP** offers qualifying residential customers no cost assessments and energy efficient improvements along with health and safety measures. The low income carveout for the CWA is delivered through this program.

Overall, this Annual Report demonstrates the following successes and hardships across the portfolio:

- **Portfolio**
 - Energy Savings of 1,510,377 therms which is at 113.5% of the targeted 2022 filed plan goal.
 - The Energy Savings of 1,510,337 therms represents 127% of the Commission goal.
 - All three programs within the portfolio, exceeded their PY2022 filed savings goal.
 - Non-energy benefits were a significant contributor to program benefits in PY2022, accounting for 40.1% of total TRC benefits across the portfolio (increased from 32.4% in PY2021).
- **Residential Solutions Program**

The program significantly increased savings and exceeded program goal. Savings increased by 22% compared to PY2020, and the program met 110.9% of its filed net savings goal.

The overall realization rate was 108.39%. Realization was high for all measure groups in ERP and HES.

- The aggregation of the Equipment Rebates and Home Energy Savings Programs has not affected service levels.
- **Commercial & Industrial Solutions Program**
 - As seen in recent program years, custom projects account for a large majority share of savings in 2022.
 - Program Effective Useful Life (“EUL”) has decreased due to the one-year EUL for SEM but this is an anticipated side-effect of encouraging this measure, in PY2022.
 - Food service participation has seen a slight increase over PY2021.
 - Water savings increased from 16,312,350 gallons to 41,015,414 gallons. This is a volatile value year-over-year as it is heavily driven by the relative prevalence of custom projects that save water. The three highest water-saving projects accounted for 85% of total PY2022 water savings. Participation increased significantly in the Prescriptive Pathway, increasing from 36,398 to 48,397.
- **Low Income Pilot Program**
 - Savings increased by 25.8% compared to PY2021 and the program met 161.8%% of its net savings goal.
 - Program offerings for the LIPP are an enhanced service level compared to the HES Pathway.
 - The program provided very detailed Health & Safety tracking.

1.2 Program Year 2022 Results

1.2.1 Major Accomplishments

For the eleventh consecutive year, the Company achieved greater than 100% of its net savings goal as established by the APSC, realizing 1,510,377 net therms for PY 2022. The Company’s 2022 filed savings goal was 1,330,541 net therms and was designed to provide savings great enough to meet or exceed the APSC-established net target for the Company. This net goal was derived by calculating 0.50% of BHEA’s 2018 retail sales, as adjusted for the 2022 sales of Self-Direct customers. In the end, BHEA’s total evaluated net energy savings for 2022 was 127% of the Company’s net Commission-established goal. In addition, BHEA’s portfolio was cost-effective, with a Total Resource Cost Benefit Ratio (“TRC”) of 2.17.

2022 Portfolio Summary										
Net Energy Savings		Costs			Cost-Effectiveness			Goal Achievement		
Demand Therms	Energy Therms	Actual Expenditures	LCFC	Performance Incentives	TRC Net Benefits (NPV)	TRC Ratio	PAC Ratio	Commission Established Target % of Baseline	Actual Savings Achieved % of Baseline	% of Target Achieved (%)
n/a	1,510,377	\$ 4,509,838	\$ 1,038,893	\$ 335,220	\$ 5,934,766	2.19	1.45	0.50%	0.64%	127%

Figure 1 – 2022 EE Portfolio Summary

1.2.2 Goals and Objectives for EE Portfolio:

BHEA’s primary goals and objectives are to provide energy savings opportunities to its customers of all rate classes and market segments. BHEA strives to meet and exceed its energy savings goal established by the APSC.

The Company has worked to achieve the following objectives in PY 2022:

Commercial & Industrial Solution Program:

- Continue evaluating, and, when possible, adding new measures for customers
- Continue to offer Direct Installation (“DI”) of measures as a gateway to further participation in BHEA’s CISP
- Continue to strive to facilitate inter-fuel coordination of projects with Southwest Electric Power Company (“SWEPCO”), Entergy Arkansas, LLC. (“Entergy”), Oklahoma Gas and Electric Company (“OG&E”), and Liberty Utilities Empire District (“Empire”) (“participating electric utilities”)
- Continue to incorporate SEM into its measure mix.

Residential Programs:

- Facilitate meetings to keep trade allies updated on changes to residential programs.
- Continue to incorporate the United States Department of Energy’s Home Performance with ENERGY STAR Program (“HPwES”) into BHEA’s HES Pathway
- Continue the successful inter-fuel promotion of HES Pathway and programs offered by SWEPCO and Entergy

The Company also worked to present all marketing materials on the website www.EnergyReady-Arkansas.com . Examples are provided in Appendix B.

BHEA’s portfolio of programs continues to seek adherence to the energy efficiency objectives listed in Section 2 of the Commission’s C&EE Rules by:

- Reducing end-use natural gas consumption in a cost-effective manner to save money for consumers and conserve non-renewable resources.
- Protecting the environment by encouraging installation of energy efficiency measures that help reduce carbon dioxide emissions and air pollutants.
- Increasing residential and commercial customer awareness of available energy efficiency opportunities, including equipment upgrades and behavioral changes.
- Generating customer awareness of energy efficiency programs through Black Hills Energy's Arkansas website at www.Energyready-Arkansas.com
- Identifying cost-effective natural gas savings measures.
- Improving relationships with customers, trade allies, and stakeholders by providing value-added energy efficiency services, training and education, hardware, verification, and support; and
- Supporting a more robust local and statewide economy by using local labor (when possible) and helping Arkansas residents reduce their monthly energy expenses.

1.2.3 Progress Achieved vs. Target and Objectives:

The APSC savings target for a gas utility in 2022 was the realization of a 0.50% reduction from the utility's 2018 baseline throughout, excluding volumes used by Self Direct customers. This represented a savings target for BHEA of 1,186,508 net therms. The Company achieved 127% of this target, and therefore qualifies for an incentive of \$335,220 according to APSC Docket 13-002-U, Order No. 7.

1.2.4 High Level Recap of Portfolio Savings, Participation Levels, and Prior Year Comparisons

The chart below details the trends of BHEA's budgets, expenses, and energy savings beginning with PY 2019 and continuing through PY 2022.

Company Statistics										
Program Year	Revenue and Expenditures					Energy				
	Total Revenue (a) (\$000's)	Budget		Actual		Total Annual Energy Sales (d) (Therms)	Plan		Evaluated	
		Portfolio Budget (b) (\$000's)	% of Revenue (% = b/a)	Portfolio Spending (c) (\$000's)	% of Revenue (% = c/a)		Net Annual Savings (e) (Therms)	% of Energy Sales (% = e/d)	Net Annual Savings (f) (Therms)	% of Energy Sales (% = f/d)
2019	\$ 176,071	\$ 3,542	2.0%	\$ 3,211	1.8%	281,485,980	1,180,976	0.42%	1,262,524	0.45%
2020	\$ 184,330	\$ 4,089	2.2%	\$ 3,651	2.0%	254,846,425	1,330,541	0.52%	1,414,973	0.56%
2021	\$ 217,934	\$ 4,205	1.9%	\$ 4,156	1.9%	303,339,040	1,330,541	0.44%	1,507,349	0.50%
2022	\$ 310,466	\$ 4,524	1.5%	\$ 4,510	1.5%	317,361,270	1,330,541	0.42%	1,510,377	0.48%

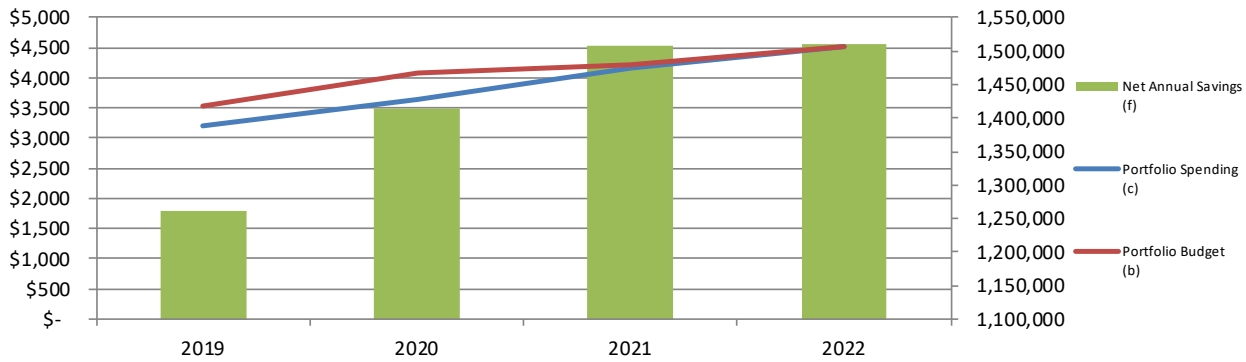


Figure 2 – Company Statistics for Program Years 2019 - 2022

BHEA spent 100% of its budget in 2022, as Figure 3 shows below. Most of the dollars the Company spent went to Customer Incentives and Marketing and Delivery.

EE Portfolio Expenditures by Program					
Program Name	Target Sector	Program Type	2022		% of Budget
			Budget (\$)	Actual (\$)	
Low Income Pilot Program	Residential	Market Specific/Hard to Reach	102,239	101,082	99%
Residential Solution Program	Residential	Other	2,728,081	2,715,499	100%
Commercial & Industrial Solutions Program	Commercial & Industrial	Custom	1,634,488	1,634,488	100%
Energy Efficiency Arkansas	All Classes	Behavior/Education	56,317	55,879	99%
Regulatory	-	-	3,000	2,890	96%
Total			4,524,125	4,509,838	100%

Figure 3 – BHEA’s 2022 EE Portfolio Costs by Program

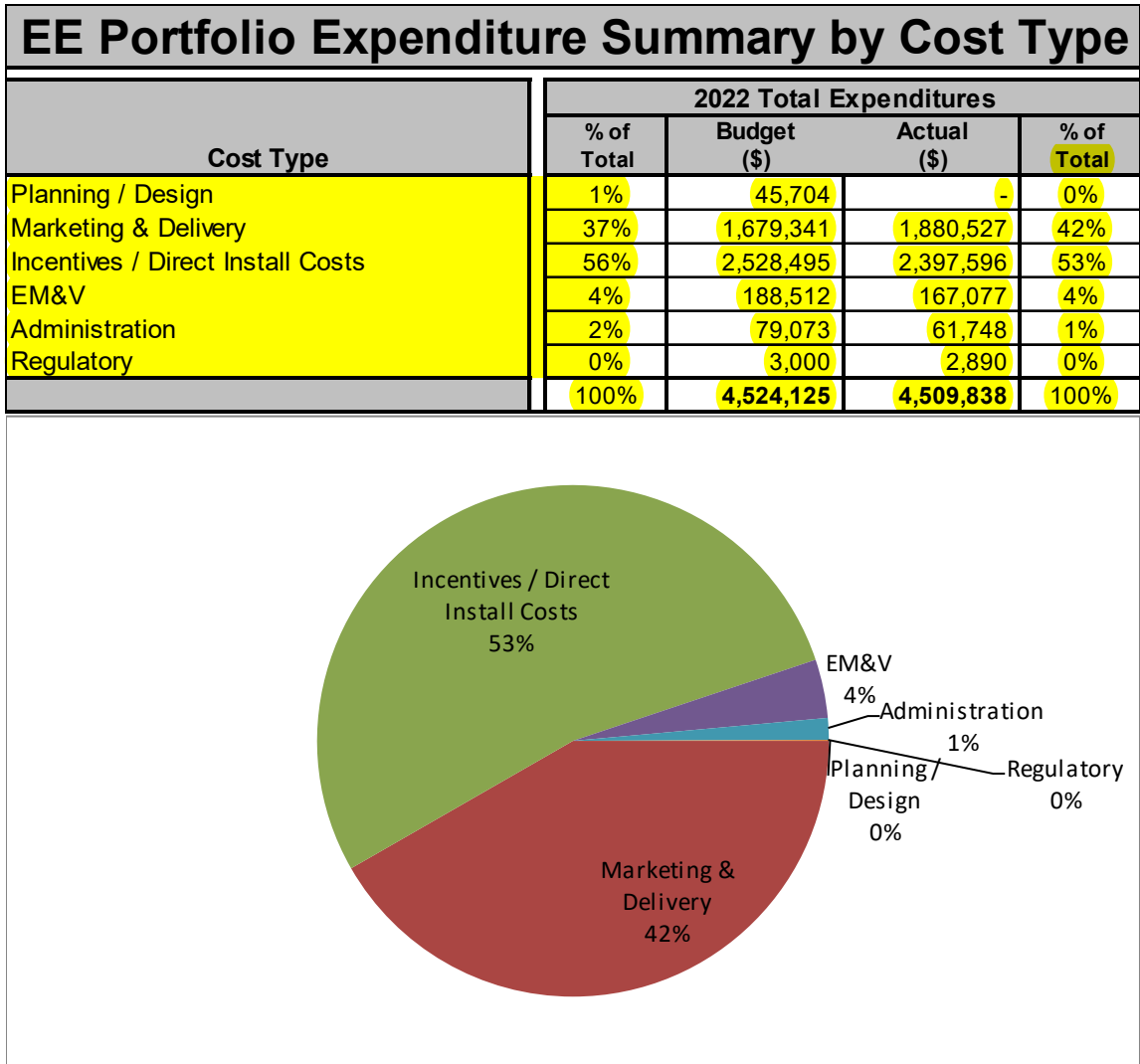


Figure 4 – BHEA’s 2022 EE Portfolio Summary by Cost Type

1.2.5 Highlights of Well-Performing Programs:

BHEA was encouraged by the performance of its CEEP as a whole. All three programs exceeded their filed goals.

Commercial & Industrial Solutions Program

BHEA had 54 C&I customers participate by installing Energy Conservation Measures (“ECM”) in 2022 through the custom and prescriptive rebates in the CISP. This represented total net savings of 675,143 therms. Energy efficient aerators, pre-rinse spray valves, showerheads, and weather stripping were installed for commercial applications at no charge to customers. Net savings for these direct install measures were 93,851 therms and involved 10 customers installing 45 measures. Ultimately, this program provided savings of **723,540** net therms or **114.8%** of the goal.

Equipment Rebate Pathway

The BHEA Equipment Rebate Pathway provided rebates for 222 high efficiency furnaces and 171 tankless water heaters during 2022. In addition, 374 Smart Thermostats were rebated. BHEA experienced net savings from this pathway of 59,222 therms. Beginning in 2020, commercial prescriptive rebates for furnaces and tankless water heaters were moved into the CISP.

Home Energy Savings Pathway

This program was awarded a Home Performance with Energy Star award as a Partner of the Year for Energy Efficiency Program Delivery for the fifth year in a row. BHEA engaged five contractors that performed 1,498 assessments across its service territory. 2,905 coupons were paid to contractors for work done in customers' homes. A total net savings of 695,917 therms was achieved for HESP.

1.2.6 What's Working and What's Not

BHEA's Equipment Rebate Pathway results were lower this year than in the previous year. Incentive funds for tankless water heaters were unavailable after August 31st Furnace and smart thermostat rebates were available through the end of 2022. The HES Pathway reached its internal goal and incentive budget at the end of October. The HES Pathway customer experience with this program has been very positive. 82.1% of respondents have recommended the program to other people. 77.8% of respondents indicated that participating in the program increased their satisfaction with BHE as their energy provider.

C&I Solutions continues to be a strong program; however, the Company is beginning to see a reduction in the number of large savings projects that typically come from manufacturing facilities. BHEA believes this reduction is due to participating customers completing the major projects that have been recommended as well as additional customers choosing to self-direct their EE efforts.

1.2.7 Planned Changes to Programs or Budgets

No Changes are planned, however, BHEA may choose to use the budget flexibility approved by the Commission.

1.2.8 Estimation of EE Resource Potential

In 2015, the Arkansas Parties Working Collaboratively ("PWC") completed and filed the results of the potential study that had been commissioned in 2015 and was performed by Navigant Consulting Group. The findings were approved by Order No. 31 in Docket 13-002-U.

1.2.9 Training

In 2022, BHEA and its implementation staff provided training to customers, trade allies, and employees of the Company, as well as continued training for the program administrator. Details of training achievements for 2022 are reported in the training sections of the Standardized Annual Report Packet (“SARP”) Workbook.

- Members of the implementation staff participated in training opportunities by attending training provided by the Association of Energy Services Professionals (“AESP”), Arkansas Chapter of The Association of Energy Engineers (“AAEE”), as well as Arkansas Manufacturing Solutions (“AMS”).
- The BHEA program administrator attended trainings to increase knowledge in marketing energy efficiency, how to incorporate new technology, and in evaluation methods. These conferences and webinars included ones held by AESP, AAEE, and the Home Performance Institute.

1.2.10 Conclusion

BHEA's success in 2022 can be attributed to being creative and adaptable during the Covid-19 pandemic. The company worked with its implementer to provide its customers and trade allies with the safest interactions possible as provided by the CDC (“Centers for Disease Control”) and the Arkansas Public Health System guidance. The Company spent 100% of its allotted Budget Dollars and achieved 127% of its APSC established target for the 2022 Program Year. BHEA's portfolio performance qualified the Company to receive an EE incentive for the 2022 Program Year.

BHEA CEEP saw a portfolio TRC of 2.17 for 2022

2.0 Portfolio Programs

2.1 Residential Solution Program - Equipment Rebate Pathway

2.1.1 Program Description

BHEA's Equipment Rebate Pathway promotes high efficiency natural gas comfort heating equipment, tankless water heating equipment and Energy Star® qualified Smart Thermostats in new and existing homes. This program is available to all residential customers. Residential new construction installations are eligible. Customers must use natural gas as their primary heating fuel to receive a furnace rebate. Potential customers who have made a commitment to take natural gas service from BHEA as the primary heating fuel are also eligible for furnace rebates.

BHEA provides a financial incentive in the form of prescriptive rebates to customers who purchase and install qualifying comfort heating and water heating measures. After purchasing and installing new equipment, customers may fill out rebate forms with detailed information about the purchase and installation and mail them in, or the rebate forms may be completed online at www.energyready-arkansas.com. Customers may expect their rebate checks in four to eight weeks. Trade allies are given a \$50 rebate (except for Smart Thermostats) for each installation to help them recover costs incurred when helping customers fill out the rebate forms.

2.1.2 Pathway Highlights

- Furnace rebates were available to customers thru December 31, 2022.
- Water heater rebates were available to customers thru August 31, 2022.
- BHEA will continue to have face-to-face meetings with builders to increase new construction participation.
- A total of 767 rebates were paid through ERP in 2022.
 - 222 Residential furnaces were rebated.
 - 171 Residential water heaters were rebated.
 - 374 Residential Smart thermostats were rebated.
 - Net therm savings of 59,222 therms were achieved.

Equipment Rebate Pathway Savings by Measure

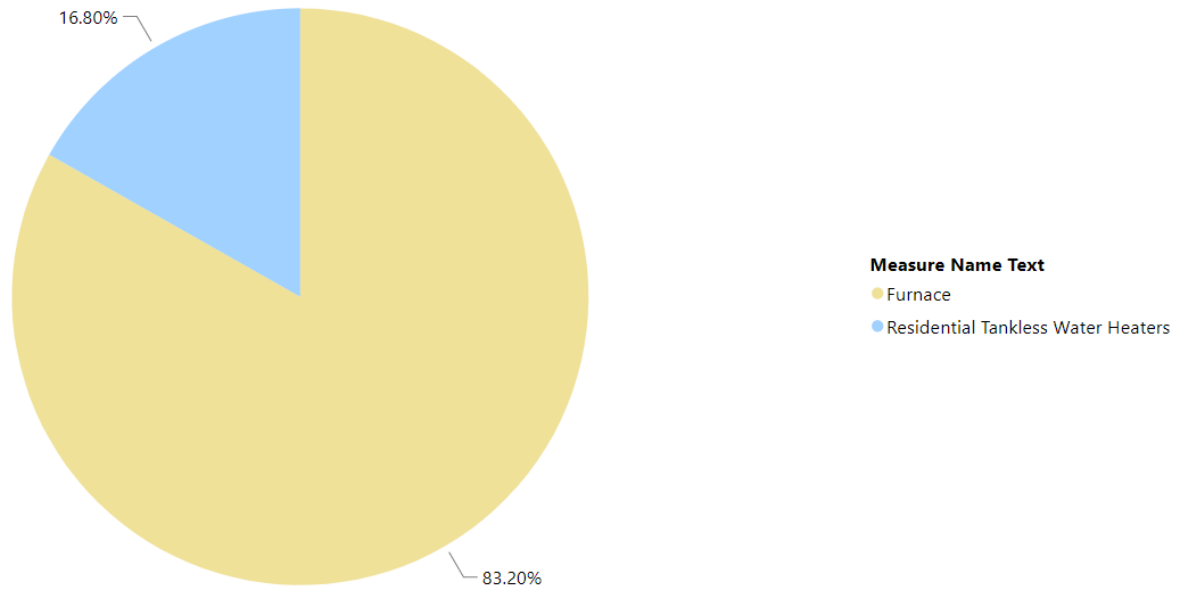


Figure 5 – 2022 Equipment Rebate Pathway Measure Mix

2.1.3 Description of Participants

- Each piece of equipment being rebated is defined as a participant.

2.1.4 Challenges & Opportunities

- Tankless rebates were available through August of 2022. The number of participating contractors who had not previously participated in the program has increased through efforts to directly contact trade allies and provide them with information about BHEA program offerings.

2.1.5 Planned or Proposed Changes to Program & Budget

- No Changes are planned, however, BHEA may choose to use the budget flexibility approved by the Commission.

2.1.6 BHEA’s Response to Evaluators’ Recommendations

- **Address project application timelines. Program staff should endeavor to return application processing times to PY2020 benchmarks.**
 - BHEA will endeavor to comply with the recommendation.
 - Accepted and worked on

- **Track purchase price for smart thermostats., RSP staff track costs for furnaces and water heaters but not smart thermostats. Doing so will allow for better cost-effectiveness tracking for new brands and models.**
 - BHEA will start tracking costs for smart thermostats.
 - Implementing and in progress

2.2 Residential Solution Program - Home Energy Savings Pathway

2.2.1 Program Description

BHEA's HES Pathway began to offer comprehensive residential energy efficiency audits on a limited basis in November of 2013. This program was added to the Company's portfolio in order to offer qualifying BHEA residential customers an EE program that will provide them with lasting energy savings benefits and increased home comfort. Building on the solid base established in prior years, this program was again successful in 2022.

HES Pathway is designed to fulfill the requirements established by the APSC in Docket 13-002-U, Order Nos. 22 and 23. These orders instructed the Investor-Owned Utilities ("IOUs") – BHEA, SWEPCO, Entergy, CenterPoint, AOG, OG&E, and Empire – to design and implement a Consistent Weatherization Approach beginning in 2016. The goal of the Commission was to provide consistent weatherization programs to all residential customers in the state of Arkansas served by the IOUs.

Through this program, BHEA residential customers are connected with trained service providers (trade allies) that perform a comprehensive home energy assessment and install EE weatherization measures designed to save energy, improve indoor comfort, air quality, and safety in existing residences. The assessment and multiple building envelop measures are provided to customers at no charge. BHEA trade allies are currently providing duct sealing, air infiltration measures, ceiling insulation, combustion safety checks, and with customer approval, installation of energy efficient aerators and showerheads. After customers' homes are weatherized, trade allies leave behind a branded folder containing information about other programs offered by BHEA, and SWEPCO when appropriate, along with a dual branded version of the U.S. Housing and Urban Development's Safe and Healthy Home booklet. The packet is given to the customer at the completion of each job along with a report on what was accomplished by the weatherization.

The Company continued its association with the Home Performance with Energy Star® Program in 2022. HPwES is a program backed by the Department of Energy and Environmental Protection Agency that promotes a "whole-house" approach to each home being assessed that begins with a comprehensive home energy assessment. BHEA received an ENERGY STAR® Partner of the Year award in 2022 for the fifth consecutive year. SWEPCO has been an HPwES partner for some time and has, in fact, received the ENERGY STAR Partner of the Year for the ninth consecutive year in 2022.

2.2.2 Pathway Highlights

- In PY 2022 the HES Pathway achieved 110.9% of its filed savings goal with a net savings of 695,917therms.
- The conversion rate for customers receiving an assessment that then results in weatherization being performed is 76.6%.

-
- Trade allies working within this program must meet minimum certification requirements (Building Performance Institute (“BPI”) or Residential Energy Service Network (“RESNET”)) as well as undergo BHEA specific program training.
 - In conjunction with SWEPCO, BPI training opportunities for trade allies were provided.
 - Trade allies are also required to complete online training provided by BHEA’s implementor.
 - To reduce customer inconvenience, quality assurance and quality control visits were coordinated with other utilities whenever possible. During 2022, many of the quality control visits were conducted virtually with the contractor onsite.
 - BHEA’s contractors provide weatherization services for the amount of the rebates.
 - The Company continues to use an allotment system to increase trade ally consistency and performance along with prolonging program availability.
 - In homes where the electric provider is not an IOU, BHEA pays the full cost of the audit as well as the installation of energy saving measures.
 - 2022 results were as follows:
 - The HES Pathway had 1,887 participants in PY2022.
 - 1498 energy assessments were performed.
 - 818 were BHEA only homes.
 - 680 were joint homes with a participating electric utility.
 - 201 homes were install-only homes (duct sealing, air sealing, ceiling insulation but no assessment.)
 - 1,262 heating systems had duct sealing done. (Some homes being weatherized had multiple heating systems)
 - 1,073 homes had air infiltration measures done.
 - 505 homes received insulation.
 - 37 showerheads were installed.
 - 21 aerators were installed.
-

Home Energy Savings Pathway Savings by Measure

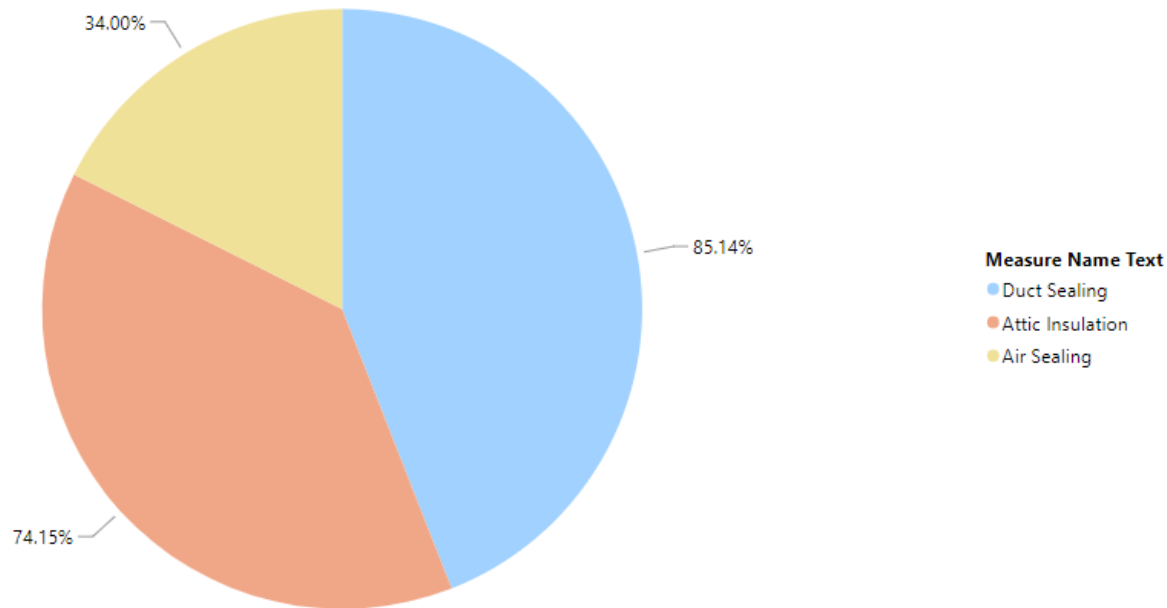


Figure 6 – 2022 HES Pathway Measure Mix2.2.3

2.2.3 Description of Participants

- A Participant of BHEA’s HES Pathway represents an incentivized measure, including assessments.

2.2.4 Challenges & Opportunities

- BHEA’s primary challenge is to strike a balance between customers wanting to participate and the funds available to provide services, particularly on assessments performed on BHEA only homes.
- Since this is the only BHEA program that requires trade allies to be registered and trained to participate, recruiting and training trade allies is critical.

2.2.5 Planned or Proposed Changes to Program & Budget

- No Changes are planned, however, BHEA may choose to use the budget flexibility approved by the Commission.

2.2.6 BHEA’s Response to Evaluators’ Recommendations

- No recommendations found for HES Pathway

2.3 Residential Solution Program Conclusion

2.3.1 Pathway Highlights

- The TRC ratio for the Residential Solution Program in 2022 was 2.25.

2.3.2 Residential Solution Budget, Savings, and Participants

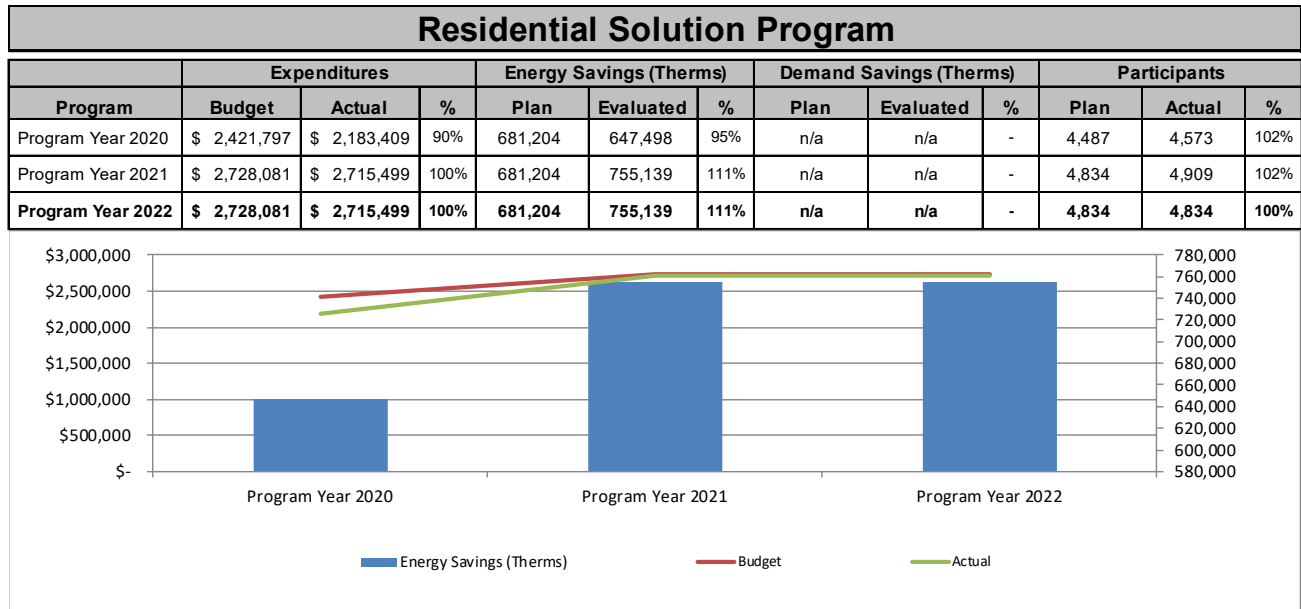


Figure 7 – 2022 Residential Solution Program Trends

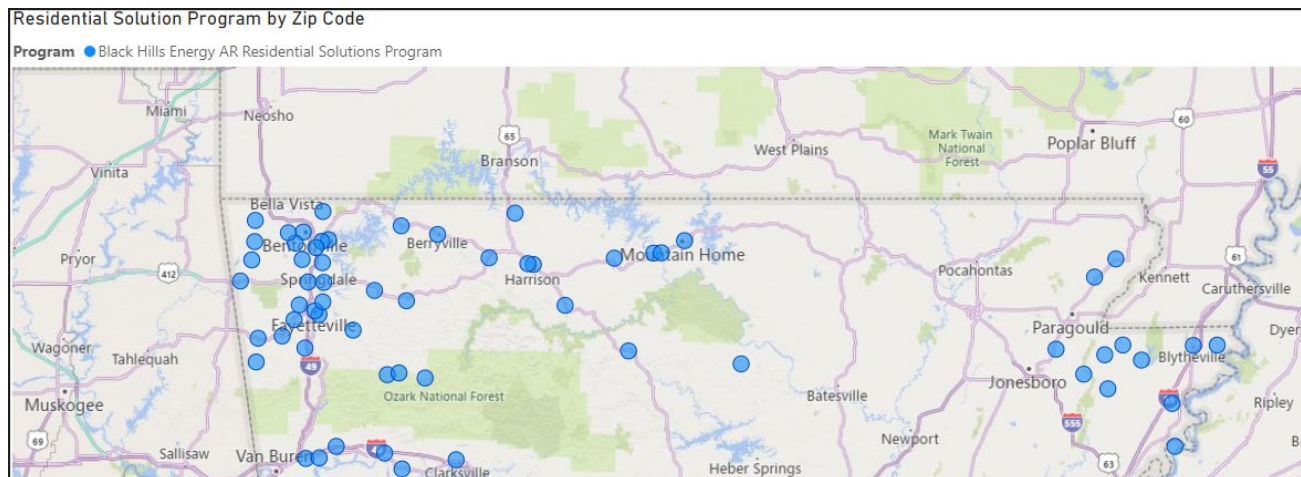


Figure 8 – 2022 Residential Solution Program Participants by Zip Code

2.4 Commercial & Industrial Solutions Program

2.4.1 Program Description

This program is available to all BHEA C&I customers, both existing facilities and new construction where natural gas is the primary heating/water heating/process fuel, or where the potential customer has made a commitment to take natural gas from BHEA as its primary heating/water heating/process fuel. BHEA provides financial incentives to encourage installation of energy efficient measures.

The CISP promotes cost effective natural gas energy savings through energy efficiency. It is a threefold program that gives C&I customers the opportunity to save on their natural gas usage. The program provides for the direct installation of water aerators, low flow showerheads, pre-rinse spray valves, and weather stripping at no cost to customers. Prescriptive rebates for comfort heating boiler equipment, boiler component installations and replacements, commercial space heating furnaces, commercial tankless water heaters as well as qualifying Energy Star commercial cooking equipment are available. Custom incentives for specific measures are also available.

The calculation of savings for CISP may be determined through use of TRM V9.0 or through custom Measurement and Verification. This process employs point of use metering of natural gas, both prior to and after measure installation.

The custom part of CISP is highly dependent on frequent customer contact by BHEA's implementers, trade allies, and BHEA account managers. Budget cycles can be long and getting EE projects approved is difficult. Facility audits are done by the Company's implementers and are presented to the customer. Follow up is necessary to keep the customer thinking about the potential for natural gas savings and reductions in process, maintenance, and facility costs. Continued contact with potential customers is facilitated through phone calls, invitations to energy efficiency learning opportunities, along with additional site visits.

2.4.2 Program Highlights

- BHEA's CISP was available to all C&I customers in 2022, except those electing to self-direct their energy savings.
 - In PY 2020, commercial prescriptive furnaces and water heaters were moved from the former Equipment Rebates Program to CISP, fully separating residential and non-residential rebates into discrete programs.
 - In PY 2022, incentives were provided for 1 steam system surveys to one customer, totaling \$2,900 in incentive spend. Of these 1 surveys, 1 resulted in a PY 2022 project, yielding a savings of 70,568 therms.
 - In PY 2022, C&I Solutions achieved 114.9% of its revised plan savings goal with a net savings of 723,540 therms.
-

- Savings were distributed as follows:
 - Custom
 - 9 customers and 12 projects
 - Savings of 541,167, therms
 - Commercial Furnaces
 - 24 customers and 108 furnaces
 - Savings of 21,494therms
 - Commercial Cooking Equipment
 - 5 customers and 25 pieces of equipment
 - Savings of 7,350therms
 - Commercial Tankless Water Heaters
 - 3 customers and 4 water heaters
 - Savings of 29 therms
 - Commercial Comfort Heating Boilers
 - 3 customers and 8 boilers
 - Savings of 32,782 therms
 -
 - Direct Install
 - 10 premises
 - 2 Pre-Rinse Spray Valves
 - 182 feet of weather stripping (exterior walk thru doors, windows, etc.)
 - 2416 feet of overhead door weather stripping
 - 371,751 gallons of water saved.
 - Savings of 93,851 therms
- The TRC for CISP was 2.20 for 2022.

C&I Therm Savings Percentage by Measure - Direct Install

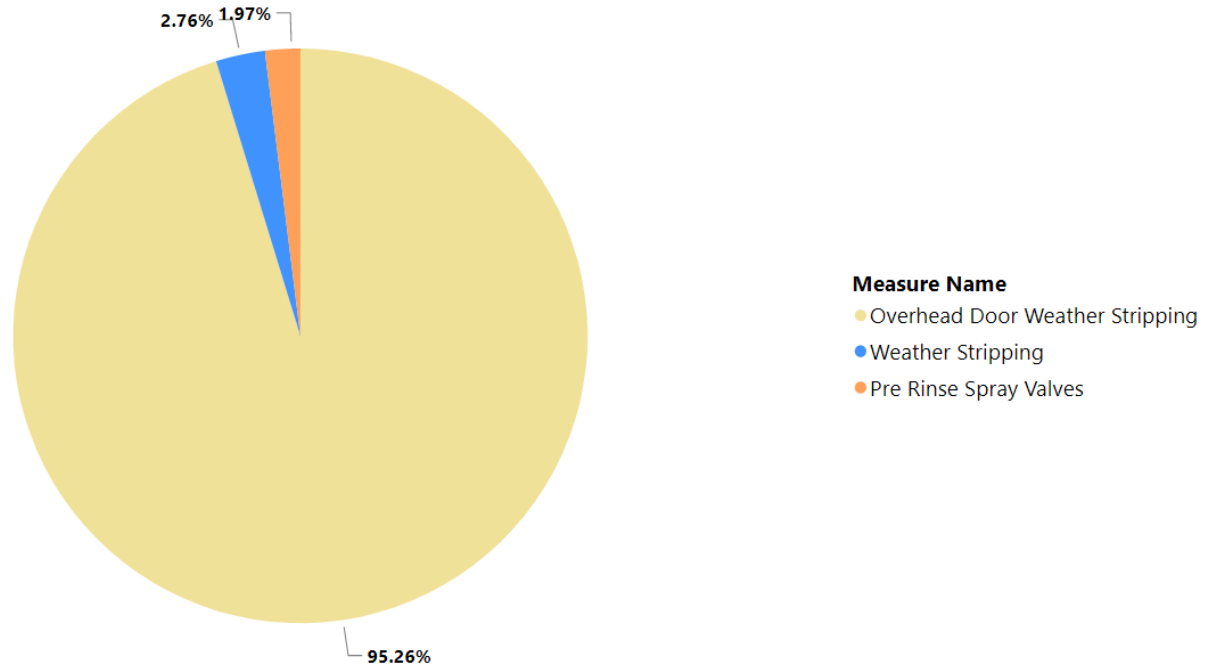


Figure 9 – 2022 Commercial & Industrial Direct Install Measure Mix

C&I Therm Savings Percentage by Measure - Custom

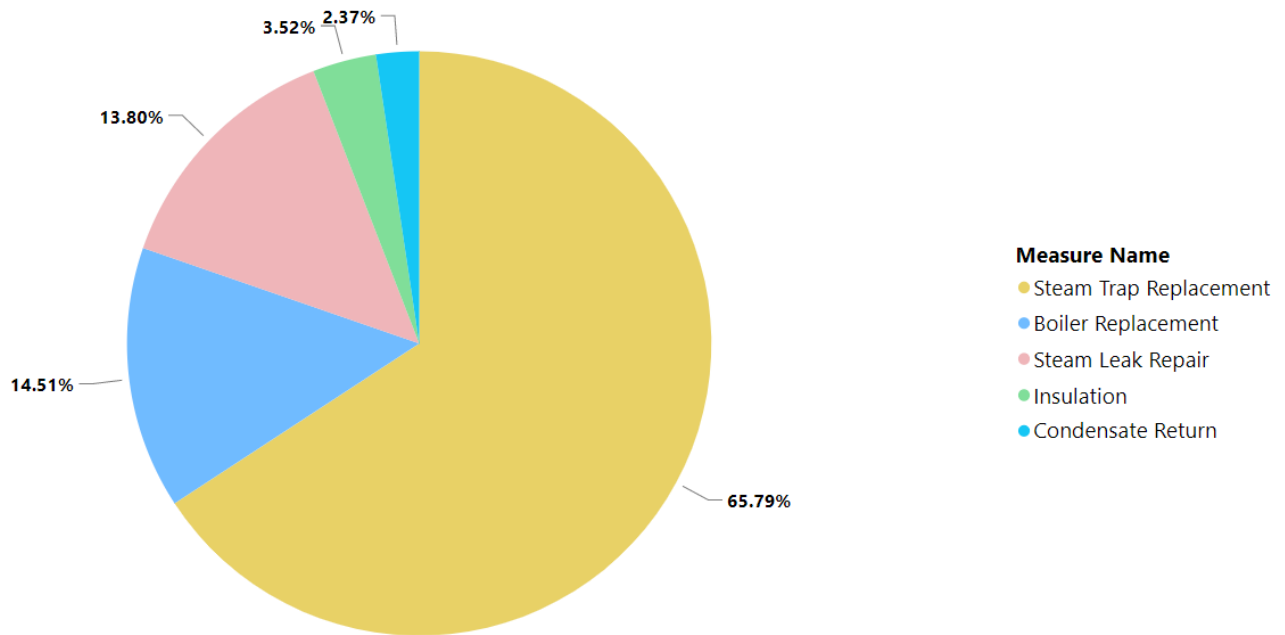


Figure 10 – 2022 Commercial & Industrial Custom Measure Mix

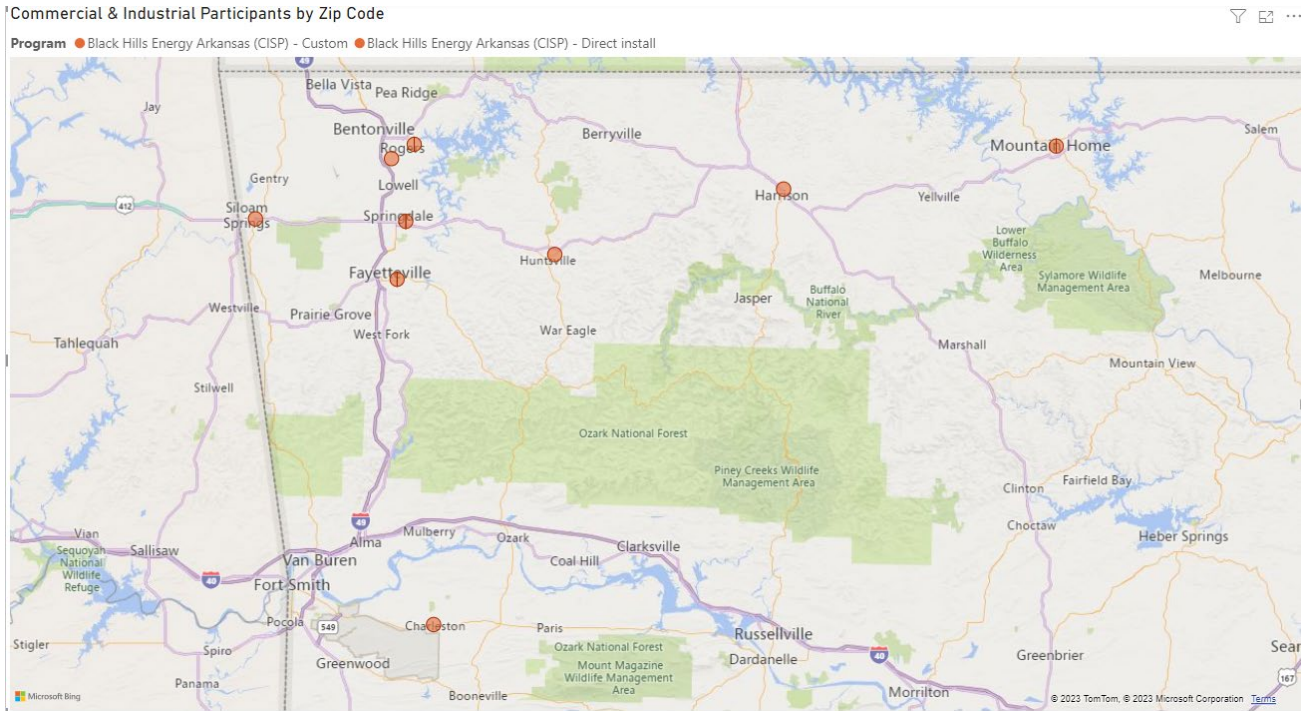


Figure 11 – 2022 Commercial & Industrial Participants by Zip Code

2.4.3 Program Budget, Savings, and Participants

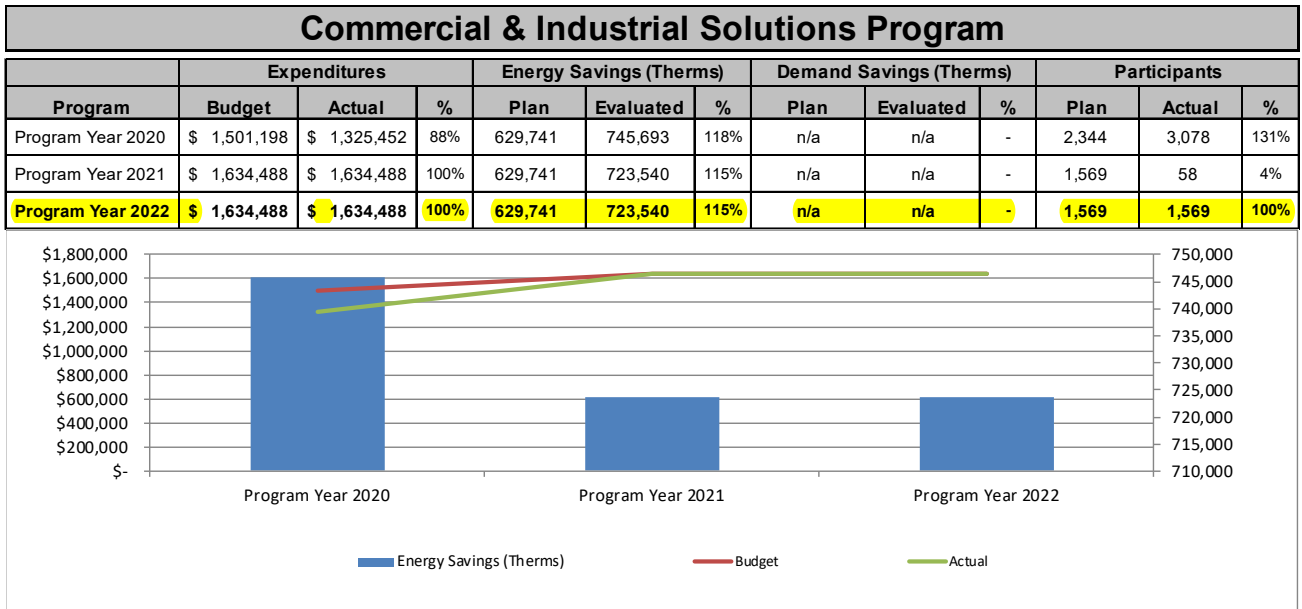


Figure 12 – 2022 Commercial & Industrial Solutions Program Trends

2.4.4 Description of Participants

- A Participant of BHEA's CISP is defined as any measure installed.

2.4.5 Challenges & Opportunities

- BHEA's primary challenge in this program is assisting CLEAResult in finding opportunities for custom projects. A large capital investment by customers can be required to participate in this program.
- BHEA employs a Commercial and Industrial Account Manager to promote the Company's EE Portfolio at customer meetings and outside events. The account manager works with CLEAResult to provide contacts for follow up.

2.4.6 Planned or Proposed Changes to Program & Budget

- BHEA will continue to update and revise the program to incorporate new technology and equipment.
- In PY 2022, the Company has included Strategic Energy Management (SEM) as an available measure.

2.4.7 BHEA's Response to Evaluators' Recommendations

- Estimate water impacts in customer audit report payback calculations/ROI for relevant projects., Projects that save water can have significantly more rapid payback periods than just based solely on their gas savings. CLEAResult should factor this into audit report calculations when the opportunity presents itself (steam leak repair, condensate return, etc.).
 - BHEA will investigate and implement if feasible.

2.5 Low Income Pilot Program

2.5.1 Program Description

The Low Income Pilot Program (LIPP) is a third year program in PY2022 that was designed to comply with Act 1102. LIPP is an extension of the Consistent Weatherization Approach (CWA), and it is targeted to customers who meet the income eligibility requirements of the Low Income Home Energy Assistance Program (LIHEAP).

The program provides energy assessments, along with direct installation of low-cost measures and pre-qualification for building envelope improvements.

- Direct install measures include:
 - Faucet aerators.
 - Low flow showerheads.
- Weatherization measures include:
 - Air infiltration.
 - Duct sealing.
 - Ceiling insulation.

Additionally, the program offers a maximum of \$500 per participating residence to meet the health code standards required to weatherize the residence. Health and safety funding may be used to provide carbon monoxide detectors, smoke detectors, or other required measures. s.

2.5.2 Program Highlights

- The program successfully completed comprehensive H&S retrofits with thorough documentation, meeting all Act 1102 requirements.
- The LIPP spent \$449 per home on H&S retrofits, and thoroughly documented the equipment installed. In response to PY2021 recommendations, BHE formalized categories for electric and plumbing repair.
- 40 homes were weatherized in 2022, which were joint projects done in conjunction with SWEPCPO.
- The focus on joint projects allowed the recipients to have up to a \$1,000 of Health & Safety equipment installed since the costs were split between the utilities. This was a great service to these customers as many of these homes needed extensive repairs before the weatherization measures could be installed.
- Savings increased by 25.8% from PY2021 to PY2022, after having already increased by 15.8% from PY2020 to PY2021.
- Respondents noted high satisfaction across all categories, including 85% reporting being “very satisfied” with the program overall.

2.5.3 Program Budget, Savings, and Participants

Low Income Pilot Program												
Program	Expenditures			Energy Savings (Therms)			Demand Savings (Therms)			Participants		
	Budget	Actual	%	Plan	Evaluated	%	Plan	Evaluated	%	Plan	Actual	%
Program Year 2020	\$ 81,904	\$ 80,675	98%	19,596	21,782	111%	n/a	n/a	-	0	0	-
Program Year 2021	\$ 102,239	\$ 101,082	99%	19,596	31,698	162%	n/a	n/a	-	123	399	324%
Program Year 2022	\$ 102,239	\$ 101,082	99%	19,596	31,698	162%	n/a	n/a	-	123	123	100%

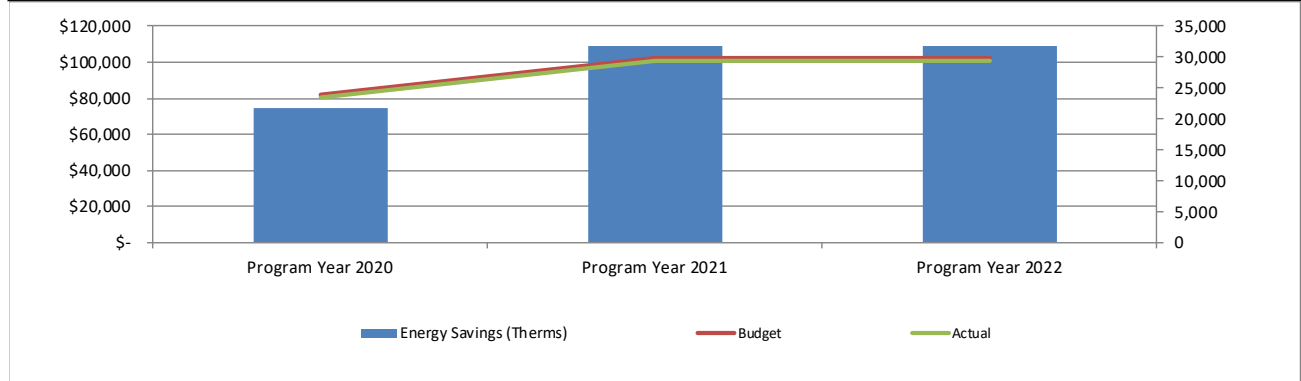


Figure 13 – 2021 Low Income Pilot Program Trends

2.5.4 Description of Participants

- A Participant of BHEA’s LIPP represents an incentivized measure, including assessments.

2.5.5 Challenges & Opportunities

- The current limit on Health & Safety measures is \$500 per project. While this meets the needs on joint projects, it falls short on BHEA only projects. Consideration will be given to increasing this limit to \$1,000 if needed.
- On the opportunity side, the program team was able to use a new CLEAResult Virtual application to remotely and in real time review the weatherization crew’s work when needed to perform quality control.

2.5.6 Planned or Proposed Changes to Program & Budget

- Currently there are no planned changes, however, BHEA will use the budget flexibility granted by the Commission if appropriate.

2.5.7 BHEA’s Response to Evaluator’s Recommendations

- **Formalize “electrician” and “AC tech” supplementary infrastructure work as H&S categories.** All instances of “Other” spending were for work from electricians or AC technicians to complete installations of H&S measures in homes where preexisting infrastructure was insufficient. This is a good strategy to meet Act 1102 requirements and complete H&S installations. As all “Other” spending fell into these readily delineable categories, establishing them as

standard H&S categories (albeit with variable incentive values) could simplify their use by program trade allies in future program years.

- ⊖ BHE has formalized this measure category.

2.6 Energy Efficiency Arkansas

2.6.1 Program Description

The Energy Efficiency Arkansas (“EEA”) program is a joint-utility program coordinated by the Arkansas Energy Office (“AEO”) to deliver cost-effective, relevant, consistent, and fuel neutral information and training that encourages people living in Arkansas to consume less energy through energy efficiency and conservation measures. This program includes the dissemination of educational material and messages through print, television, and radio advertisements, as well as training and certification programs.

Through the work done by the PWC Commercial and Industrial Collaborative, the EEA website www.energyarkansas.com is now a springboard for national accounts and other C&I customers to gain EE information for all participating utilities.

2.6.2 Program Highlights

- EEA was available to all BHEA customers for all of 2022.
- For more detailed information, see the separate annual report being filed by the EEA Program in Docket No. 07-083-TF.

2.6.3 Program Budget, Savings, and Participants

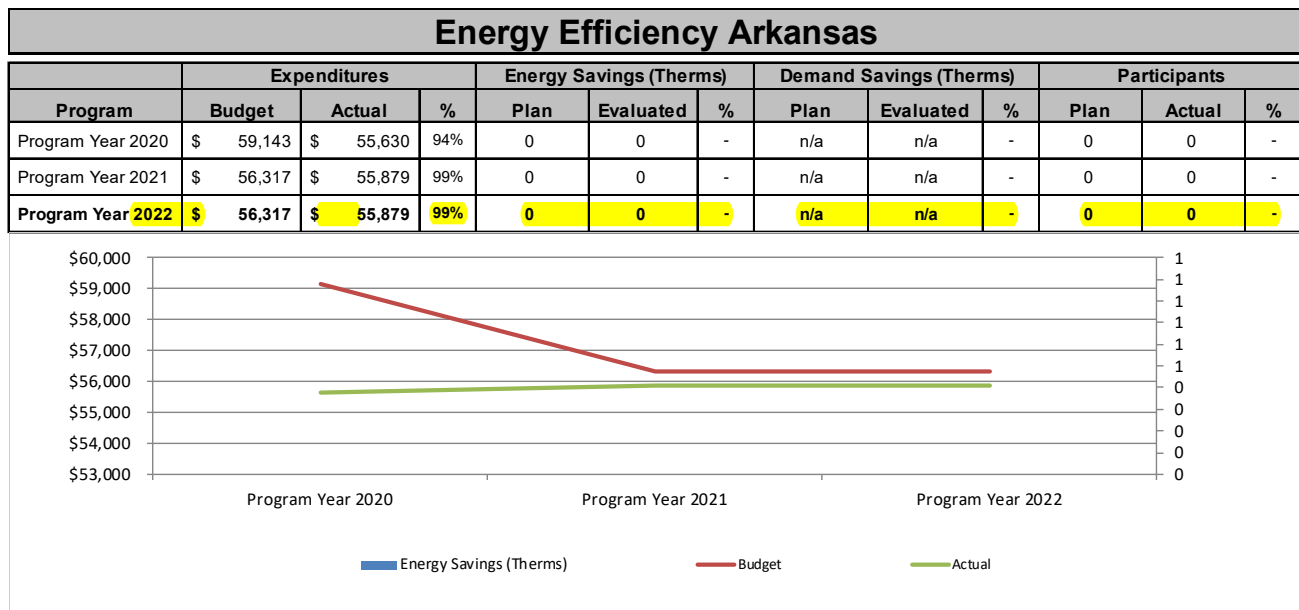


Figure 14 – 2022 Energy Efficiency Arkansas Program Trends

2.6.4 Description of Participants

- Participants in this program are difficult to quantify due to the nature of the program.

For more detailed information, see the separate annual report being filed by the EEA Program

2.6.5 Challenges & Opportunities

- For more detailed information, see the separate annual report being filed by the EEA Program in Docket No. 07-083-TF.

2.6.6 Planned or Proposed Changes to Program & Budget

- For more detailed information, see the separate annual report being filed by the EEA Program in Docket No. 07-083-TF.

3.0 Supplemental Requirements

3.1 Staffing

- Current staffing for BHEA's EE programs is one full-time individual.
- The Company has a Commercial and Industrial Account Manager who continues to leverage any contact with customers as an opportunity to promote EE programs.
- BHEA's implementer, CLEAResult, employs the equivalent of 6 full-time employees to work on BHEA's programs.

3.2 Stakeholder Activities

BHEA's EE team, including its program implementation and evaluation team members, was again very active with the PWC. The PWC held virtual meetings from February to October in 2022. The majority (n=10) of these discussions focused on making changes and updates to the Technical Reference Manual (TRM). The TRM discussions covered a variety of topics including accounting for the effects in the changes in the lighting market due to the roll-back of the Energy Independence and Security Act (EISA).

During 2022, the PWC also held multiple discussions regarding the impacts of COVID-19 on energy efficiency programs and evaluation activities.

The PWC also addressed concerns raised in prior Commission orders regarding the clarification of the National Standard Practice Manual (NSPM), the SARP Workbooks, and the discussion of the Carbon Calculator approaches.

Program evaluators provided timely updates throughout the year regarding the status of evaluation activities and worked proactively with the IEM to develop new studies for 2022 based on feedback from the PWC.

Table 1: Summary of PWC Meetings and Topics in 2020

3.3 Information Provided to Consumers to Promote EE

BHEA's marketing plan relies on traditional marketing channels to promote the programs. Additionally, BHEA uses customer touch points such as service calls, customer newsletters, and speaking engagements at seminars, conferences, and community events to spread the word about its programs. Over the past year, marketing for BHEA's energy efficiency programs has included:

- Continued Internet presence through the www.energyready-arkansas.com website which features:
 - A website that is mobile and tablet compatible;
 - A list of energy savings tips;
 - Information on all BHEA's EE programs and instructions on how to participate in each program, with contact information for further questions;
 - Printable rebate forms;
 - Online rebate application;
 - Links to other useful resources, such as a free online energy audit tool and energy efficiency organizations;
 - Samples of marketing materials;
 - A direct email link for more information or questions regarding any BHEA EE program
- Program materials are distributed at multiple events during the year, where BHEA customers are able to learn more about the programs.

Comprehensive Energy Efficiency Plan

Program Year 2022

Annual Report

Appendix A – Evaluation, Measurement and
Verification Report For The 2022 Arkansas Energy
Efficiency Portfolio



EVALUATION, MEASUREMENT AND VERIFICATION REPORT FOR THE 2022 ARKANSAS ENERGY EFFICIENCY PORTFOLIO

SUBMITTED TO: BLACK HILLS ENERGY ARKANSAS

SUBMITTED ON: APRIL 24, 2023

SUBMITTED BY: ADM ASSOCIATES, INC.

ADM Associates, Inc
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Black Hills Energy



Acknowledgements

We would like to thank the staff at Black Hills Energy Arkansas for their time and effort in contributing to the EM&V of the PY2022 programs. This evaluation was conducted with regular coordination with staff at BHE, who provided quick feedback and turnaround to the requests of the evaluation team as well as open and forthright insights into the operations of their programs.

Further, we would like to acknowledge our gratitude towards BHE customers, implementation contractor staff, and trade allies. As with the staff at BHE, their active participation allowed for the evaluation team to collect all needed data for this effort.

In final, we would like to thank staff at the Independent Evaluation Monitor for their involvement in providing thorough answers and clarification to the evaluation team when higher-level questions arose over the course of the PY2022 EM&V effort.

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TABLE OF CONTENTS

1	Executive Summary.....	1-1
2	General Methodology.....	2-1
3	Portfolio-Level Summary	3-1
4	Residential Solutions.....	4-1
5	Commercial & Industrial Solutions Program (CISP)	5-1
6	Low Income Pilot Program.....	6-1
7	Appendix A: Site Reports	7-1
8	Appendix B: Deferred Replacement Cost Calculations.....	8-1
9	Appendix C: Sample TRM Calculations	9-1
10	Appendix D: Detailed NTG Tables.....	10-1
11	Appendix E: Cost-Benefit Inputs	11-1

LIST OF TABLES

Table 1-1: BHE PY2022 Energy Efficiency Portfolio Overview	1-3
Table 1-2: BHE PY2022 Energy Efficiency Portfolio Sectors Served.....	1-3
Table 1-3: Gross Impact Summary	1-4
Table 1-4: Net Impact Summary	1-4
Table 1-5: BHE PY2022 EE Portfolio Performance against Goals.....	1-5
Table 1-6: BHE PY2022 Ex Post Electric Savings.....	1-6
Table 1-7: BHE PY2022 Ex Post Water Savings (Gallons)	1-6
Table 1-8: BHE PY2022 Avoided/Deferred Replacement Cost	1-7
Table 2-1: PY2022 Impact Evaluation Activities by Program	2-8
Table 2-2: PY2022 NTG Approaches by Program.....	2-9
Table 3-1: Summary of Data Collection Efforts.....	3-1
Table 3-2: Assessment of Customer Education by Program.....	3-3
Table 3-3: Assessment of Trade Ally Training by Program	3-3
Table 3-4: Assessment of Marketing & Outreach by Program	3-4
Table 3-5: Assessment of Budgetary, Management, and Program Delivery Resources by Program	3-5
Table 3-6: End-Uses Addressed by Program.....	3-6
Table 3-7: Installation of Multiple Measures.....	3-8
Table 3-8: Assessment of Project Comprehensiveness by Program.....	3-8
Table 3-9: Assessment of Targeted Customer Sectors by Program.....	3-10
Table 3-10: Assessment of Cost-Effectiveness.....	3-11
Table 3-11: Assessment of Data & QA/QC Procedures by Program	3-12
Table 3-12: Cost-Effectiveness Summary.....	3-13
Table 3-13: Residential NEBs	3-13
Table 3-14: Commercial & Industrial NEBs	3-13

Table 4-1: Residential Solutions Performance against Goals	4-1
Table 4-2: RSP PY2022 Impact Evaluation Activities.....	4-2
Table 4-3: RSP Non-Energy Benefits	4-3
Table 4-4: Determining Appropriate Timing to Conduct a Process Evaluation	4-4
Table 4-5: Determining Appropriate Conditions to Conduct a Process Evaluation.....	4-4
Table 4-6: Residential Solutions Response to PY2021 Recommendations.....	4-4
Table 4-7: RSP Equipment Rebates Pathway Data Collection Summary	4-7
Table 4-8: RSP Home Energy Savings Pathway Data Collection Summary	4-14
Table 4-9: CWA Required Process Evaluation Metrics.....	4-16
Table 4-10: HES Pathway Alignment with CWA Requirements	4-16
Table 4-11 Summary of Home Participation.....	4-17
Table 4-12: RSP Summary of Free-ridership, Spillover, and NTGRs.....	4-22
Table 4-13: Residential Furnace RUL	4-28
Table 4-14: RSP Ex Post Gross Therms Savings.....	4-33
Table 4-15: RSP Net Savings Summary	4-33
Table 4-16: RSP Ex Post Net Electric Savings	4-34
Table 4-17: RSP Ex Post Net Water Savings	4-34
Table 5-1: CISP Historical Performance against Goals.....	5-1
Table 5-2: Custom Project Participation Summary.....	5-4
Table 5-3: Determining Appropriate Timing to Conduct a Process Evaluation	5-4
Table 5-4: Determining Appropriate Conditions to Conduct a Process Evaluation.....	5-5
Table 5-5: BHE CISP Data Collection Summary	5-6
Table 5-6: CISP Response to PY2020 Recommendations	5-6
Table 5-7: CISP Non-Energy Benefits	5-13
Table 5-8: BHE CISP Prescriptive Project Summary	5-15

Table 5-9: BHE CISP Custom Project Summary	5-16
Table 5-10: CISP Custom Project Free-Ridership Results.....	5-20
Table 5-11: CISP Ex Post Therms Savings	5-21
Table 5-12: CISP Net Savings Summary	5-21
Table 5-13: Total Marginal Water Rates	5-22
Table 5-14: Commercial & Industrial Solutions Ex Post Net Water Savings	5-22
Table 6-1: LIPP Historical Performance against Goals	6-1
Table 6-2: Determining Appropriate Timing to Conduct a Process Evaluation	6-3
Table 6-3: Determining Appropriate Conditions to Conduct a Process Evaluation.....	6-3
Table 6-4: CWA Required Process Evaluation Metrics.....	6-4
Table 6-5: LIPP Alignment with CWA Requirements	6-4
Table 6-6: LIPP Response to PY2020 Recommendations.....	6-6
Table 6-7: BHE LIPP Data Collection Summary	6-7
Table 6-8: Respondents by Utility (n=20)	6-10
Table 6-9: LIPP Ex Ante Summary	6-16
Table 6-10: LIPP Ex Post Savings Summary	6-17
Table 3. Estimated Useful Life by Respective Measure	7-20
Table 9-1: TRM V9.0 Annual Furnace Heating Load	9-1
Table 9-2: Residential Water Heating Baseline Uniform Energy Factors.....	9-2
Table 9-3: TRM V9.0 Estimated Annual Hot Water Use	9-2
Table 9-4: Residential Water Supply Inlet Temperatures.....	9-3
Table 9-5: Smart Thermostat Deemed Savings Factors.....	9-3
Table 9-6: EFLH Values.....	9-4
Table 9-7: Hot Water Requirements by Facility Size.....	9-5
Table 9-8: Hot Water Requirements by Unit or Person.....	9-5

Table 9-9: DI Aerator Savings Calculation Parameters	9-6
Table 9-10: 1.0 GPM Commercial Aerator Savings	9-6
Table 9-11: 0.5 GPM Commercial Aerator Savings	9-7
Table 9-12: Pre-Rinse Spray Valves Savings Calculation Parameters	9-8
Table 9-13: DI Showerhead Savings Calculation Parameters	9-9
Table 9-14: Daily Hot Water Reduction	9-9
Table 9-15: DI Door Infiltration Savings Calculation Parameters.....	9-10
Table 9-16: EFLH _H By Weather Zone	9-10
Table 9-17: Deemed Annual Therm Savings per Linear Foot.....	9-10
Table 11-1: BHE Avoided Cost Values	11-1
Table 11-2: BHE Discount Rates.....	11-1
Table 11-3: Line & Distribution Losses.....	11-1

LIST OF FIGURES

Figure 1-1: Savings Share by Measure – Residential	1-4
Figure 1-2: Savings Share by Measure – C&I	1-5
Figure 1-3: Summary of Goal Attainment & Budget Expenditure by Program	1-6
Figure 1-4: Disposition of PY2020 Recommendations	1-9
Figure 2-1: Residential Free-ridership Designations.....	2-5
Figure 3-1: Comparison of Program Plan vs. Actual Acquisition Costs.....	3-6
Figure 3-2: Benefit Summary by Program	3-14
Figure 4-1: Program Savings Share by Measure	4-2
Figure 4-2: ERP Participation Summary	4-5
Figure 4-3: Installer Type by Brand.....	4-6
Figure 4-4: Savings per Unit by Brand.....	4-6
Figure 4-5: HES Pathway - Per-Home Therms Savings: Assessment vs. Install-Only.....	4-11
Figure 4-6: HES Pathway - % Houses with Each Measure	4-11
Figure 4-7: HES Pathway Trade Ally Participation Summary.....	4-12
Figure 4-8: HES Pathway Home Efficiency Graphic (source: https://energy-readyarkansas.com/home-energy-savings-evaluation.html).....	4-15
Figure 4-9: Program Awareness (n=117)	4-18
Figure 4-10: Participation Motivation (n=117)	4-18
Figure 4-11: Home Energy Assessment Motivation (n=88).....	4-19
Figure 4-12: Home Energy Assessment Satisfaction (n=80).....	4-20
Figure 4-13: Home Energy Assessment Usefulness (n=80)	4-20
Figure 4-14: Likelihood of Installing Equipment (n=117).....	4-20
Figure 4-15: Changes in Energy Bill (n=117)	4-21

Figure 4-16: Program Satisfaction (n=117)	4-21
Figure 4-17: RSP FR Diagram.....	4-22
Figure 4-18: Air Infiltration Field Data Collection Results (n=55)	4-26
Figure 4-19: Duct Sealing Field Data Collection Results (n=56).....	4-26
Figure 4-20: Residential Furnace Early Retirement Flowchart	4-29
Figure 4-21: Equipment Rebates Pathway - Baseline Thermostat for Smart Thermostat Rebates	4-31
Figure 4-22: Realization Rate by Tracking System: ERP	4-32
Figure 4-23: Realization Rate by Tracking System: HES.....	4-32
Figure 5-1: Total Net Therms by Program Pathway	5-2
Figure 5-2: Direct Install Participation Summary.....	5-3
Figure 5-3: CISP Prescriptive Participation Summary	5-3
Figure 5-4: C&I Solutions Process Flow.....	5-11
Figure 5-5: CISP Custom Project Free-Ridership Diagram	5-19
Figure 6-1: Program Savings Share by Measure	6-2
Figure 6-2: Percent of Homes Receiving LIPP Measures	6-3
Figure 6-3: LIPP Spending Per-Home	6-5
Figure 6-4: BHE LIPP Act 1102 Eligibility Summary.....	6-5
Figure 6-5: Summary of H&S Measure Spending	6-10
Figure 6-6: Program Awareness (n=20)	6-11
Figure 6-7: Participation Motivation (n=20)	6-12
Figure 6-8: Home Improvement Motivations (n=20)	6-12
Figure 6-9: Home Energy Assessment Motivation (n=14)	6-13
Figure 6-10: Home Energy Assessment Satisfaction (n=15)	6-13
Figure 6-11: Home Energy Assessment Usefulness (n=15)	6-14

Figure 6-12: Changes in Energy Bill (n=16) 6-14

Figure 6-13: Program Satisfaction (n varies)..... 6-15

Figure 8-1: Residential Tankless WH Avoided Replacement Cost Calculation 8-1

Figure 8-2: C&I Tankless WH Avoided Replacement Cost Calculation 8-2

Figure 8-3: Furnace Early Retirement Deferred Replacement Cost Calculation 8-2

1 Executive Summary

In March of 2019, Black Hills Energy Arkansas (BHE) filed its 2020–2022 Energy Efficiency Plan (EE Plan) in response to Commission Order No. 25 in Docket No. 13-002-U. The Arkansas Public Service Commission (APSC) approved the 2020–2022 programs, which builds upon BHE’s Quick Start Energy Efficiency programs that were implemented from late 2007 through early 2011 and the Comprehensive programs that have been implemented in Arkansas since mid-2011. The EE Plan was filed in compliance with Order No. 43 of Docket No. 13-002-U, which required investor-owned natural gas utilities in Arkansas to capture energy savings equivalent to 0.5% of their 2018 energy sales reduced by those customers choosing to self-direct their energy efficiency efforts.

This report presents the Evaluation, Measurement, & Verification (EM&V) results for BHE’s energy efficiency programs implemented in Program Year (PY) ~~2021~~2022. In accordance with APSC Conservation & Energy Efficiency (C&EE) Rules, BHE selected an independent, third-party EM&V contractor. The selected EM&V contractor is ADM Associates. The ADM staff, collectively referred to as the Evaluators, evaluated the BHE portfolio.

The PY2022 BHE evaluation included impact and process analyses that are specified in the APSC rules and follow the Arkansas TRM Version 9.0 (TRM V9.0) protocols and savings algorithms. In addition, ADM developed the program evaluation activities based upon discussions with BHE staff and its implementation contractors, reviews of program tracking and program documentation, a review of prior years’ EM&V efforts and BHE annual reports, and input from the Independent Evaluation Monitor (IEM).

BHE’s Plan includes a portfolio of energy efficiency programs designed to facilitate energy savings in every customer class. BHE services approximately 169,000 customers in Arkansas. BHE’s service area is primarily comprised of communities in Northwest Arkansas, including Fayetteville, Springdale, and Rogers, as well as North-central (Mountain Home) and Northeast (Blytheville, Manila, Osceola) communities.

1.1 Summary of BHE Energy Efficiency Programs

In PY2022, BHE offered a portfolio of three energy efficiency programs, which provided a comprehensive range of customer options for natural gas efficiency. BHE designed its programs to achieve the following objectives:

- Program plan net therm savings target of 1,330,541, exceeding the APSC target;
- Significant energy-savings opportunities for all customers and market segments;
- Broad ratepayer benefits; and

- Comprehensiveness in seven areas (comprehensiveness factors) defined by the APSC.¹

The Evaluators calculated the results for PY2022 for one commercial and industrial (C&I) and two residential programs. Those programs and pathways are described below:

- **Commercial & Industrial Solutions Program (CISP):**

- **Custom:** CISP offers technical assistance to support C&I customers in identifying and implementing energy savings opportunities. In its custom program offering, the CISP offers on-site technical assistance, trade ally incentives for steam system surveys, and incentives based on verified performance of custom measures that are outside of the scope of the TRM V9.0.
- **Prescriptive:** CISP offers prescriptive incentives for measures that have deemed savings established in the TRM, including commercial furnaces, water heaters, boilers, boiler controls, and food service equipment.
- **Direct Install:** The direct install component provides installation of high-saving, low-cost measures at no cost to the participant. Direct install measures include low flow showerheads, faucet aerators, pre-rinse spray valves, and weather stripping for exterior doors.

- **Residential Solutions Program (RSP)**

- **Equipment Rebates Pathway:** The Equipment Rebates Pathway offers residential customers rebates for purchasing energy efficient furnaces, tankless water heaters, and smart thermostats. The Equipment Rebates Pathway is designed to help provide customers assistance in identifying potential measures that are eligible for rebate and installation in qualifying residential homes.
- **Home Energy Solutions Pathway (HES Pathway):** The HES Pathway offers residential customers no cost assessments and energy efficient improvements. The Consistent Weatherization Approach (CWA) is delivered through this program. The HES Pathway is designed to help customers achieve savings by consulting with a qualified contractor who will analyze their energy use, identify, and install core energy efficiency improvements at no cost to the customer.

- **Low Income Pilot Program (LIPP):**

¹ As defined by the APSC in the C&EE Rules of Order No. 17 in Docket 08-144-U.

- **Low Income Pilot Program (LIPP)** offers qualifying residential customers no cost assessments and energy efficient improvements. The low income carveout for the Consistent Weatherization Approach (CWA) is delivered through this program.

Through its energy efficiency portfolio, BHE seeks to provide customers with easy program entry points, flexible options for saving energy and ongoing support for those who want to pursue deeper energy savings. Table 1-1 shows a list of the BHE programs, Pathways, and sectors served.

Table 1-1: BHE PY2022 Energy Efficiency Portfolio Overview

Program	Pathway	Sector
Residential Solutions	Equipment Rebates	Residential
	Home Energy Savings	Residential
CISP	Custom	Commercial, Industrial
	Prescriptive	Commercial, Industrial
	Direct Install	Commercial, Industrial
Low Income Pilot	N/A	Residential

Table 1-2: BHE PY2022 Energy Efficiency Portfolio Sectors Served

Program	Single Family	Multifamily	Small Business	Large C&I	Municipal	Agricultural
Residential Solutions	✓	✓				
CISP		✓	✓	✓	✓	✓
Low Income Pilot	✓	✓				

1.2 Evaluation Objectives

The goals of the PY2022 EM&V effort are as follows:

- Develop sampling plans that allow for attaining 90% confidence and ±10% precision for each of the (3) programs in the BHE portfolio.
- For prescriptive measures, verify that savings are being calculated according to appropriate Technical Resource Manual (TRM) V9.0 guidelines.
- For custom measures, this effort comprises the calculation of savings according to accepted protocols (such as International Performance Measurement and Verification Protocol). This is to ensure that custom measures are cost-effective and provide reliable savings.
- Assign net-to-gross (NTG) values for each pathway in the BHE portfolio.
- Conduct process evaluation of all BHE programs and of the portfolio overall. This is to provide a comprehensive review of program operations, marketing and outreach, quality control procedures, and program successes relative to goals. From this, the Evaluators provide program and portfolio-level recommendations for BHE. Process evaluation activities include interviews of key program actors, surveys of participants

and non-participants, literature reviews and best-practices assessments, and documentation of program activities, successes, and shortcomings.

1.3 Impact Findings

Table 1-3 and 1-4 present the gross and net impact by program.

Table 1-3: Gross Impact Summary

Program	Annual Energy Savings (Therms)		Lifetime Energy Savings (Therms)		Gross Realization Rate
	Ex Ante	Ex Post	Ex Ante	Ex Post	
Residential Solutions	775,314	822,948	13,020,099	13,820,026	106.1%
Commercial & Industrial Solutions	739,589	740,536	6,517,848	6,526,188	100.1%
Low Income Pilot	30,393	31,698	520,438	542,778	104.3%
Total	1,545,297	1,595,181	20,058,385	20,888,992	103.2%

Table 1-4: Net Impact Summary

Program	Annual Energy Savings (Therms)		Lifetime Energy Savings (Therms)		NTGR	Net Realization Rate
	Ex Ante	Ex Post	Ex Ante	Ex Post		
Residential Solutions	696,657	755,139	11,737,441	12,722,752	91.8%	108.39%
Commercial & Industrial Solutions	722,693	723,540	6,226,027	6,233,327	97.7%	100.12%
Low Income Pilot	30,393	31,698	520,438	542,778	100.0%	104.29%
Total	1,449,743	1,510,377	18,483,906	19,498,857	94.7%	104.18%

Figure 1-1 and Figure 1-2 summarize the share of savings by measure category for residential and non-residential segments, respectively.

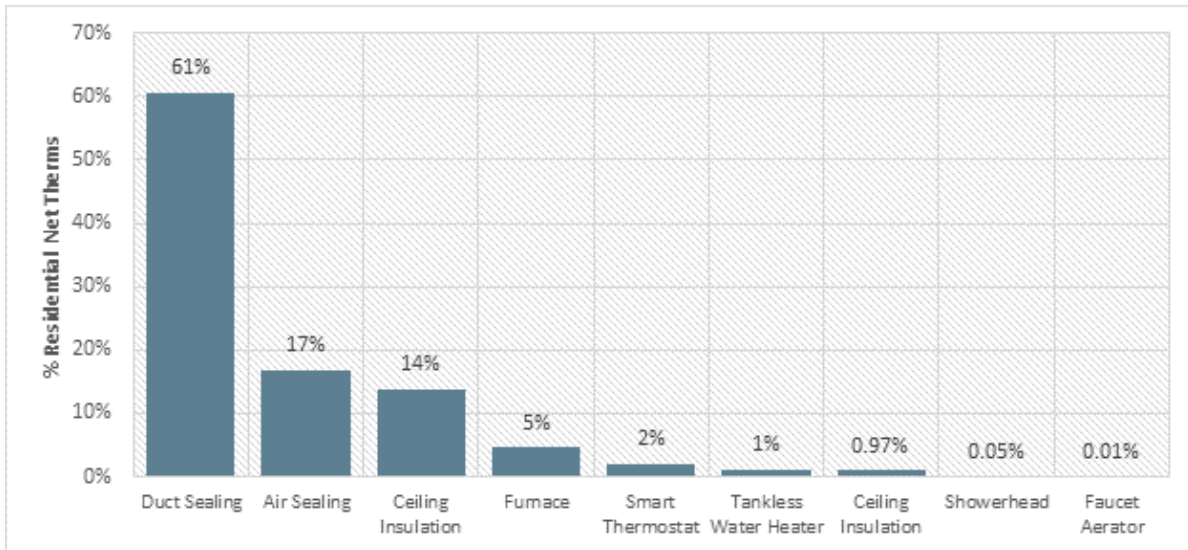


Figure 1-1: Savings Share by Measure – Residential

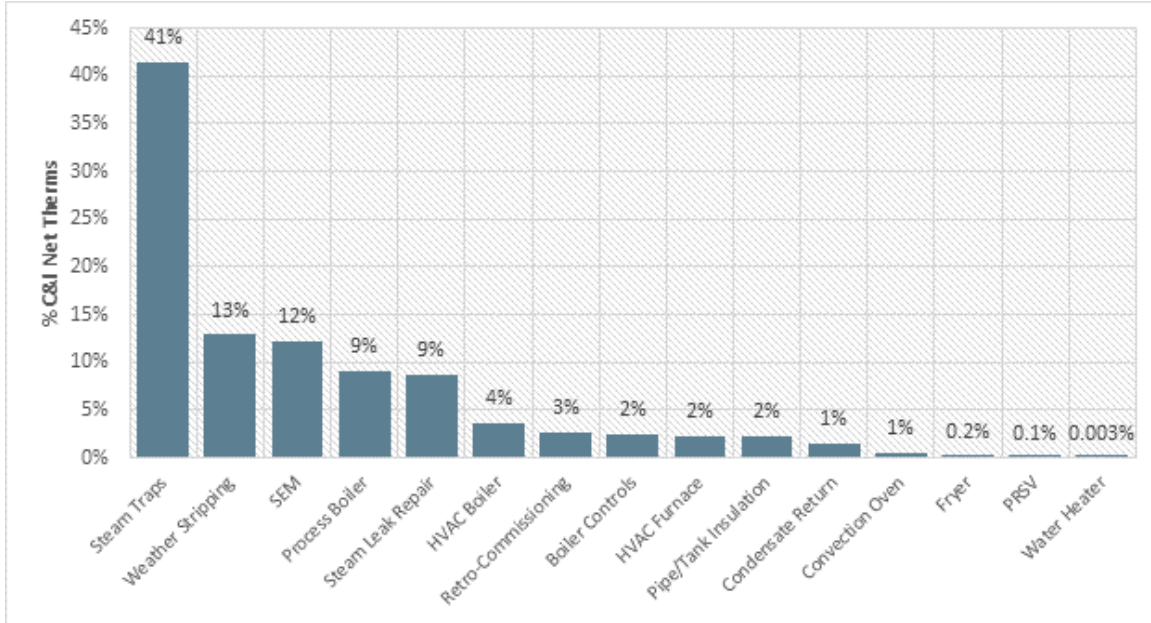


Figure 1-2: Savings Share by Measure – C&I

From this, the Evaluators have identified the following High Impact Measure (HIMs):

- Residential
 - Duct sealing
 - Air sealing
 - Ceiling insulation
 - Furnace replacement
- Non-residential
 - Steam trap replacement
 - Weather stripping
 - SEM
 - Process boilers
 - Steam leak repair

Further, the Evaluators put the net savings into the context of BHE’s filed PY2022 goal. BEH’s filed goal exceeds the requirements established by the APSC. Table 1-5 summarizes the performance against filed goals of programs evaluated in this report.

Table 1-5: BHE PY2022 EE Portfolio Performance against Goals

Program	PY2022 Ex Post Net Therms	PY2022 Net Therms Goal	% Goal Reached
RSP	755,139	681,204	110.9%
CISP	723,540	629,741	114.9%
LIPP	31,698	19,596	161.8%
Total	1,510,377	1,330,541	113.5%

The BHE portfolio overall met 113.5% of the filed savings goal, compared to 113.3% in PY2021. Percent of goal attained, and budget spent by program is summarized in Figure 1-3. This was achieved while spending 107.6% of the program budget, compared to 94.1% in PY2021.

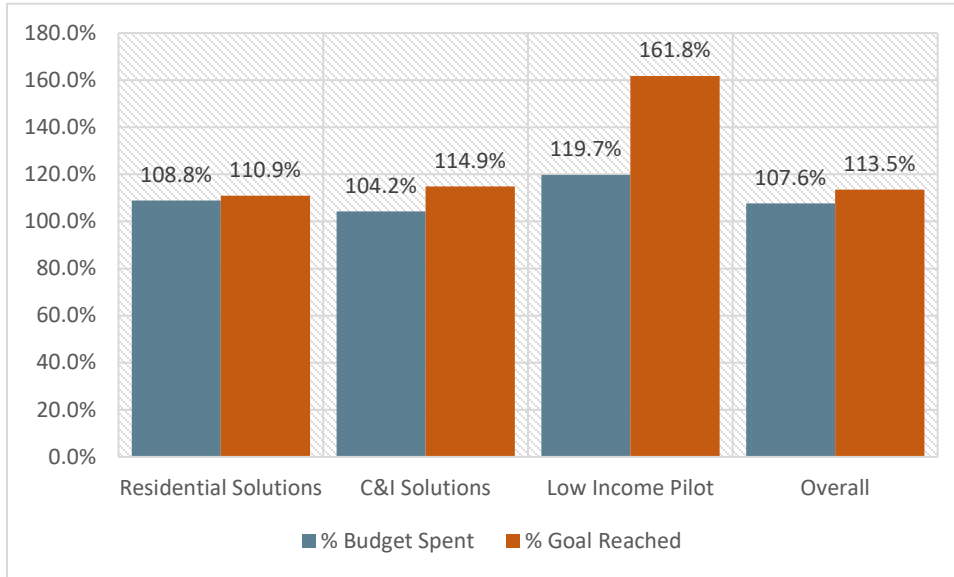


Figure 1-3: Summary of Goal Attainment & Budget Expenditure by Program

The non-energy benefits (NEBs) attained by the BHE portfolio in PY2022 are detailed below.

Table 1-6: BHE PY2022 Ex Post Electric Savings

Program	Measure	Net Annual kWh	Net Peak kW	Lifetime Net kWh
RSP	Smart Thermostats	163,078	0	1,793,863
	Air Infiltration	122,361	73.34	1,345,967
	Ceiling Insulation	231,294	193.32	4,625,881
	Duct Sealing	1,121,867	524.06	20,193,600
Total		1,638,600	790.72	27,959,311

Table 1-7: BHE PY2022 Ex Post Water Savings (Gallons)

Program	Measure	Net Annual Water	Net Lifetime Water
RSP	Faucet Aerators	102,365	1,023,653
	Showerheads		
CISP ²	Custom	40,941,063	409,410,632
	Direct Install	74,351	371,753
Total		41,117,779	410,806,037

² Direct Install included showerheads. Custom was comprised of steam leak repair, condensate return improvement, and low flow devices.

Table 1-8: BHE PY2022 Avoided/Deferred Replacement Cost

Program	Measure	Net ARC/DRC per Unit	Total DRC
RSP	Res Furnace Early Retirement	\$710.32	\$113,579.89
	Res Tankless WH	\$355.33	\$57,860.92
CISP	C&I Tankless WH	\$109.48	\$437.91
Total			\$171,878.72

1.4 Program Findings

1.4.1 Residential Solutions

The program significantly increased savings and exceeded program goal.	Savings are similar to PY2021, and the program met 110.9% of its filed net savings goal.
Realization rates were high across most measure categories.	The overall realization rate was 106.1%. Realization was high for all measure groups other than smart thermostats
The Virtual Energy Audit tool was removed from program operations.	Program staff elected to remove the VEA tool as restrictions related to COVID-19 eased. In PY2021, the VEA produced 619 smart thermostat projects.
Savings discrepancies found in some measures.	Smart thermostats installed in New Construction projects were shown with a mix of manual and programmable thermostat baselines.
Savings calculations differed after the database migration.	Calculation of deemed savings differed across the Catalyst and DSMT systems. The new system (DSMT) appear to be more conservative in estimates of savings, and higher realization rates were found for furnaces, water heaters, and attic insulation. Though the realization rate is a positive finding, it nonetheless warrants investigation into assumptions used in the new system.

1.4.2 C&I Solutions

<p>The program met savings goals and was highly cost-effective.</p>	<p>Though savings decreased by 2.5% compared to PY2021, and the program met 114.8% of its net savings goal</p> <p>Participation increased significantly in the Prescriptive Pathway for the second straight year. Savings by year from this pathway for the program cycle were:</p> <ul style="list-style-type: none"> • PY2020: 24,400 • PY2021: 36,398 • PY2022: 48,397
<p>NEBs have increased significantly.</p>	<p>Water savings increased significantly for the second straight year. Savings by year from this pathway for the program cycle were:</p> <ul style="list-style-type: none"> • PY2020: 435,401 • PY2021: 16,312,350 • PY2022: 41,015,414 <p>This is a volatile value year-over-year as it is heavily driven by the relative prevalence of custom projects that save water. The three highest water-saving projects accounted for 85% of total PY2022 water savings.</p>
<p>SEM is growing in prevalence in the Custom Pathway.</p>	<p>SEM constituted 15% of CISP Custom Pathway savings in PY2022. The one-year EUL for this measure as contributed largely to the decline in Custom EUL (declining from 11.09 in PY2021 to 8.81 in PY2022) but this is an anticipated side-effect of encouraging this measure.</p> <p>BHE plays a lower incentive per therm for SEM projects to account for this difference.</p>

1.4.3 Low Income Pilot

<p>The program met savings goals and was highly cost-effective.</p>	<p>Savings increased by 25.8% from PY2021 to PY2022, after having already increased by 15.8% from PY2020 to PY2021.</p>
<p>Survey respondents indicated high satisfaction.</p>	<p>Respondents noted high satisfaction across all categories, including 85% reporting being “very satisfied” with the program overall.</p>

The program successfully completed comprehensive H&S retrofits and met all Act 1102 requirements.

The LIPP spent \$449 per home on H&S retrofits, and thoroughly documented the equipment installed. In response to PY2021 recommendations, BHE formalized categories for electric and plumbing repair.

1.5 Response to Program Recommendations

In PY2021, four program or portfolio level recommendations were provided to BHE as part of the EM&V of their portfolio. The Evaluators reviewed BHE’s response to recommendations from the PY2021 EM&V report and categorized them as follows:

- 1) **Completed.** Recommendation fully implemented.
- 2) **Continuing.** Recommendation fully implemented. However, due to the nature of the recommendation, this will be an area monitored throughout the next program year.
- 3) **Rejected.** This applies to recommendations which are reviewed by BHE and rejected.
- 4) **In progress.** Recommendation accepted and will be adopted before next program year.
- 5) **Under consideration.** Recommendation still under review by program staff or implementers and no decision yet made.
- 6) **Reviewed and rejected.** Recommendation considered and subsequently rejected or no longer applicable due to changes in program design or operations.

The Evaluators found the disposition of the recommendations as follows:

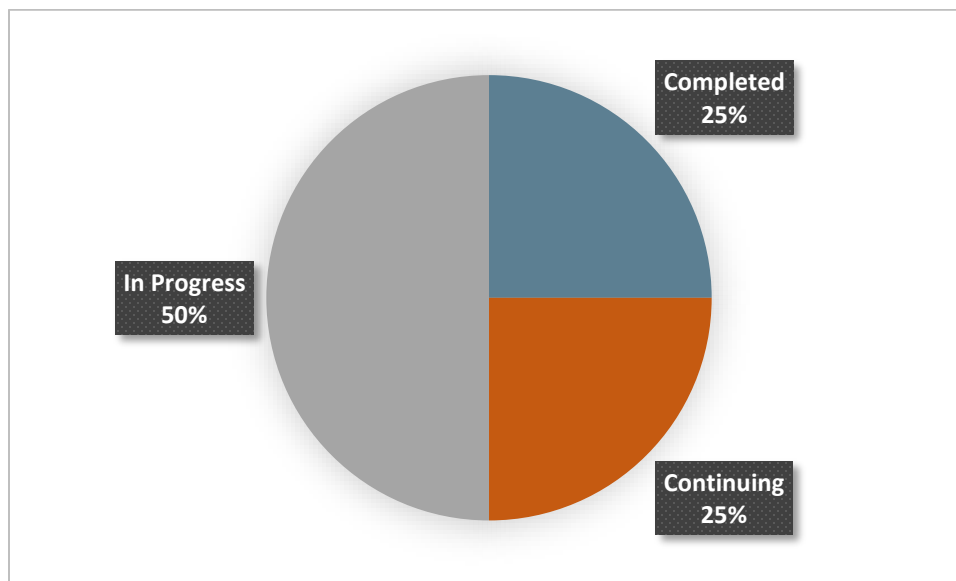


Figure 1-4: Disposition of PY2021 Recommendations

1.6 Report Organization

This report is organized with one chapter providing the full impact and process summary of a specified program. The report is organized as follows:

- Chapter 2 provides general methodologies;
- Chapter 3 provides a summary of portfolio-level issues;
- Chapter 4 provides results for the Residential Solutions Program;
- Chapter 5 provides results for the C&I Solutions Program;
- Chapter 6 provides results for the Low Income Pilot Program;
- Appendix A provides the site-level custom reports for the CISP;
- Appendix B provides Deferred Replacement Cost Calculations;
- Appendix C summarizes TRM deemed savings values;
- Appendix D presents NTG survey tabulations; and
- Appendix E summarizes cost-benefit inputs.

2 General Methodology

This section details general impact evaluation methodologies by program-type as well as data collection methods applied. This section will present full descriptions of:

- Gross Savings Estimation;
- Sampling Methodologies;
- Free-Ridership Determination;
- Process Evaluation Methodologies; and
- Data Collection Procedures.

2.1 Glossary of Terminology

As a first step to detailing the evaluation methodologies, the Evaluators provide a glossary of terms to follow³:

- *Ex Ante* – Forecasted savings used for program and portfolio planning purposes (from the Latin for “beforehand”)
- *Ex Post* – Savings estimates reported by the Evaluators after the energy impact evaluation has been completed (From the Latin for “From something done afterward”)
- *Deemed Savings* – An estimate of an energy savings or demand savings outcome (gross savings) for a single unit of an installed energy efficiency measure. This estimate (a) has been developed from data sources and analytical methods that are widely accepted for the measure and purpose and (b) is applicable to the situation being evaluated (e.g., assuming 17.36 Therms savings for a low-flow showerhead)
- *Gross Savings* – The change in energy consumption and/or demand that results directly from program-related actions taken by participants in an efficiency program, regardless of why they participated
- *Gross Realization Rate* – Ratio of Ex Post Savings / Ex Ante Savings (e.g., if ADM verifies 15 Therms per showerhead, Gross Realization Rate = $15/17.36 = 86\%$)
- *Free-Rider* – A program participant who *would have* implemented the program measure or practice in the absence of the program. Free riders can be total, partial, or deferred
- *Spillover* – Reductions in energy consumption and/or demand caused by the presence of the energy efficiency program that exceed the program-related gross savings of the

³ Arkansas TRM V9.0, Volume 1, Pg. 89-95

participants. There can be participant and/or non-participant spillover rates depending on the rate at which participants (and non-participants) adopt energy efficiency measures or take other types of efficiency actions on their own (i.e., without an incentive being offered).

- *Net Savings* – The total change in load that is attributable to an energy efficiency program. This change in load may include, implicitly or explicitly, the effects of free drivers, free riders, energy efficiency standards, changes in the level of energy service, and other causes of changes in energy consumption or demand (e.g., if Free-Ridership for low-flow showerheads = 50%, net savings = 15 Therms x 50% = 7.5 Therms).
- *Net-to-Gross-Ratio (NTGR)* = $(1 - \text{Free-Ridership \%} + \text{Spillover \%})$, also defined as *Net Savings / Gross Savings*
- *Ex Ante Net Savings* = Ex Ante Gross Savings x Ex Ante Free-Ridership Rate
- *Ex Post Net Savings* = Ex Post Gross Savings x Ex Post Free-Ridership Rate
- *Net Realization Rate* = Ex Post Net Savings / Ex Ante Net Savings
- *Effective Useful Life (EUL)* – An estimate of the median number of years that the efficiency measures installed under a program are still in place and operable
- *Gross Lifetime Therms* = Ex Post Gross Savings x EUL

2.2 Overview of Methodology

The proposed methodology for the evaluation of the PY2022 BHE portfolio is intended to provide:

- Net impact results at the 90% confidence and +/-10% precision at the program-level; and
- Program feedback and recommendations via process evaluation

In doing so, this evaluation will provide the verified net savings results, provide the recommendations for program improvement, and ensure cost-effective use of ratepayer funds.

2.3 Sampling

Sampling is necessary to evaluate savings for the BHE EE portfolio insomuch as verification of a census of program participants is typically cost-prohibitive. As per evaluation requirements set forth by the IEM, samples are drawn in order to ensure 90% confidence at the +/- 10% precision level. Programs are evaluated on one of three bases:

- Census of all participants
- Simple Random Sample

- Stratified Random Sample

2.3.1.1 Census of Participants

A census of participant data was used for programs where such review is feasible. Programs that received analysis of a census of participants include:

- Commercial & Industrial Solutions – Custom Component

2.3.1.2 Simple Random Sampling

For programs with relatively homogenous measures (largely in the residential portfolio), ADM conducted a simple random sample of participants. The sample size for verification surveys is calculated to meet 90% confidence and ±10% precision (90/10). The sample size to meet 90/10 requirements is calculated based on the coefficient of variation (CV) of savings for program participants. CV is defined as:

$$CV(x) = \frac{\text{Standard Deviation}(x)}{\text{Mean}(x)}$$

Where x is the average Therms savings per participant. Without data to use as a basis for a higher value, it is typical to apply a CV of 0.5 in residential program evaluations. The resulting sample size is estimated at:

$$n_0 = \left(\frac{1.645 * CV}{RP} \right)^2$$

Where,

1.645 = Z score for 90% confidence interval in a normal distribution

CV = Coefficient of Variation

RP = Required Precision, 10% in this evaluation

With 10% required precision (RP), this calls for a sample of 68 for programs with a sufficiently large population. However, in some instances, programs did not have sufficient participation to make a sample of this size cost-effective. In instances of low participation, ADM then applied a finite population correction factor, defined as:

$$n = \frac{n_0}{1 + n_0/N}$$

Where

n_0 = Sample Required for Large Population

N = Size of Population

n = Corrected Sample

For example, if a program were to have only 100 participants, the finite population correction would result in a final required sample size of 41. The Evaluators applied finite population correction factors in instances of low participation in determining samples required for surveying or onsite verification.

Programs subject to Simple Random Sampling included pathways of the Residential Solutions Program.

2.3.1.3 Stratified Random Sampling

For the BHE Commercial & Industrial Solutions program, Simple Random Sampling is not an effective sampling methodology as the CV values observed in business programs are typically very high because the distributions of savings are generally positively skewed. Often, a relatively small number of projects account for a high percentage of the estimated savings for the program.

To address this situation, we use a sample design for selecting projects for the M&V sample that takes such skewness into account. With this approach, we select a number of sites with large savings for the sample with certainty and take a random sample of the remaining sites. To further improve the precision, non-certainty sites are selected for the sample through systematic random sampling. That is, a random sample of sites remaining after the certainty sites have been selected is selected by ordering them according to the magnitude of their savings and using systematic random sampling. Sampling systematically from a list that is ordered according to the magnitude of savings ensures that any sample selected will have some units with high savings, some with moderate savings, and some with low savings. Samples cannot result that have concentrations of sites with atypically high savings or atypically low savings. Programs that were evaluated using stratified random sampling include:

- Commercial & Industrial Solutions – Direct Install (DI).

2.4 Free-Ridership

In determining ex post net savings for the BHE EE portfolio, the Evaluators provide estimates of free ridership for individual programs. Free riders are program participants that would have implemented the same energy efficiency measures at nearly the same time absent the program. As per TRM V9.0 guidelines, free riders are defined as:

“...program participants who received an incentive but would have installed the same efficiency measure on their own had the program not been offered. This includes partial free-riders, defined as customers who, at some point, would have installed the measure anyway, but the program persuaded them to install it *sooner* or customers who would have installed the measure anyway, but the program persuaded them to install more efficient equipment and/or more equipment. For the purposes of EM&V activities, participants who would have installed the equipment within one

year will be considered full free-riders; whereas participants who would have installed the equipment later than one year will not be considered to be free-riders (thus no partial free-riders will be allowed).”⁴

Given this definition, participants are defined as free riders through a binary scoring mechanism, in being either 0% or 100% free riders. Models of free ridership utilized in these EM&V efforts were aimed at providing a probability of free ridership; this probability value was then rounded to a whole-number free ridership value.

2.4.1.1 Residential Free-Ridership

The Evaluators determine free ridership by measure type and installation type for BHE programs. Free-ridership study groups are delineated by technology, delivery mechanism and target market. The taxonomy of residential free-ridership designations is summarized in Figure 2-1. Blocks marked in light blue indicate a final free-ridership category.

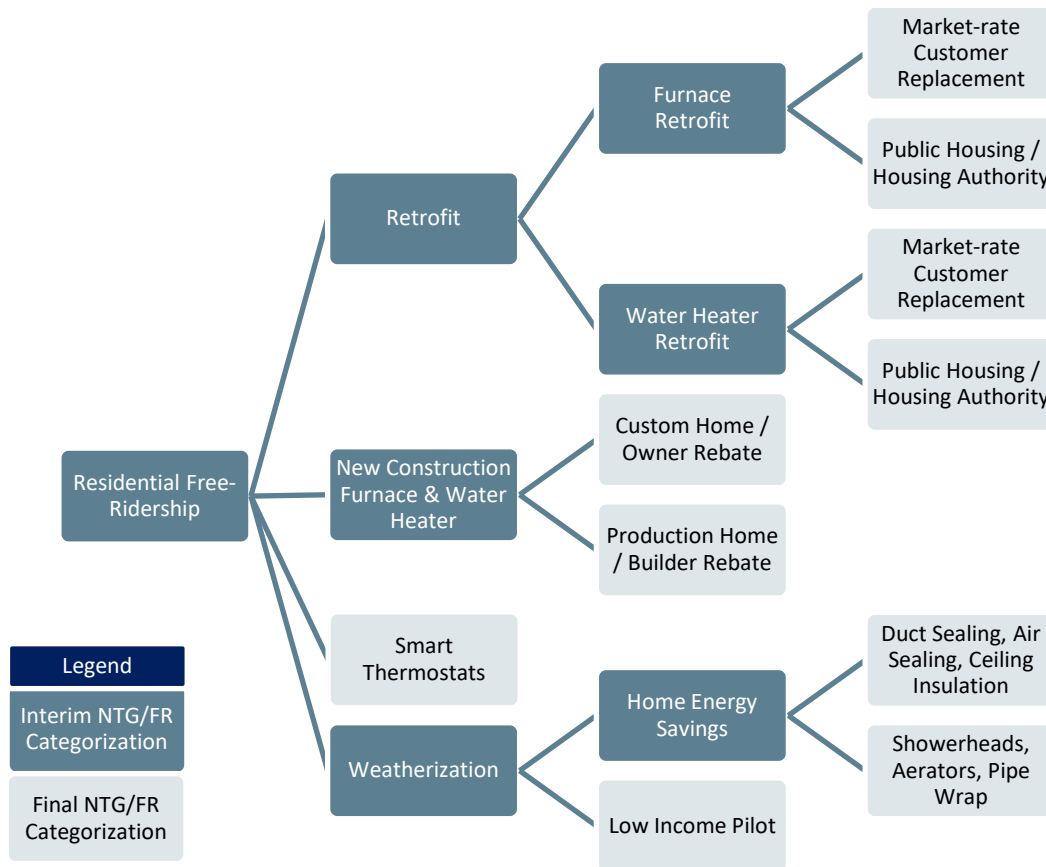


Figure 2-1: Residential Free-ridership Designations

⁴ Arkansas TRM V9.0, Pg. 450.

Certain measures were selected to have NTG evaluated by different market segments, as these segments can demonstrate markedly different decision-making processes and cost sensitivities. For example, installation of a high efficiency furnace or tankless water heater is a simpler process in new construction than in retrofit, and the decision is often made by a home builder rather than a homeowner. In instances such as this, the Evaluators segmented participation into key subgroups to better-differentiate the impact of BHE program interventions on various customer segments' decision-making.

The general methodology for evaluating free ridership among residential participants involved examination of four factors:

- (1) Demonstrated financial ability to purchase high-efficiency equipment absent the rebate
- (2) Importance of the rebate in the decision-making process
- (3) Prior planning to purchase high-efficiency equipment
- (4) Demonstrated behavior in purchasing similar equipment absent a rebate

In this methodology, Part (1) is essentially a gateway value, in that if a participant does not have the financial ability to purchase energy efficient equipment absent a rebate, the other components of free ridership become moot. As such, if they could not have afforded the high-efficiency equipment absent the rebate, free ridership is scored at 0%. If they did have the financial capability, the Evaluators then examine the other three components. The respondent is determined to be a free rider based upon a preponderance of evidence of these three factors; that is, if the respondent's answers indicate free ridership in two or more of these three components, they are considered free riders. Specific questions and modifications to this general methodology are presented in the appropriate program chapters.

For residential programs, free ridership is calculated as the average score determined for the sample of participants surveyed. For programs that are contractor-driven, the free rider score of a survey respondent incorporates the relative importance of advice from their contractor, provided that the contractor is a program trade ally that received training from the appropriate program. This value is then applied to the program-level savings to discount savings attributable to free ridership.

2.4.1.2 Prescriptive Non-Residential Free-Ridership

The general methodology for evaluating free ridership among prescriptive program participants involved examination of four factors:

- (1) Demonstrated financial ability to purchase high-efficiency equipment in the absence of the rebate
- (2) Importance of the rebate in the decision-making process

(3) Prior planning to purchase high-efficiency equipment

(4) Importance of the contractor in influencing the decision-making process⁵

In this methodology, Part (1) is essentially a gateway value, in that if a participant does not have the financial ability to purchase energy efficient equipment absent a rebate, the other components of free ridership become moot. As such, if they could not have afforded the high-efficiency equipment absent the rebate, free ridership is scored at 0%. If they did have the financial capability, the Evaluators then examine the other three components. The respondent is determined to be a free rider based upon a preponderance of evidence of these three factors; that is, if the respondent's answers indicate free ridership in two or more of these three components, they are considered free riders. Specific questions and modifications to this general methodology are presented in the appropriate program chapters.

For non-residential programs, free ridership is calculated as the average score determined for the sample of participants surveyed. This value is then applied to the program-level savings to discount savings attributable to free ridership.

2.4.1.3 Custom Free-Ridership

For custom projects from the CISP, free ridership is assessed on a case-study basis, through which the Evaluators conduct an in-depth interview that includes a battery of questions addressing:

- The timing of learning of the program relative to the timing of the planning of the retrofit;
- The impact the program incentive has on measure payback relative to the stated payback requirements by the respondent;
- Whether the respondent learned of the energy efficiency measure from a program-funded audit; and
- Whether any influence the program had in modifying the project affected savings by greater than 50%.

In the CISP chapter, the free rider “case studies” are provided for every custom project.

⁵ Contractor recommendations were considered to be program-inducement in instances where findings from vendor interviews showed that the program changed the mix of products sold by the vendor and that the vendor responsible for the customers' installation was a program trade ally.

2.5 Impact Evaluation Activities by Program

The Evaluators used established, industry-standard approaches to estimate energy savings at the measure, program, and portfolio levels. We followed all applicable measure- and program-level guidelines and protocols from the AR TRM V9.0.

To evaluate program impacts, the Evaluators adjusted program-reported gross savings using the results of our research, relying primarily on engineering desk reviews, TRM deemed savings calculation, and onsite verification and metering for applicable programs. To calculate deemed savings, we verified the appropriateness of savings algorithms and values in program tracking data as compared to guidelines in the TRM V9.0. Where sampling was used (for surveys and site visits), we designed a sampling plan to achieve a minimum precision of $\pm 10\%$ of the gross realized savings estimate with 90% confidence at the program-level.

Impact evaluation activities by program are summarized in Table 2-1.

Table 2-1: PY2022 Impact Evaluation Activities by Program

Program	Residential Solutions	CISP	Low Income Pilot
Database & Document Review	✓	✓	✓
Engineering Desk Review		✓	
TRM Deemed Savings Review	✓	✓	✓
On-site Verification / Metering	✓		
Simulation Modeling		✓	
Billing Analysis		✓	

2.5.1.1 Net-to-Gross Approach by Program

For the PY2022 evaluation, the evaluation team conducted data collection and analysis to support NTG calculations. Table 2-2 shows the NTG approach the Evaluators followed for each program based on our assessment of specific program needs and the availability of accurate, existing information. These data collection and analysis activities are in compliance with one of the five accepted approaches listed in the TRM V9.0, Protocol F.

Table 2-2: PY2022 NTG Approaches by Program

Program	Assigned PY2021 Value	Literature Review	BHE-specific Survey	Multi-utility Survey
Residential Solutions				
■ Residential furnace retrofit	✓			
■ Residential DHW retrofit	✓			
■ Residential smart thermostats	✓			
■ Housing authority furnace & DHW	✓			
■ New construction – builders	✓			
■ New construction – homeowner / custom	✓			
■ Commercial furnace & DHW	✓			
■ Home Energy Savings			✓	
CISP				
■ Direct install	✓			
■ Custom			✓	
■ Prescriptive boilers	✓			
■ Prescriptive food service	✓			
Low Income Pilot		✓		

2.6 Process Evaluation

The Evaluators’ general approach to process evaluation begins with a review of the tests for timing and appropriateness of process evaluation as defined in Protocol C of the TRM V9.0. In this review, the Evaluators determine what aspects of the program warrant a process evaluation.

The PY2022 process overviews began with interviews of program staff. These interviews, along with guidance from IEM protocols, inform the establishment of goals for the process evaluation, provide background history of programs, and give an introduction to portfolio-level issues. From these interviews, the Evaluators then develop a list of data collection activities.

The data collection procedures for process evaluations typically included:

- *Participant Surveying.* The Evaluators surveyed statistically significant samples of participants in each program in order to provide feedback for the program and provide an assessment of participant satisfaction.
- *In-Depth Interviews.* The Evaluators conducted in-depth interviews with high-level program actors, including BHE program staff, third-party implementation staff, and program trade allies. These interviews are semi-structured, in having general topics to be covered, without fully prescribed question and answer frameworks.

3 Portfolio-Level Summary

This chapter provides a summary of the portfolio-level findings and any cross-cutting evaluation activities that occurred over the course of the PY2022 EM&V effort. Specifically, this chapter includes:

- A summary of program and portfolio performance in PY2022;
- A summary of EM&V activities and expenditures in PY2022; and
- High-level findings that cut across programs.

3.1 Summary of EM&V Effort

Table 3-1 summarizes the data collection efforts for the PY2022 EM&V effort. “Interviews” should be distinguished from “Surveys” in that “Interviews” reflect semi-structured, in-depth discussions with high-level program actors (such as utility staff and third-party implementation staff) whereas surveys are fully structured and typically conducted with program participants.

Table 3-1: Summary of Data Collection Efforts

Program	# Site Visits	# Surveys	# Interviews
Residential Solutions	70	117	2
CISP	0	8	4
Low Income Pilot	0	20	2
Total	70	145	8

3.2 Tests of Portfolio Comprehensiveness

The APSC has in place a set of criteria in order to determine whether an EE portfolio qualifies as “Comprehensive”. These criteria are:

- **Factor 1:** *Whether the programs and/or portfolio provide, either directly or through identification and coordination, the education, **training**, marketing, or outreach needed to address market barriers to the adoption of cost-effective energy efficiency measures;*
- **Factor 2:** *Whether the programs and/or portfolio, have adequate **budgetary**, management, and program delivery resources to plan, design, implement, oversee, and evaluate energy efficiency programs;*
- **Factor 3:** *Whether the programs and/or portfolio, reasonably address all major **end-uses** of electricity or natural gas, or electricity and natural gas, as appropriate;*
- **Factor 4:** *Whether the programs and/or portfolio, to the maximum extent reasonable, comprehensively address the needs of customers at one time, in order to avoid **cream-skimming** and lost opportunities;*

- **Factor 5:** *Whether such programs take advantage of opportunities to address the comprehensive needs of **targeted customer sectors** (for example, schools, large retail stores, agricultural users, or restaurants) or to leverage non-utility program resources (for example, state or federal tax incentive, rebate, or lending programs);*
- **Factor 6:** *Whether the programs and/or portfolio enables the delivery of all achievable, **cost-effective** energy efficiency within a reasonable period of time and maximizes net benefits to customers and to the utility system;*
- **Factor 7:** *Whether the programs and/or portfolio, have evaluation, measurement, and verification "EM&V") procedures **adequate** to support program management and improvement, calculation of energy, demand and revenue impacts, and resource planning decisions.*

The Evaluators reviewed the BHE programs and portfolio in order to assess whether it complied with the APSC Comprehensiveness Goals. In assessing these metrics, the Evaluators score them on numerous subcomponents. The scoring methodology is as follows:

- : Meets all requirements and is in full compliance with this performance indicator
 - ◐: Meets some requirements and is in partial compliance with this performance indicator
 - : Is not in compliance with this performance indicator.
- NA: Performance indicator is not applicable to this program.

3.2.1 Factor 1: Education, Training, Marketing, and Outreach

3.2.1.1 Assessment of Education

The Evaluators assessed the educational components of the BHE programs, in order to identify whether the programs were providing potential participants with the needed information to guide their decision-making, and whether the channels used to reach the target markets are appropriate. The Evaluators found that:

- BHE's programs used a range of channels to provide educational materials to their programs' target markets. The educational materials included brochures, case studies, and presentations to trade & industry groups.
- BHE program staff conducts outreach and education through a wide range of potential program partners, including contractors, retailers, home builders, and local governments.

The breadth of educational materials by program is summarized in Table 3-2.

Table 3-2: Assessment of Customer Education by Program

<i>Program</i>	<i>Provides Educational Materials</i>	<i>Outreach Through Multiple Channels</i>	<i>Education Targeted to Specific Market Barriers</i>	<i>Coordination of Education by Multiple Entities</i>
Residential Solutions	■	■	■	■
CISP	■	■	■	■
Low Income Pilot	■	■	■	■

- Educational materials broadly provided
- ◐ Program budgeting includes educational materials, but materials not broadly provided
- Educational materials not offered

3.2.2 Assessment of Training

The Evaluators reviewed each BHE program to assess whether:

- 1) The program is trade ally-driven;
- 2) If not, could or should the program be trade ally-driven;
- 3) The program provides training classes to support their program offerings; and
- 4) The program needs trade ally certification.

A summary of the Evaluators’ assessment of training for each BHE program is presented in Table 3-3.

Table 3-3: Assessment of Trade Ally Training by Program

<i>Program</i>	<i>Trade Ally Training Offered</i>	<i>Training Requirements Adhere to Best Practices</i>	<i>Trade Allies Participate in Training</i>
Residential Solutions	■	■	■
CISP	■	■	■
Low Income Pilot	■	■	■

- Category fulfilled in most instances (deviations are an exception)
- ◐ Category fulfilled in some instances (deviations occur regularly)
- Category not offered not offered/not fulfilled at all

BHE does not require trade ally registration to participate for most program pathways. Their approach has been to allow all licensed dealers or contractors to apply for the appropriate equipment rebates. Trade ally training and registration is required for the Home Energy Savings Pathway and for the Low Income Pilot, however. Staff at BHE and CLEAResult came to this conclusion given the extent of service provided by the program, thus requiring trade ally training and registration as warranted.

3.2.3 Marketing & Outreach

The Evaluators reviewed the marketing and outreach strategies associated with each of the BHE programs. These strategies were reviewed to assess whether they adequately addressed the relevant participant barriers, the extent to which trade allies were actively marketing the program (where appropriate), and whether the materials were correctly targeted in marketing a comprehensive approach to energy efficiency.

A summary of the Evaluators’ assessment of BHE marketing and outreach is presented in Table 3-4.

Table 3-4: Assessment of Marketing & Outreach by Program

<i>Program</i>	<i>Marketing Addresses Specific Barriers</i>	<i>Trade Allies Promote Program</i>	<i>Marketing Support Provided to Trade Allies</i>	<i>Marketing Performed Through Diverse Channels</i>
Residential Solutions	■	■	■	■
CISP	■	■	■	■
Low Income Pilot	■	■	■	NA

- Category fulfilled in most instances (deviations are an exception)
- Category fulfilled in some instances (deviations occur regularly)
- Category not offered not offered/not fulfilled at all

After reviewing the marketing and outreach materials, the Evaluators concluded that:

- Most programs have marketing materials that address specific barriers associated with the targeted segments or technologies.
- The BHE programs are marketed through a diverse range of channels, including mass-media advertising, online advertising, meetings and training sessions with professional organizations and trade groups, and partnered marketing with municipal governments.
- The BHE programs for the non-residential sector all apply past participant case studies in their marketing.
- The Low Income Pilot is not presently intended to be broadly marketed and has been assigned “N/A”.

3.2.4 Factor 2: Budgetary, Management, and Program Delivery Resources

Several performance indicators were assessed in reviewing the adequacy of budgetary, management, and program delivery resources presented in Table 3-5. This included:

- Self-reports from program management staff
- Cost per Therm saved
- Review of trade ally resources dedicated to program promotion

Table 3-5: Assessment of Budgetary, Management, and Program Delivery Resources by Program

<i>Program</i>	<i>Budget is Sufficient to Support Program Goals</i>	<i>Cost per-Therm Aligns with Program Plan</i>	<i>Program Has Sufficient Staffing</i>	<i>Program Has Sufficient Trade Ally Support</i>
Residential Solutions	■	■	■	■
CISP	■	■	■	■
Low Income Pilot	■	■	■	■

- Quantitative: meets of expectation/requirement
 Qualitative: Category fulfilled in most instances (deviations are an exception)
- ▼ Quantitative: value no lower than 90% of expectation/requirement
 Qualitative: Category fulfilled in some instances (deviations occur regularly)
- Quantitative: value is lower than 90% of expectation/requirement
 Qualitative: Category not offered not offered/not fulfilled at all

From this review, the Evaluators concluded that the BHE portfolio overall has adequate budget allocations. In PY2021 , the Evaluators had concluded that the programs were not adequately staffed as the role of “Manger, Energy Efficiency” had been vacant for more than a full quarter. This position was subsequently filled and as a result BHE has fulfilled staffing requirements pursuant to the Comprehensiveness Checklist for PY2022.

Aggregated across all programs, actual cost per therm is significantly lower than planned. As demonstrated in Figure 3-1, in PY2022 the BHE portfolio had an acquisition cost of \$2.99 per net therm, lower than the program plan value of \$3.15. At the individual program level, the LIPP significantly outperformed relative to its planned acquisition cost, with acquisition costs at 74% of the program plan value.

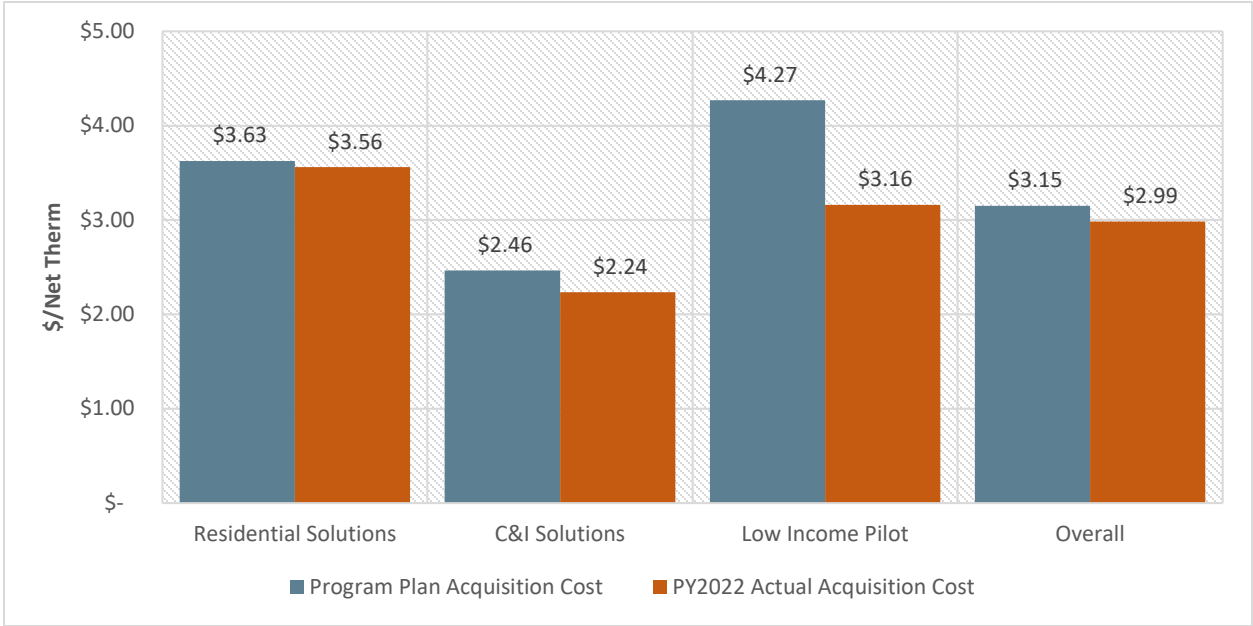


Figure 3-1: Comparison of Program Plan vs. Actual Acquisition Costs

Overall, the BHE portfolio had acquisition costs that were 5% lower than PY2022 plan values.

3.2.5 Factor 3: Addressing Major End-Uses

The Evaluators identified the end-uses served by each of the BHE programs. Most BHE programs are designed around a specific technology or end-use. Table 3-6 summarizes the end-uses addressed by each program.

Table 3-6: End-Uses Addressed by Program

Program	HVAC	Hot Water	Appliances	Food Service	Building Envelope	Industrial Process	Behavioral
Residential Solutions	■	■	■	■	■	■	■
CISP	■	■	■	■	■	■	■
Low Income Pilot	■	■	■	■	■	■	■

■ Measure targeted ◐ Measure offered ■ Measure not offered

Presently, the BHE portfolio covers most end-uses. The Evaluators found that sectors where the program offerings were not providing sufficient outreach and market transformation included:

- **Behavioral savings.** BHE cancelled their Home Energy Reports program to allow for the development of the Home Energy Savings weatherization program. This has had the tradeoff of filling residential building envelope but leaving a gap in behavioral savings. Given the program budget allotment, the Evaluators concluded that BHE was correct in prioritizing weatherization over behavioral savings.
- **Residential appliances.** The TRM V9.0 includes deemed savings for residential appliances, including dishwashers and clothes washers. These are not presently offered

in any BHE programs. However, given the low unit energy savings of these measures, any offering for this end-use would need to be an upstream, multi-utility effort to be cost-effective.

Table 3-7 summarizes the percent of projects that are single- versus multiple-measure installations by program. The Evaluators define “multiple measures” as follows:

- **Residential Solutions:** Completing more than one of the following four categories:
 - Furnace
 - Water Heater
 - Smart Thermostat
 - Duct Sealing
 - Air Sealing
 - Ceiling Insulation
 - Faucet Aerators
 - Showerheads
- **CISP:** Completing more than one of the following measures:
 - Custom
 - Prescriptive Boiler
 - Prescriptive Food Service
 - DrySmart Controls
 - Water Pump Controls
 - Direct Install Aerators
 - Direct Install Showerheads
 - Direct Install PRSVs
 - Direct Install Weather Stripping

Or having completed more than one custom measure, either as part of one application or multiple applications.

- **Low Income Pilot:** Completing more than of the energy-saving improvements as part of weatherization, excluding the Assessment and Health & Safety:
 - Duct Sealing
 - Air Sealing
 - Ceiling Insulation
 - Faucet Aerators
 - Showerheads
 - Smart Thermostats
 - Pipe Wrap

Table 3-7: Installation of Multiple Measures

Program	% Single-Measure	% Multi-Measure
Residential Solutions	44.3%	56.7%
CISP	87.0%	13.0%
Low Income Pilot	0%	100.0%

3.2.6 Factor 4: Comprehensively Addressing Customer Needs

To assess Factor 4, the Evaluators reviewed BHE programs to discern the extent of:

- Program-provided technical assistance;
- Incentives of comprehensive projects/measure suites; and
- Tiered incentives for higher efficiency levels.

The BHE portfolio has no specific requirements for installation of multiple measures. Customers are able to participate to an extent of their choice. This is a program best-practice in enabling customers to engage in energy efficiency in a manner in accordance with their budget constraints.

Table 3-8 summarizes the comprehensiveness of offerings for each program.

Table 3-8: Assessment of Project Comprehensiveness by Program

Program	Technical Assistance and/or Audits	Information Provided for Comprehensive Efficiency	Bundled Incentives for Multiple Measures	Tiered Incentives for Premium Efficiency	Trade Ally Incentives for Premium Efficiency
Residential Solutions	■	■	■	N/A	■
CISP	■	■	■	■	■
Low Income Pilot	■	■	NA	NA	NA

■ Broadly provided ◡ Available ■ Not offered

Findings from the assessment of this factor included:

- Most BHE prescriptive programs offer incentives to trade allies for installation of top-tier efficiency measures. This has included incentives for condensing furnaces, and tankless water heaters.
- The BHE portfolio formerly offered tiered incentives for premium efficiency across all of their rebate programs. In some cases, this tiering has been removed in lieu of only including premium efficiency. Examples include:
 - The incentives for furnaces in the former Equipment Rebates Program used to increase from \$400 for units with 90-94.99 AFUE to \$600 for units with 95 AFUE

or greater. The program now only offers incentives for 95 or greater AFUE (\$400 per unit). This decision was made due to low participation in this group; most program participants historically elected for the 95% AFUE model. BHE has by necessity reduced rebates for furnaces as avoided costs have declined since program inception.

- BHE has removed incentives for storage tank water heaters, opting to incentivize tankless units exclusively.
- Retained tiered incentives include:
 - High efficiency boiler incentives are \$1,400/million BTUs per hour (MMBTUh) input rating for units < 94% efficient and \$2,000/MMBTUh for units with 94% efficiency or greater.
 - The CISP pays an incentive per verified therm, and as a result projects with higher savings are by design paid a higher incentive.
- The BHE portfolio has programs that bundle on-site technical assistance with direct installation.
- The range of technical assistance varies by program. The Residential Solutions Equipment Rebates Pathway offers technical assistance through participating HVAC and plumbing contractors, while the Home Energy Savings Pathway and LIPP offer technical assistance through program-registered trade allies. CISP provides on-site technical assistance that is directly funded by the program.
- The programs have procedures for following up with customers after their participation (including thank-you calls or emails) and verification inspection.
- Marketing materials typically make attempts at cross-promotion of programs.
- The Low Income Pilot was assigned “N/A” for Tiered Incentives, Bundled Incentives, and Trade Ally Incentives categories as all measures are provided without a customer co-pay as part of an enhanced weatherization package under Act 1102 requirements.

3.2.7 Factor 5: Targeting Market Sectors & Leveraging Opportunities

The Evaluators reviewed whether the BHE portfolio offered a comprehensive range of energy efficiency opportunities to all major customer sectors. Table 3-9 summarizes the market sectors and what programs target or allow each sector.

Table 3-9: Assessment of Targeted Customer Sectors by Program

<i>Program</i>	Residential	Multifamily	Mobile Home	Small Commercial	Large Commercial	Industrial	Agricultural	Public Sector
Residential Solutions	■	◐	◐	■	■	■	■	■
CISP	■	◐	■	■	■	■	■	■
Low Income Pilot	■	◐	◐	■	■	■	■	■

■ Program targets this sector
 ◐ Sector is eligible for this program
 ■ Sector is ineligible for this program

Each sector has several programs for which they are eligible, and at least one program that targets them. Segment-specific findings include:

- Public Sector facilities are targeted with a wide range of programs. This has included residential programs that reach out to public housing authorities.
- Rebates for commercial furnaces and water heaters formerly offered through the Equipment Rebates Program are now offered under the CISP.
- Multifamily and mobile homes are technically eligible for BHE residential programs (including the LIPP). In practice, however, these market segments rarely participate in BHE programs as they have a high share of all-electric space heating and water heating equipment.

In addition, the Evaluators reviewed the extent of collaboration and leveraging of available partnership opportunities by BHE.

Examples of cross-utility coordination included:

- BHE has brought on a third-party implementer (CLEAResult) for their CISP. This implementer uses the same program design and similar incentive levels for CenterPoint and AOG. This has allowed for reduced program costs for CISP, which is the largest program in each of the three gas utility portfolios. Further, dual-fuel projects are coordinated with SWEPCO and EAI.
- In late PY2013, BHE established the Home Energy Savings Program. This weatherization program used a program model applied elsewhere in Arkansas by Entergy. Beginning in PY2016, the program corresponded to the Consistent Weatherization Approach as designed by the Arkansas Parties Working Collaboratively (PWC). BHE has program partnering agreements with multiple electric utilities to leverage the effectiveness of program funds.

- BHE has developed the Low Income Pilot in accordance with Act 1102, and this also manifests with a similar program design across utilities.

Examples of coordination with non-utility partners included marketing through industry partners such as professional organizations, trade groups, universities, and homeowners' associations.

3.2.8 Factor 6: Cost-Effectiveness of Energy Efficiency

To assess this factor, the Evaluators reviewed whether:

- Programs met net savings goals;
- The NTGR ratios were in line with industry norms; and
- Programs passed cost-effectiveness (TRC) testing.

A summary of Factor 6 findings is provided in Table 3-10.

Table 3-10: Assessment of Cost-Effectiveness

<i>Program</i>	<i>NTGR</i>	<i>NTGR Within Industry Norms</i>	<i>Met Net Savings Goal</i>	<i>Program TRC</i>
Residential Solutions	91.8%	Yes	Yes	2.27
CISP	97.7%	Yes	Yes	2.20
Low Income Pilot	100.0%	Yes	Yes	1.75

All programs and the portfolio overall had a TRC benefit-cost ratio of 1.0 or greater in PY2022.

3.2.9 Factor 7: Adequacy of EM&V Procedures

The Evaluators conducted a review of EM&V procedures by program as implemented by several parties:

- Quality assurance and quality control (QA/QC) and EM&V procedures by BHE program staff;
- QA/QC and EM&V procedures by third-party implementation staff (where applicable)
- QA/QC and EM&V procedures by the Evaluators.

The EM&V of the BHE programs incorporated industry best practices and was conducted in an iterative process that incorporated feedback from BHE and implementation contractors as well as the IEM.

Further, the Evaluators found that BHE has QA/QC procedures that align with industry best-practices, including randomized post-inspection to their programs and targeting of new trade allies for early feedback.

Finally, the Evaluators reviewed the quality of program tracking data in order to assess whether the data allowed for complete evaluation. Further, the Evaluators reviewed the extent to which individual savings calculations were performed using facility-specific inputs into the TRM V9.0 algorithms versus the use of simplifying assumptions⁶. The results of the review are summarized in Table 3-11.

Table 3-11: Assessment of Data & QA/QC Procedures by Program

<i>Program</i>	<i>Tracking Contains Necessary Fields</i>	<i>Savings Calculations Performed and Reported</i>	<i>Savings Calculations Based on Facility Data</i>	<i>QA/QC Inspections by Program Staff</i>
Residential Solutions	■	■	■	■
CISP	■	■	■	■
Low Income Pilot	■	■	■	■
■ Process fully developed ◐ Process partially developed ■ No process in place				

Findings of this review included:

- QA/QC inspections are in place for all programs.
- CLEAResult conducts inspections of an adequate percent of projects annually and align with industry best practices.

3.3 Cost-Effectiveness Results

Table 3-12 summarizes the cost-effectiveness results by program. Tests performed include:

- **Total Resource Cost (TRC):** Evaluating benefits and costs simultaneously from the perspective of BHE and program participants.
- **Utility Cost Test (UCT):** Evaluating benefits and costs from the perspective of BHE.
- **Ratepayer Impact Measure (RIM):** Evaluating benefits and costs from the perspective of all BHE customers (including participants and non-participants).
- **Participant Cost Test (PCT):** Evaluation benefits and costs from the perspective of program participants.

⁶ Examples of this could include assuming average facility square footage for commercial water heating and using that as an input to the savings calculation, as opposed to collecting facility-specific square footage.

Table 3-12: Cost-Effectiveness Summary

Program	TRC	UCT	PCT	RIM	TRC Net Benefits
Residential Solutions	2.25	1.54	4.70	2.25	\$3,528,978
CISP	2.20	1.37	3.80	2.20	\$2,388,359
Low Income Pilot	1.75	1.75	N/A	1.75	\$75,551
EEA	.00	.00	.00	.00	(\$55,233)
Regulatory	.00	.00	.00	.00	(\$48,083)
Total	2.17	1.45	4.44	.38	\$5,889,573

3.3.1.1 NEBs Summary

NEBs claimed by-program are as follows:

- **RSP:** avoided replacement costs, deferred replacement costs, kWh, kW, and water;
- **CISP:** avoided replacement costs, kWh, kW, and water; and
- **LIPP:** water. Measures in the LIPP can produce kWh and kW NEBs. However, in PY2022 the homes in BHE’s LIPP had 100% overlap with SWEPCO and all homes received electric utility funding so no electric NEBs were credited.

Table 3-13: Residential NEBs

Measure	Water	kWh / kW	Avoided Replacement Cost	Deferred Replacement Cost	AR TRM V9.0 Section
Furnace (early retirement only)				✓	2.1.3
Duct sealing		✓			2.1.11
Smart thermostats		✓			2.1.12
Ceiling insulation		✓			2.2.2
Air infiltration		✓			2.2.9
Tankless water heater			✓		2.3.1
Faucet aerators	✓				2.3.4
Low-flow showerheads	✓				2.3.5

Table 3-14: Commercial & Industrial NEBs

Measure	Water	kWh / kW	Avoided Replacement Cost	Deferred Replacement Cost	AR TRM V9.0 Section
Weather stripping		✓			3.2.11
Tankless water heater			✓		3.3.1
Pre-rinse Spray Valves	✓				3.7.12
Steam leak repair	✓				N/A - Custom
Condensate Return	✓				N/A - Custom

NEBs were a significant contributor to program benefits in PY2022, accounting for 39.9% of total TRC benefits across the portfolio (increased from 32.4% in PY2020). Figure 3-2 summarizes the percent of total TRC benefits derived from NEBs.

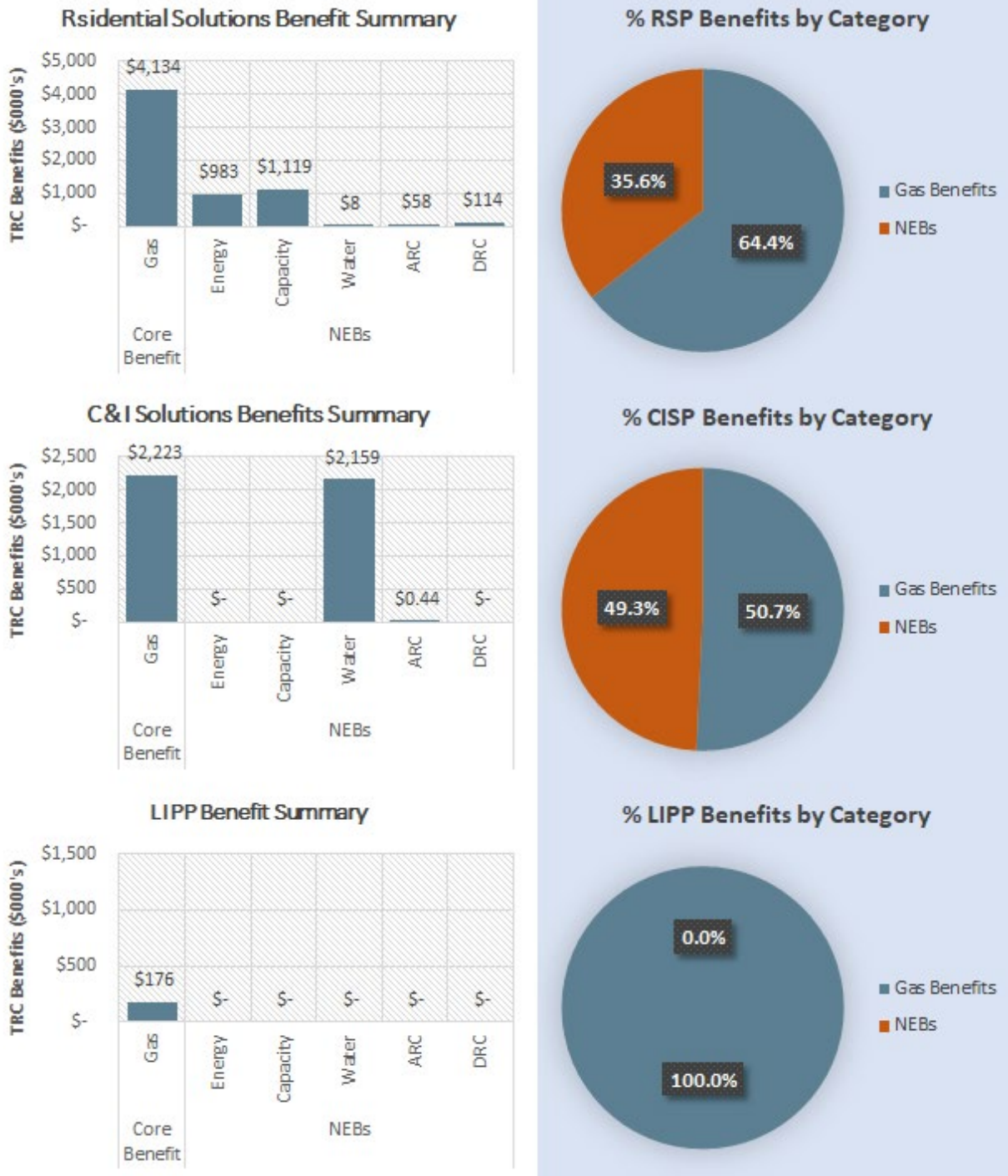


Figure 3-2: Benefit Summary by Program

RSP had NEBs that were largely similar to past program years. C&I Solutions had a significantly higher percent of TRC benefits from NEBs in PY2022 (increasing from 29.0% in PY2021 to 49.3% in PY2022). This is due to multiple custom projects with water savings, including three condensate return improvements and five steam leak repair projects. LIPP had no NEBs as all

projects were performed in coordination with SWEPCO, who claimed the electric savings from the joint projects.

3.4 Staff Transition at BHE

Following the departure of the longstanding portfolio manager at Black Hills Energy, the previous Black Hills Energy C&I manager at CLEAResult stepped into the portfolio manager role at Black Hills Energy. Although the outgoing manager retired at the end of 2021, the new manager did not fully take over until April 2022. BHE staffed an interim manager during the initial months of 2022 and the previous manager was available as a consultant during the filing season in May 2022, but the programs were slow to start in 2022 due to this transitional period. CLEAResult staff were able to hire additional staff to fill the gap when the previous C&I manager transitioned to Black Hills Energy.

Overall, the staff transition has gone smoothly. Both Black Hills Energy and CLEAResult staff indicated that having someone already familiar with the portfolio takeover made for a smoother and easier transition than if someone completely new had to be onboarded. The transition period with an interim manager between January and April was challenging, but things have improved considerably since May.

4 Residential Solutions

The Residential Solutions Program is comprised of two previously separate programs: the Equipment Rebate Program and the Home Energy Savings Program.

The Equipment Rebate Pathway provides incentives to residential customers for high-efficiency space heating, water heating equipment and smart thermostats. Further, a \$50 trade ally incentive is provided for all qualifying furnace and water heating equipment.

Eligible measures for this pathway include:

- \$400 for furnaces with 95% or higher AFUE;
- \$300 for tankless water heaters with an EF of 0.90 or greater; and
- \$75 \$50 for a smart thermostat.

The Home Energy Savings Pathway is a weatherization program launched by BHE in late PY2013. The program is designed to train contractors and home energy consultants to analyze the energy use for single and multifamily homes and identify specific energy efficiency improvements which may be undertaken by the customer.

The Home Energy Savings Pathway provides energy assessments, direct installation of low-cost measures and weatherization improvements for qualifying homes.

The HES pathway provides the following measures:

- Faucet aerators;
- Low flow showerheads;
- Air sealing;
- Duct sealing; and
- Ceiling insulation.

The program is implemented by CLEARResult.

4.1 Program Overview

The history of program performance and expenditures is presented in Table 4-1.

Table 4-1: Residential Solutions Performance against Goals

Program Year	# Participants		Budget			Net Therms		
	Actual	Goal	Spent	Allocated	%	Achieved	Goal	%
2020	4,909	4,834	\$2,183,409	\$2,421,798	90.2%	647,495	681,204	95.0%
2021	6,867	4,834	\$2,256,751	\$2,421,798	93.2%	791,836	681,204	116.2%
2022	4,982	4,834	\$2,688,648	\$2,470,073	108.8%	784,542	681,204	115.2%

4.2 Participation Summary

Figure 4-1 summarizes verified net therms savings by measure for PY2022 compared to PY2021.

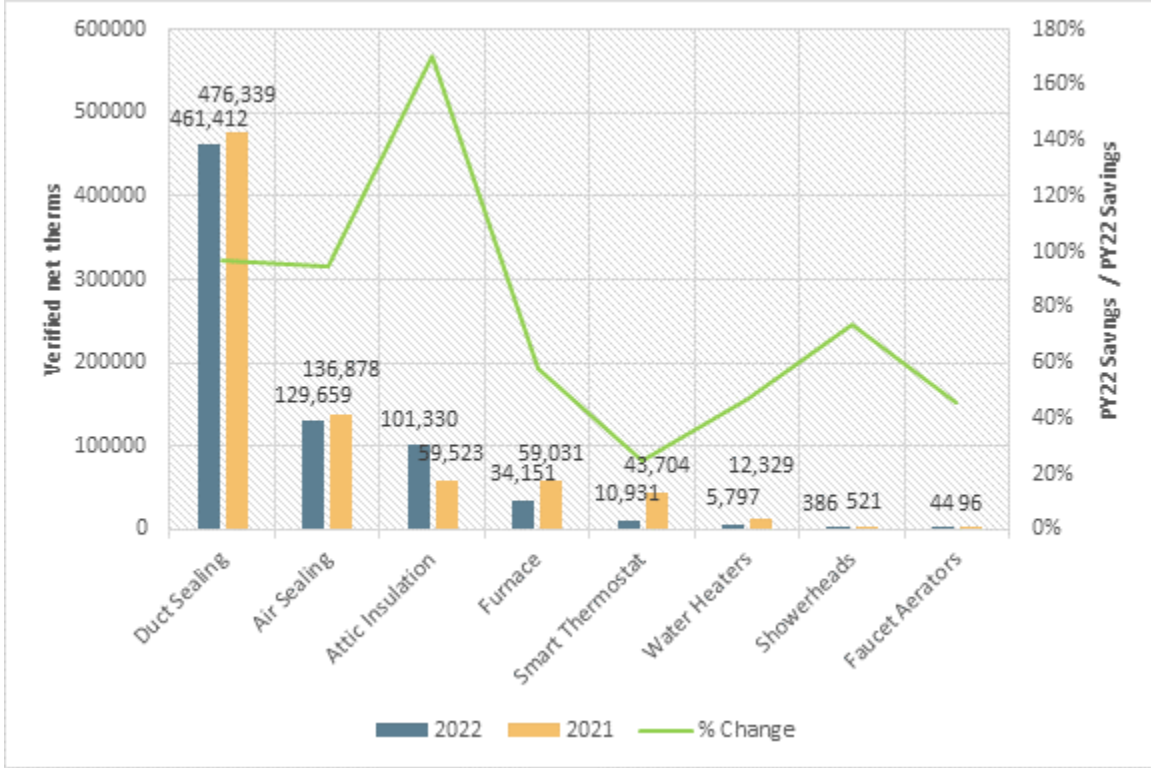


Figure 4-1: Program Savings Share by Measure

4.3 Residential Solutions Program Impact Evaluation

This section provides a brief overview of the data collection activities, gross and net impact calculation methodologies, and process evaluation activities that the Evaluators employed in the evaluation of RSP. The evaluation activities conducted are summarized in Table 4-3.

Table 4-2: RSP PY2022 Impact Evaluation Activities

Gross Impact Evaluation	Net-to-Gross
<ul style="list-style-type: none"> Database review TRM deemed savings calculation review 	<ul style="list-style-type: none"> Phone survey with participating customers Citing prior NTG studies for non-sampled measure groups

4.3.1.1 Gross Impact Evaluation

The evaluation of gross therm savings from projects incentivized through the RSP can be broken down into the following steps:

- First, the program tracking database was reviewed to determine the scope of the program and to ensure there were no duplicate project entries.
- Next, a detailed desk review was conducted for a census of projects in the tracking system. The desk review process entails recalculation of therms and non-energy benefits for each measure and for each participant.
- For the HES Pathway, the Evaluators scheduled on-site inspections with program participants subsequent to completion of documentation reviews. The visits were used to collect data for savings calculations, to verify measure installation, and to determine measure operating parameters.
- After determining the ex-post savings impacts for each sampled project, the ex post savings were combined with the ex-ante savings from the projects not included in the sample to determine a program level savings.

4.3.1.2 Summary of Non-Energy Benefits

Table 4-4 summarizes the non-energy benefits by measure that were credited to the Residential Solutions Program.

Table 4-3: RSP Non-Energy Benefits

Measure	Electric Savings	Water Savings	Propane Savings	Avoided Replacement Cost	Deferred Replacement Cost
Equipment Rebates Pathway					
■ Furnace Early Retirement					✓
■ Tankless Water Heater				✓	
■ Smart Thermostat	✓				
HES Pathway					
■ Duct Sealing	✓				
■ Ceiling Insulation	✓				
■ Air Infiltration	✓				
■ Low Flow Showerhead	✓	✓			
■ Faucet Aerator	✓	✓			

4.4 Residential Solutions Process Evaluation

Table 4-3: and Table 4-4 summarize the Evaluators’ review of the Residential Solutions Program in comparison to TRM V9.0 Protocol C for timing and conditions of conducting a process evaluation. The Residential Solutions Program is itself a new program but is the combination of two preexisting programs. When assessing the Residential Solutions Program per Protocol C,

the Evaluators did so via a combined examination of past program performance for the formerly separate Equipment Rebates Program and Home Energy Savings Program.

Table 4-4: Determining Appropriate Timing to Conduct a Process Evaluation

<i>Component</i>	<i>Determination</i>
New and Innovative Components	No. The program is unchanged from PY2021.
No Previous Process Evaluation	No. A limited process evaluation was conducted in PY2021.
New Vendor or Contractor	No. The restructured program continues to be implemented by CLEAResult.

Table 4-5: Determining Appropriate Conditions to Conduct a Process Evaluation

<i>Component</i>	<i>Determination</i>
Are program impacts lower or slower than expected?	No. The program met 116% of goal in PY2021.
Are the educational or informational goals not meeting program goals?	No. The program has an established trade ally network.
Are the participation rates lower or slower than expected?	No. The program met 93% of participation goals in PY2021.
Are the program’s operational or management structure slow to get up and running or not meeting program administrative needs?	No. The PY2021 process evaluation found that the operational and management structure for the Equipment Rebates Program and Home Energy Savings Program to be up to speed and efficient in administering the program.
Is the program’s cost-effectiveness less than expected?	No. The program was cost-effective.
Do participants report problems with the programs or low rates of satisfaction?	No. Participant surveys found high satisfaction levels.
Is the program producing the intended market effects?	Yes. Interviews with participants and trade allies have shown market transformation is occurring.

Based on these findings, a limited process evaluation was conducted in PY2022 to address response to PY2021 recommendations.

4.4.1 Residential Solutions - Response to Program Recommendations

In PY2021, the Evaluators provided two program recommendations for the residential solutions program.

Table 4-6: Residential Solutions Response to PY2021 Recommendations

Residential Equipment Rebate Program		
Address project application timelines. Program staff should endeavor to return application processing times to PY2020 benchmarks.	Accepted and worked on Working on speeding up on timeline for processing rebates.	Continuing
Track purchase price for smart thermostats. RSP staff track costs for furnaces and water heaters but not smart thermostats. Doing so will allow for better cost-effectiveness tracking for new brands and models	BHE has agreed to this recommendation but implementation was not completed in PY2022	In progress

4.4.2 Equipment Rebates Pathway

PY2022 participation in the Equipment Rebates Pathway is as follows:

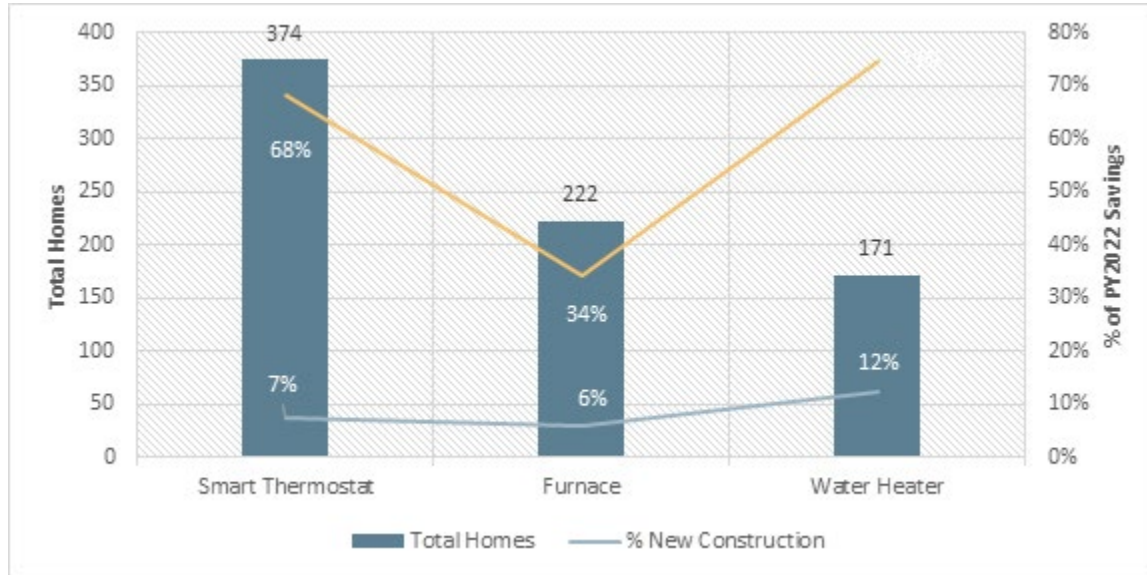


Figure 4-2: ERP Participation Summary

4.4.2.1 Detailed Review - Smart Thermostats

There were 10 HVAC contractors listed as having installed smart thermostats. For projects that did not include a contractor, the line items are marked as “Self-Install”. Ninety-six percent of participants installed their thermostat themselves, compared to 74% in PY2021. Figure 4-3 summarizes the installer type by brand. Although Nest remained the top smart thermostat brand in PY2022, Honeywell replaced Ecobee as the second most popular brand.

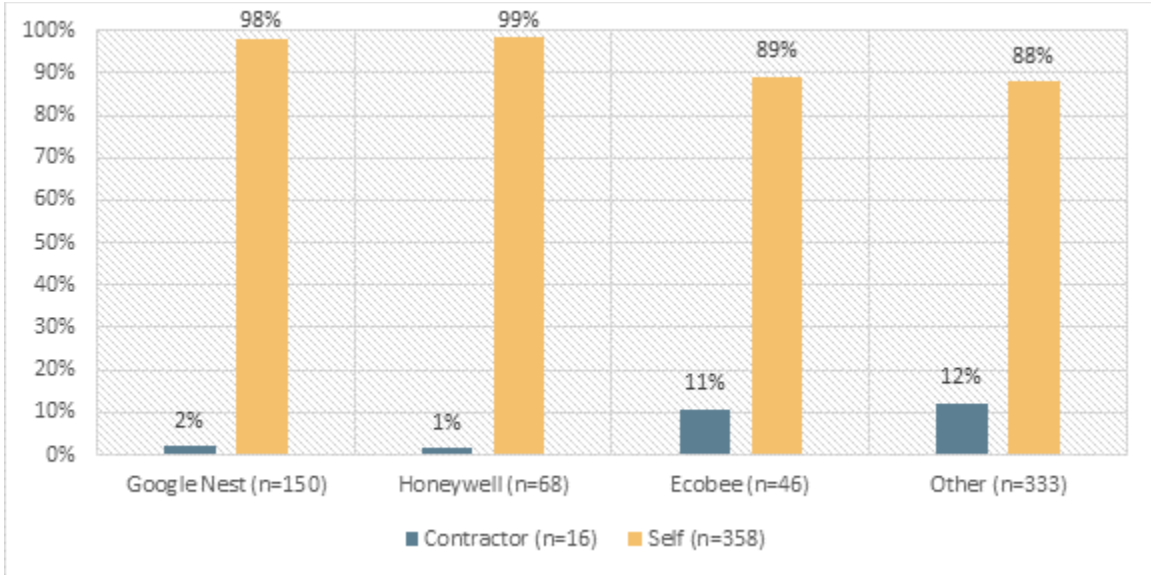


Figure 4-3: Installer Type by Brand

Figure 4-4 summarizes savings per unit by thermostat brand. In other PY2022 evaluations, the Evaluators noted that acquisition costs for certain brands were significantly higher. This was not evaluated for BHE as thermostat product cost was not tracked. It was notable that some brands costs are high enough to make the specific model not cost-effective; RSP program staff should keep apprised of product costs for brands growing in prevalence.

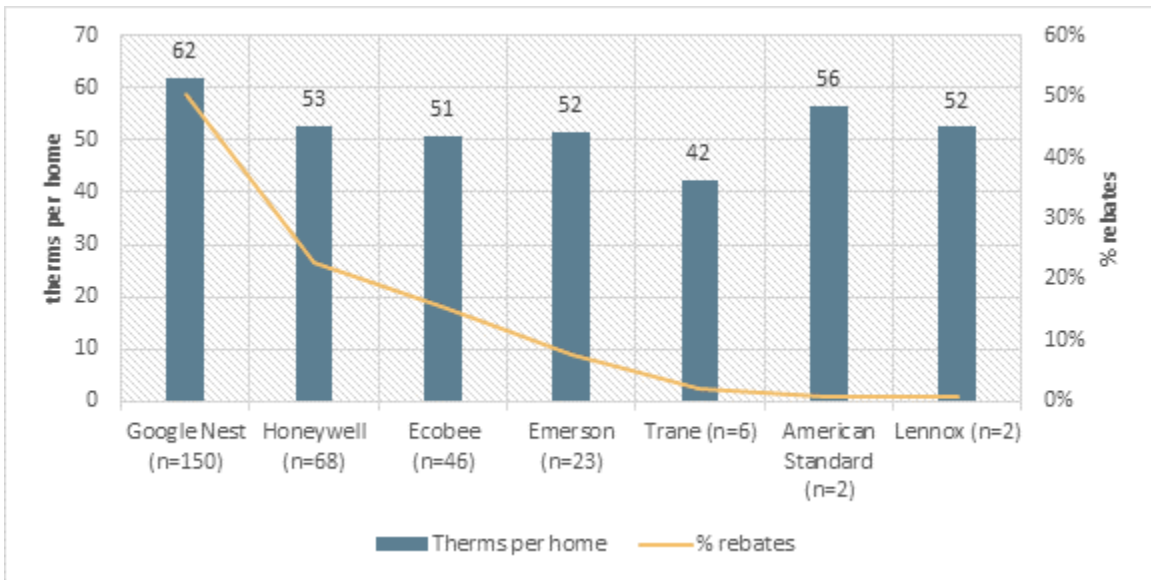


Figure 4-4: Savings per Unit by Brand

The Evaluators then cross-referenced participant tracking between the thermostat and furnace replacement tracking datafiles. In total, 10.2% of thermostat participants had also received a rebate for a high efficiency furnace, compared to 19.1% in PY2021, 15.5% in PY2020 and 4.1% in PY2019.

4.4.2.2 Equipment Rebates Pathway Process Evaluation Results

This section includes the process evaluation findings for the Equipment Rebates Pathway.

4.4.2.2.1 Equipment Rebates Pathway - Data Collection Activities

The process evaluation of Equipment Rebates Pathway included the following activities:

- *Program Actor In-Depth Interviews.* The Evaluators conducted in-depth interviews with a series of program actors. These interviews covered a range of topics, including marketing efforts, feedback on program delivery, an assessment of barriers to program implementation and success, and recommendations for program improvement. Program Actors interviewed include:
 - *BHE Program Staff.* The Evaluators interviewed staff at BHE involved in the administration of the Equipment Rebates Pathway.
 - *Third Party Implementation Staff Interviews.* The Evaluators conducted interviews with CLEAResult involved with the Equipment Rebates Pathway.

Table 4-9 summarizes the data collection for this process evaluation effort. This includes the titles, role, and sample sizes for data collection.

Table 4-7: RSP Equipment Rebates Pathway Data Collection Summary

Target	Component	Activity	n	Precision Met	Role
BHE Program Staff	Manager of Energy Efficiency	Interview	1	NA	Overall administration of BHE EE programs. This manager is involved in the larger strategic decisions associated with the EE portfolio and is involved with the HES Pathway and in the overall coordination of utility resources.
CLEAResult Staff	Program Manager	Interview	1	NA	Handles day-to-day operations, including mass market outreach, application review, billing, and logistics

4.4.2.2.2 Equipment Rebates Pathway - Protocol A Database Review

The CLEAResult tracking system contained full detail with project addresses, contact information, and measure inputs. Further, the tracking system provided the therm savings for each line item.

During PY2022, the Evaluators received quarterly tracking data updates as well as final tracking exports. The tracking system was updated to include necessary inputs as per TRM V9.0. Other than these updates, there were no major updates to the structure or content of program tracking data. The Evaluators reviewed program tracking to assess its compliance with Protocol A of the TRM V9.0 which specifies that tracking data should be checked for:

- Participating Customer Information;

- Measure Specific Information;
- Vendor Specific Information;
- Program Tracking Information;
- Program Costs; and
- Marketing & Outreach Activities.

The Evaluators conducted a review of each of the above factors within PY2022 tracking data except for marketing and outreach activities as these are outside the scope of the tracking system's reporting.

Customer, Premise, Cost, and Vendor Information

Each of these factors was assessed individually based on the guidelines stated in TRM V9.0. Overall, the Evaluators conclude the following regarding tracking data completeness:

- Participating customer information was complete for almost all participants. This included Job IDs, telephone numbers, addresses, full names, and utility account numbers for BHE and participating electric utility. In PY2022, 98% of all projects had a complete name, address, phone number, and account information.
- All participant records included the name of the installation contractor for the project (including entries that indicate for self-install).
- Tracking data included the measure and project costs for each home.
- Tracking data included the weather zone for each home.
- As with prior program years, premise characteristics such as home heating type, cooling type, and ceiling square footage were present for all participants where appropriate and needed.

Measure Specific Information

The content of tracking data was found to include sufficient information for all measures in PY2022. There were no large issues with measure specific information in the PY2022 program tracking data.

4.4.2.2.3 Equipment Rebates Pathway - Program Theory & Design

The Equipment Rebates Pathway is designed to provide straightforward prescriptive incentives for high efficiency furnaces, water heaters, and smart thermostats. The program is designed to engage both the retrofit and new construction markets. Contractors may participate as long as they have the appropriate licensing.

4.4.2.2.4 Equipment Rebates Pathway - Program Administration

The Equipment Rebates Pathway was overseen by the Manager of Energy Efficiency at BHE. This manager's responsibilities primarily included interfacing with CLEARResult, who directly

implements the program. Other activities by this manager included providing updated customer lists to CLEAResult to better facilitate their implementation, participation in outreach events, and at times assisting CLEAResult in customer interactions. At the time of reporting, this role was unfilled subsequent to the retirement of BHE's Manager of Energy Efficiency, however BHE is endeavoring to find a replacement.

For CLEAResult, the roles and responsibilities of program staff are as follows:

- **Program Manager.** The Program Manager oversees day-to-day activities, supervises program staff, and handles complaints from customers or contractors.
- **Program Coordinator/Specialist.** This staff member coordinates tracking data, develops samples for quality assurance inspection, and supports reporting and invoicing requirements.

4.4.2.2.5 Equipment Rebates Pathway - Program Implementation & Delivery

The Equipment Rebates Pathway promotes high efficiency natural gas equipment in new and existing homes. It will drive participation in the program by developing relationships with participating partners and educating consumers to influence their purchasing behavior.

This offering promotes the purchase of energy efficient products by providing the benefits of downstream incentives. Mail in/online rebates are available for installation of qualified equipment to BHE residential customers. All eligible measures have deemed savings values in the TRM. Participating contractors and implementation staff will provide customers with assistance in identifying potential measures. Monetary incentives are paid to eligible customers for the installation of eligible measures in qualifying residential homes.

As of the end of the third quarter, the program had reach 72% of its goal, but spent 77% of its budget. Staff explained that the disparity between goal and budget stemmed from the fact that some end of year 2021 reimbursements got charged to the 2022 and the increased reimbursement rate for duct sealing and insulation. Staff noted that the program is *"not in danger-danger, but we need to keep an eye on the budget."* BHE and CLEAResult staff are working together to make sure trade allies deposit their 2022 checks before the end of the year to prevent similar issues during the 2023 program year.

4.4.2.2.6 Home Energy Savings - Measures

Although the program did not offer any new measures in 2022, staff did change the incentive levels offered for air sealing, duct sealing, and attic insulation. These increases were made in conjunction with SWEPCO AR and the utilities decided to increase the incentive amount because the incentives had remained constant since 2013 and they felt like the incentives needed to better reflect material costs. Moving into the 2023 gap year and planning for the

next triennial cycle, staff plan to explore additional measures, specifically health and safety measures, they might be able to offer to customers.

Supply chain issues remained a concern in 2022. Although availability of products has improved, higher efficiency equipment can be difficult to acquire. Moreover, contractors struggle to employ staff, thereby slowing down their project turnover time. Additionally, the cost of insulation materials has increased dramatically.

4.4.2.2.7 Equipment Rebates Pathway – Trade Allies

Although equipment rebate customers can use any trade ally they like for the rebates program as long as they are licensed plumbers, HVAC installers, or contractors, weatherization customers must use someone from the list of pre-approved trade allies for the home energy audit and subsequent weatherization measure offerings. The weatherization program has about five active trade allies in its network, all of whom have been involved for multiple years and are therefore experienced and well versed with the program.

4.4.2.2.8 Equipment Rebates Pathway - Marketing

CLEAResult is the implementer for the Equipment Rebates Pathway and oversees marketing efforts. The program is directly marketed by participating HVAC and plumbing contractors, who use program incentives as part of their business' customer outreach. Other marketing efforts include encouragement of program referral among participants and promotion of the program on the BHE website.

4.4.3 Home Energy Savings Pathway

4.4.3.1 Home Energy Savings Participation Summary

The HES Pathway had 1,887 participants in PY2022. This includes:

- 1,498 customers that received one assessment;
- 201 customers received duct sealing, air sealing, or ceiling insulation but no assessment in PY2022.

4.4.3.1.1 Home Energy Savings Pathway Impact of Home Assessments

The Evaluators reviewed the measure installations energy savings for participants in the HES Pathway. The Evaluators key findings from this review were:

- 79.4% of participating homes received an assessment.
- Similar to prior program years, assessment homes had significantly higher savings than homes that install-only.

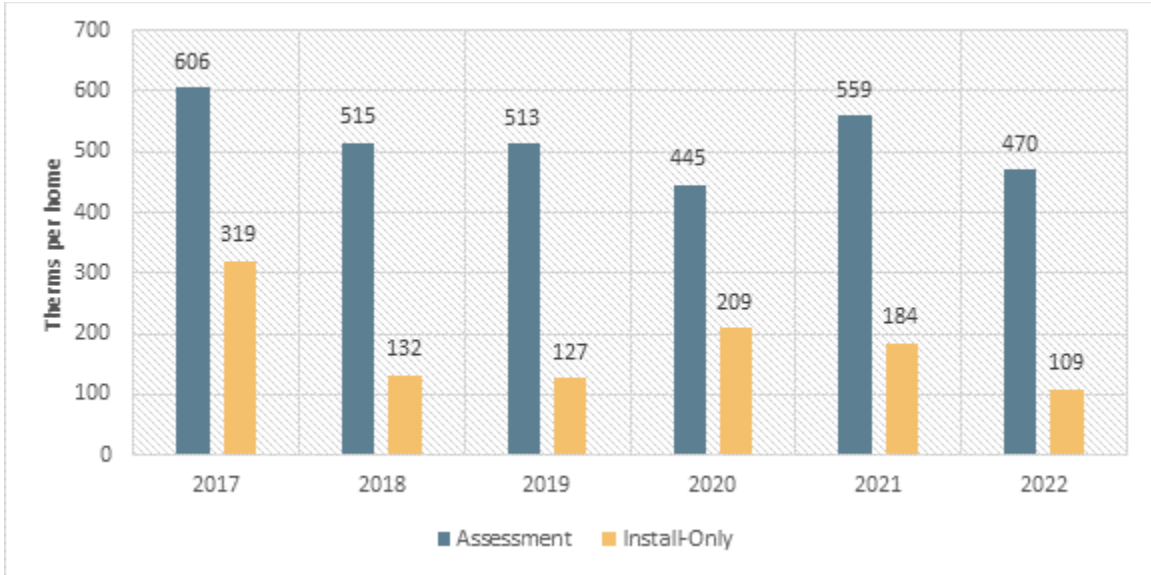


Figure 4-5: HES Pathway - Per-Home Thermos Savings: Assessment vs. Install-Only

As shown in Figure 4-10, the measure mixes largely remained the same between 2020 and 2022, aside from a decline in air sealing over the three-year period.

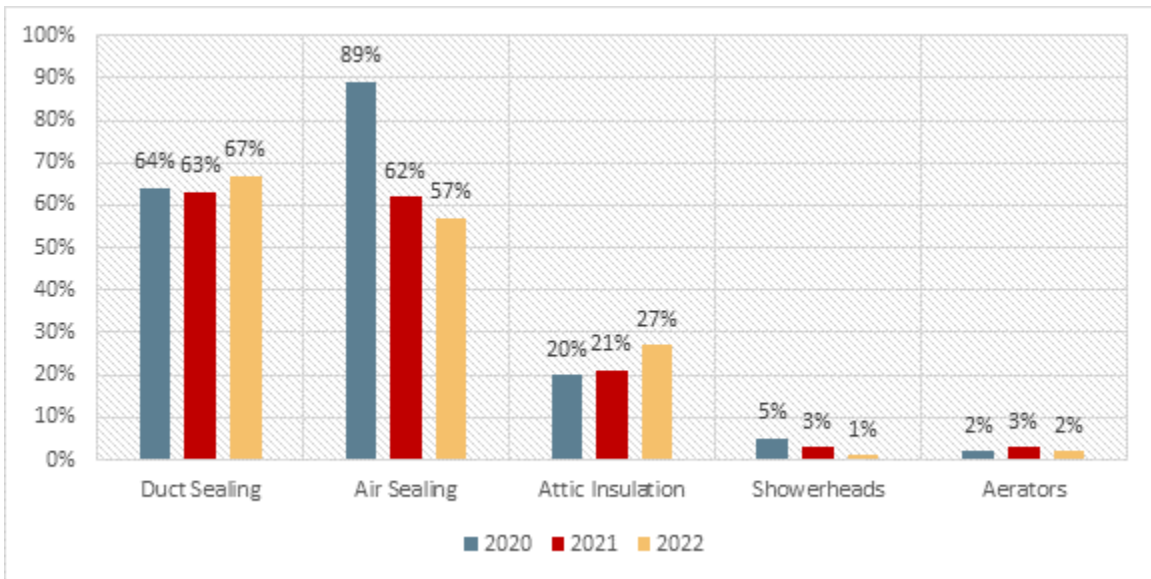


Figure 4-6: HES Pathway - % Houses with Each Measure

4.4.3.1.2 Home Energy Savings Pathway Contractor Participation

In PY2022, the Home Energy Solutions pathway had five registered trade allies. All registered allies were active in the program in PY2022. As shown in Figure 4-11, most trade allies installed duct sealing and air sealing improvements at a large majority of their projects. In PY2022, one

trade ally completed 35% of total projects. Other trade allies completed between 5% and 32% of total projects.

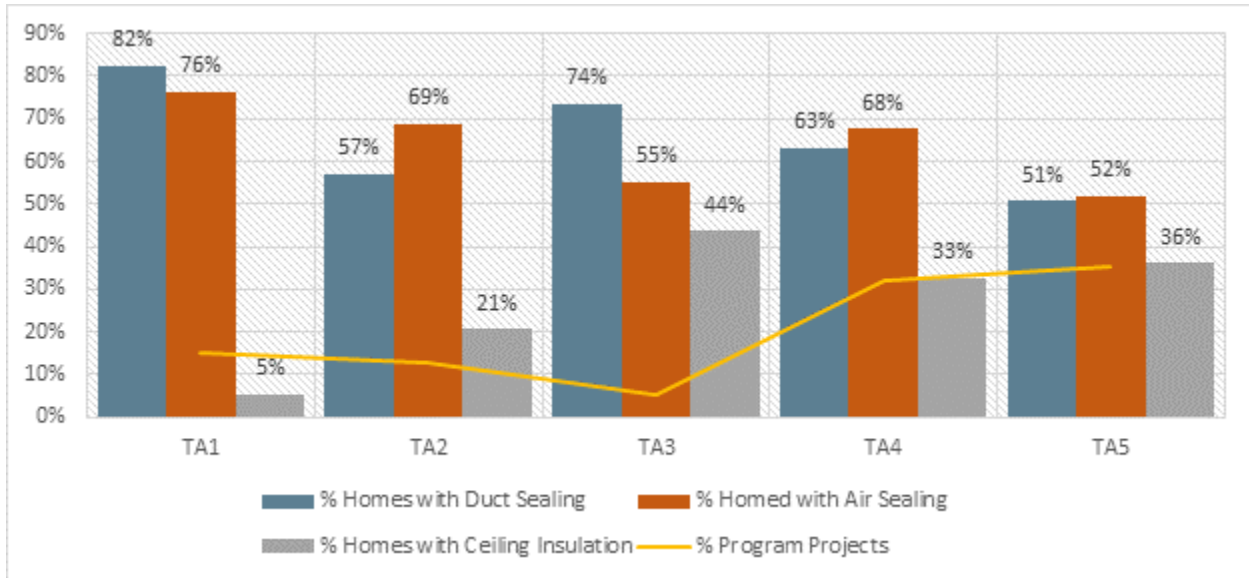


Figure 4-7: HES Pathway Trade Ally Participation Summary

4.4.3.1.3 Home Energy Savings Pathway Customer, Premise, Cost, and Vendor Information

Each of these factors was assessed individually based on the guidelines stated in TRM V9.0. Overall, the Evaluators conclude the following regarding tracking data completeness:

- Participating customer information was complete for all participants. This included Job IDs, telephone numbers, addresses, full names, and utility account numbers for BHE and participating electric utility. In PY2022, 100.0% of all projects had complete name, address, phone number, and account information.
- All participant records included the name of the installation contractor who performed the implementation as well as the invoice date and weatherization date.
- Tracking data included the measure and project costs for each home.
- Tracking data included the weather zone for each home.
- As with the prior program year, premise characteristics such as home heating type, cooling type, and ceiling square footage were present for all participants where appropriate and needed.

4.4.3.1.4 Home Energy Savings Pathway Measure Specific Information

The content of tracking data was found to include sufficient information for all measures in PY2022. There were no large issues with measure specific information in the PY2022 program tracking data.

4.4.3.2 Home Energy Savings Pathway Process Evaluation Results

This section includes the process evaluation findings for the HES Pathway.

4.4.3.2.1 Home Energy Savings Pathway - Protocol A Database Review

The CLEAResult tracking system contained full detail with project addresses, contact information, and measure inputs. Further, the tracking system provided the therm savings for each line item.

During PY2022, the Evaluators received quarterly tracking data updates as well as final tracking exports. The tracking system was updated to include necessary inputs as per TRM V9.0. Other than these updates, there were no major changes to the structure or content of program tracking data. The Evaluators reviewed program tracking to assess its compliance with Protocol A of the TRM which specifies that tracking data should be checked for:

- Participating Customer Information;
- Measure Specific Information;
- Vendor Specific Information;
- Program Tracking Information;
- Program Costs; and
- Marketing & Outreach Activities.

The Evaluators reviewed each of the above factors within PY2022 tracking data except for marketing and outreach activities as these are outside the scope of the tracking system's reporting.

4.4.3.2.2 Home Energy Savings Pathway - Data Collection Activities

The process evaluation of Home Energy Savings Pathway included the following activities:

- *Program Actor In-Depth Interviews.* The Evaluators conducted in-depth interviews with a series of program actors. These interviews covered a range of topics, including marketing efforts, feedback on program delivery, an assessment of barriers to program implementation and success, and recommendations for program improvement. Program Actors interviewed include:
 - *BHE Program Staff.* The Evaluators interviewed staff at BHE involved in the administration of the Home Energy Savings Pathway.
 - *Third Party Implementation Staff Interviews.* The Evaluators conducted on-site inspections at 70 homes, receiving a total of 127 measures.
- *Field Data Collection.* The Evaluators conducted surveys with HES Pathway participants, collecting feedback on the participant experience as well as collecting data for NTG estimation.

Table 4-10 summarizes the data collection for this process evaluation effort. This includes the titles, role, and sample sizes for data collection.

Table 4-8: RSP Home Energy Savings Pathway Data Collection Summary

Target	Component	Activity	n	Precision Met	Role
BHE Program Staff	Manager of Energy Efficiency	Interview	1	NA	Overall administration of BHE EE programs. This manager is involved in the larger strategic decisions associated with the EE portfolio and is involved with the HES Pathway and in the overall coordination of utility resources.
CLEAResult Staff	Program Manager	Interview	1	NA	Handles day-to-day operations, including mass market outreach, application review, billing, and logistics
Program Participants	RSP: HES Pathway	Field Data Collection	70	±9.8%	Field data collection was performed to verify duct sealing, air sealing, and ceiling insulation projects.
		Surveys	117	±7.7%	This survey was conducted on a sample of residents who participated in the consistent weatherization approach program.

4.4.3.2.3 Home Energy Savings Pathway - Program Theory & Design

The HES Pathway is designed to follow Department of Energy’s Home Performance with ENERGY STAR® (HPwES) Program guidelines. The HES Pathway offers a comprehensive, whole-home approach to improving energy efficiency of existing homes. The HES Pathway also is consistent with the approved APSC-mandated Consistent Weatherization Approach. The program maintains a closed contractor network, emphasizing training and quality control for a small group of providers who are allocated a share of total weatherization projects to complete for the program year.

4.4.3.2.4 Home Energy Savings Pathway - Program Administration

The HES Pathway is overseen by the Manager of Energy Efficiency at BHE. This manager’s responsibilities primarily include interfacing with CLEAResult, who directly implements the program. Other activities by this manager include providing updated customer lists to CLEAResult to better facilitate their implementation, participation in outreach events, and at times assisting CLEAResult in customer interactions.

For CLEAResult, the roles and responsibilities of program staff are as follows:

- **Program Manager.** The Program Manager oversees day-to-day activities, supervises program staff, and handles complaints from customers or contractors.
- **Program Coordinator/Specialist.** This staff member coordinates tracking data, develops samples for quality assurance inspection, and supports reporting and invoicing requirements.

- **QA Verification Specialist.** The QA Verification Specialist conducts post inspections and communicates inspection results to contractors.

4.4.3.2.5 Home Energy Savings Pathway - Program Implementation & Delivery

For the HES Pathway, homes must be at least 10 years old or have gas costs that are at \$.05 per square foot based on the customers' highest bill in the past 12 months. Eligible homes must have been occupied for the previous 12 months and have not received weatherization services in the past five years.

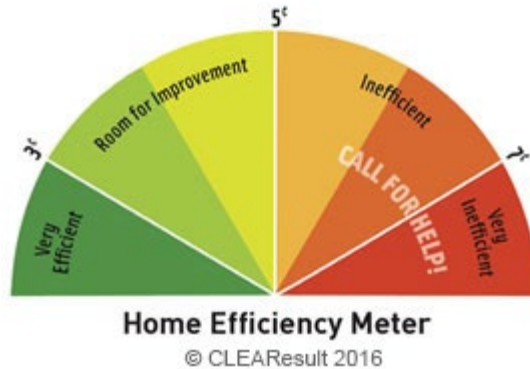


Figure 4-8: HES Pathway Home Efficiency Graphic (source: <https://energy-readyarkansas.com/home-energy-savings-evaluation.html>)

The key delivery aspects specific to this outreach channel include the follow elements:

- **Customer verification:** Potential customers interested in the program will be confirmed as a qualified BHE customer by program staff.
- **A comprehensive assessment of the customer's home:** Once the customer is prequalified, the contractor will schedule a comprehensive audit of the home and develop a recommended action plan of weatherization upgrades for the homeowner.
- **Direct installation of immediate energy savings measures:** While performing the comprehensive audit, the contractor will also install energy efficient measures throughout the home, including low-flow aerators and showerheads, at no cost to the customer.
- **Installation of a set of weatherization measures:** The contractor and customer will decide on what upgrades will be undertaken for the home. Based on review of the plan, the customer and contractor will develop an installation plan, and upgrades will be installed by the contractor.

4.4.3.2.6 Home Energy Savings Pathway Virtual Assessments

The HES Pathway suspended its virtual in-home assessment offering in PY2022 following loosening pandemic restrictions.

4.4.3.2.7 Home Energy Savings Pathway - Marketing

CLEAResult is the implementer for the HES Pathway and oversees marketing efforts. The program is directly marketed by the five registered trade allies. Other marketing efforts include encouragement of program referral among participants and promotion of the program on the BHE website.

4.4.3.2.8 Home Energy Savings Pathway Required Participant Demographics and Consistent Weatherization Approach (CWA) Metrics

This section presents the required metrics for BHE’s CWA program (the Home Energy Savings Pathway).

Table 4-9: CWA Required Process Evaluation Metrics

Metric	Value
Program Name	Residential Solutions Program - HES Pathway
CWA Implementation	Yes
Total Audits Completed	1,498
Total Submitted Measures	2,905 at 1,345 homes
Conversion Rate	76.6%
Measures installed per-project	1.52 (excluding Assessment)
Cost per participant	\$854.78 (including Assessment)
Percent of contractors promoting program	100% (5 contractors)

Table 4-10: HES Pathway Alignment with CWA Requirements

Requirement	Alignment with Requirement	Percent of Participants Receiving
Includes Applicable DI Measures	Yes	2.8%
Aerators	Yes	2%
Showerheads	Yes	1%
Efficient lighting	Yes	N/A
Smart strips	Yes	N/A
Prequalifies homes based on year of construction or energy costs	Yes, the customer must have had a bill in the last twelve months that exceeded five cents per square foot or the home’s age is 10 years or greater.	Not in tracking data
TRC is used to assess program cost-effectiveness	Yes	N/A
Measures screened using SIR or comparable metric	Program uses TRC	N/A
Includes Core No Cost Measures	Yes	766%
Audit (walk through)	Yes	85.5%
Ceiling insulation	Yes	28.5%
Duct sealing	Yes	59.6%

Requirement	Alignment with Requirement	Percent of Participants Receiving
Air infiltration reduction	Yes	61.1%
Safety testing and/or measures	Yes	.4%
Offers other utility measures	Yes	N/A
Contractors are certified BPI Building Analyst or RESNET HERS Rater	Yes, for duct sealing, air infiltration, and assessments. Insulation requires Arkansas Home Improvement Specialty License.	N/A

On average, HES Pathway participants received measures that resulted in 403 therm savings and incentives that averaged \$854.55 (Table 4-11).

Table 4-11 Summary of Home Participation

Average Ex ante Therm Savings	Average Incentive Amount	Average Number of Measures Implemented
402.6	\$854.55	1.52

4.4.3.2.9 HES Pathway – Consistent Weatherization Approach Participant Survey Results

The Evaluators surveyed 117 participants in the CWA program. These surveys were to collect data on participant experience with the program including sources of program awareness, motivations for participating, and satisfaction with the program. Furthermore, the evaluators collected demographic information on the respondents during the survey.

Respondent Profile

The majority of respondents own their home (94.4%, n=101), and just half of respondents live with one to two other people (49.6%, n=58). Half of respondents were at least 45 years old (51.3%, n=60), and just over three-quarters worked or attended school (78.6%, n=92).

Program Awareness

Respondents learned about the program through a variety of avenues including word of mouth (41.0%, n=48), social media (23.9%, n=28), as well as BHE website, bill insert, mailing, email, or another program (24.8%, n=29) (Figure 4-9).

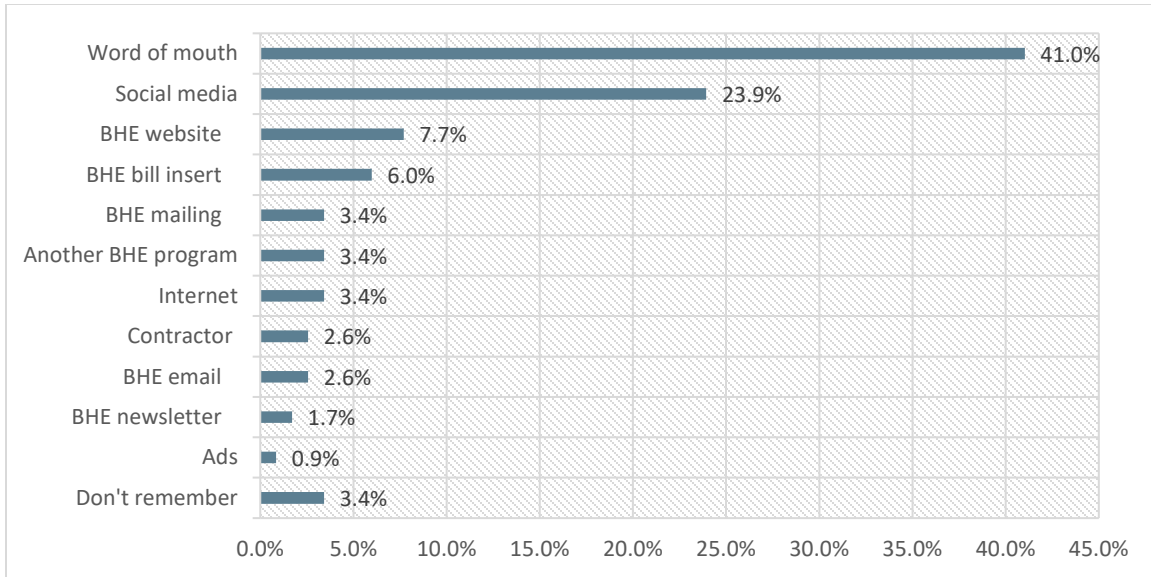


Figure 4-9: Program Awareness (n=117)

About half of respondents (47.9%, n=56) were interested in participating in the program to save money on utility bills (Figure 4-10).

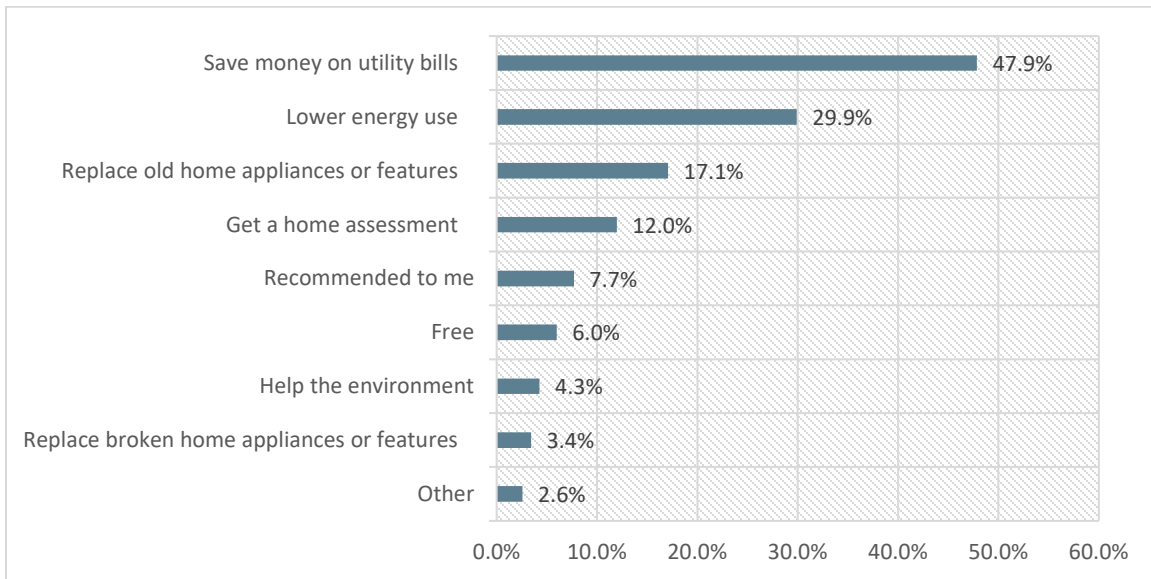


Figure 4-10: Participation Motivation (n=117)

Home Energy Assessment

The majority of respondents remember receiving a home energy assessment as part of their participation in the program (73.3%, n=88). Among the 88 respondents who remember receiving a home energy assessment, more than half were interested in the assessment to learn ways they could save energy and money (60.2%, n=53) (Figure 4-11).

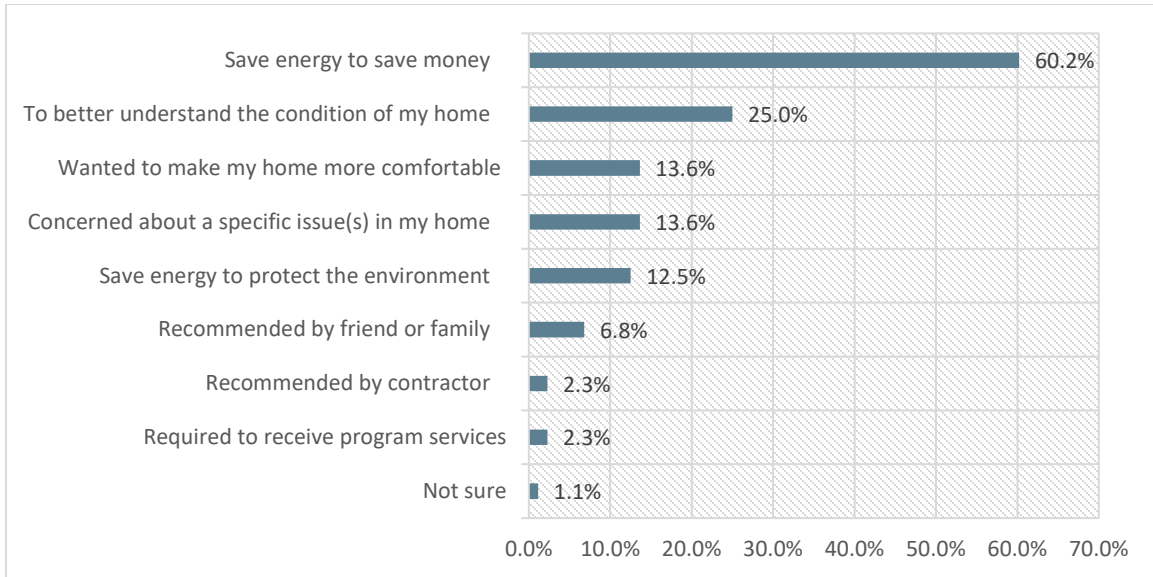


Figure 4-11: Home Energy Assessment Motivation (n=88)

Most respondents who were home for the energy assessment indicated the assessment occurred in-person (90.9%, n=80) and all but one of these respondents noted that the assessor discussed the assessment findings with them (98.8%, n=79). About two-thirds of respondents who were home for the assessment noted they received an energy report with recommendations following the assessment (63.8%, n=51).

Respondents were pleased with the home energy assessment (Figure 4-12) and found the information provided in to be useful (Figure 4-13). More than one-third of respondents would have made the improvements to their home even if they were not recommended in the assessment (39.3 %, n=4) (Figure 4-14).

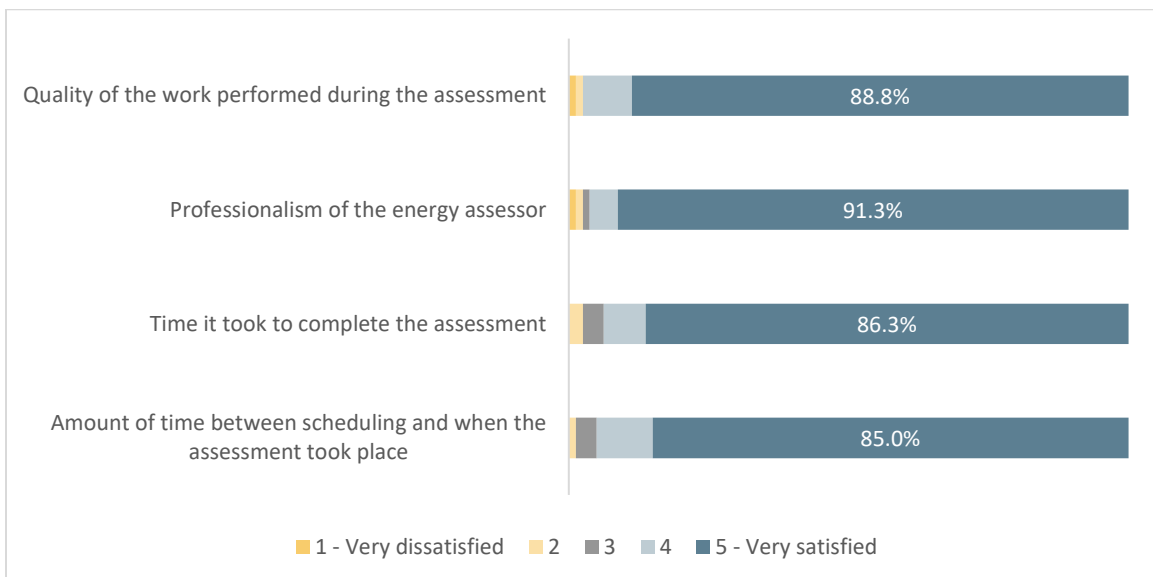


Figure 4-12: Home Energy Assessment Satisfaction (n=80)

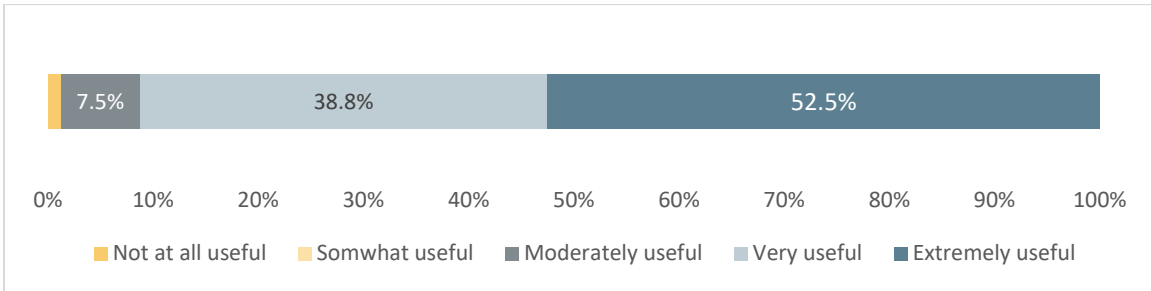


Figure 4-13: Home Energy Assessment Usefulness (n=80)

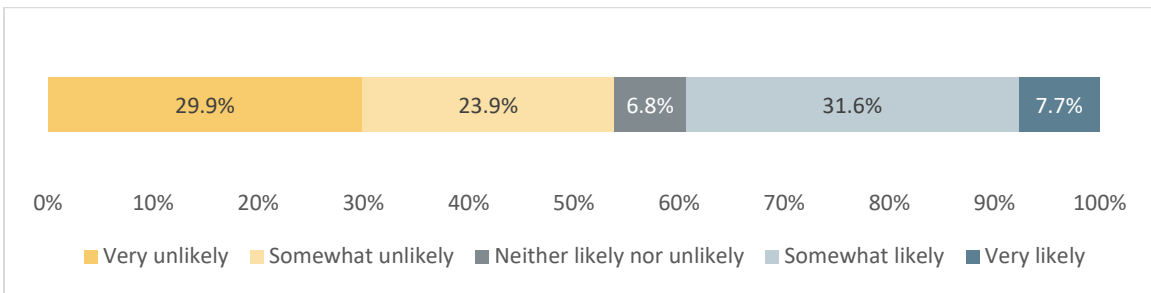


Figure 4-14: Likelihood of Installing Equipment (n=117)

Program Participation

Less than a third of respondents (29.1%, n=34) had planned to complete similar work prior to their participation in the program and only a third (33.3%, n=39) of respondents indicated they would have been able to complete these improves without the financial assistance provided through the program. More than half of respondents indicated they would have taken longer to complete these home improvements if the assistance from the program had not been available (59.0%, n=69); about a three-quarters of these respondents (72.5%, n=50) indicated it would have taken at least another year before they made those improvements.

Seventy percent of respondents completed the program application themselves (70.9%, n=83) and the majority of these respondents found the application easy to complete (91.6%, n=76). Half of respondents have noticed a decrease in their energy bill since their participation in the program (49.6%, n=58) (Figure 4-15). Few respondents (n=9) reached out to BHE staff for assistance or questions while participating in the program.

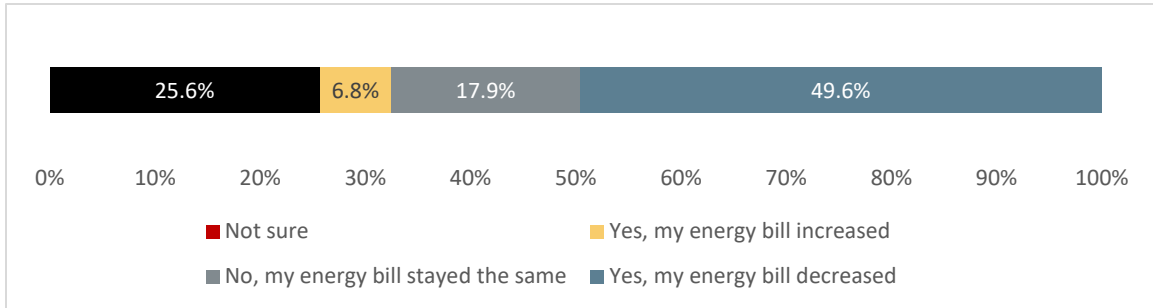


Figure 4-15: Changes in Energy Bill (n=117)

Program Satisfaction

Respondents were generally satisfied with the home energy solutions program (Figure 4-16) and 82.1% of respondents have recommended the program to other people (n=96). 77.8% of respondents indicated that participating in the program increased their satisfaction with BHE as their energy provider (n=91).

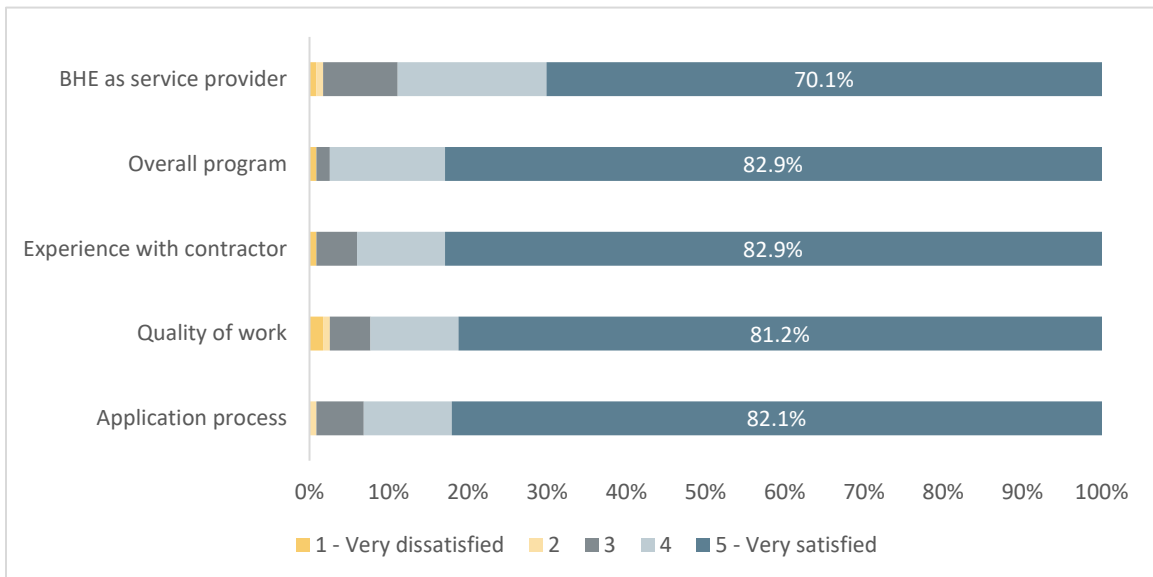


Figure 4-16: Program Satisfaction (n=117)

4.4.4 Free-Ridership and Spillover Findings

The Evaluators used participant survey responses to develop net savings for the Equipment Rebates and HES Pathways. Figure 4-17 details the scoring mechanism for residential free ridership in the Residential Solutions Program.

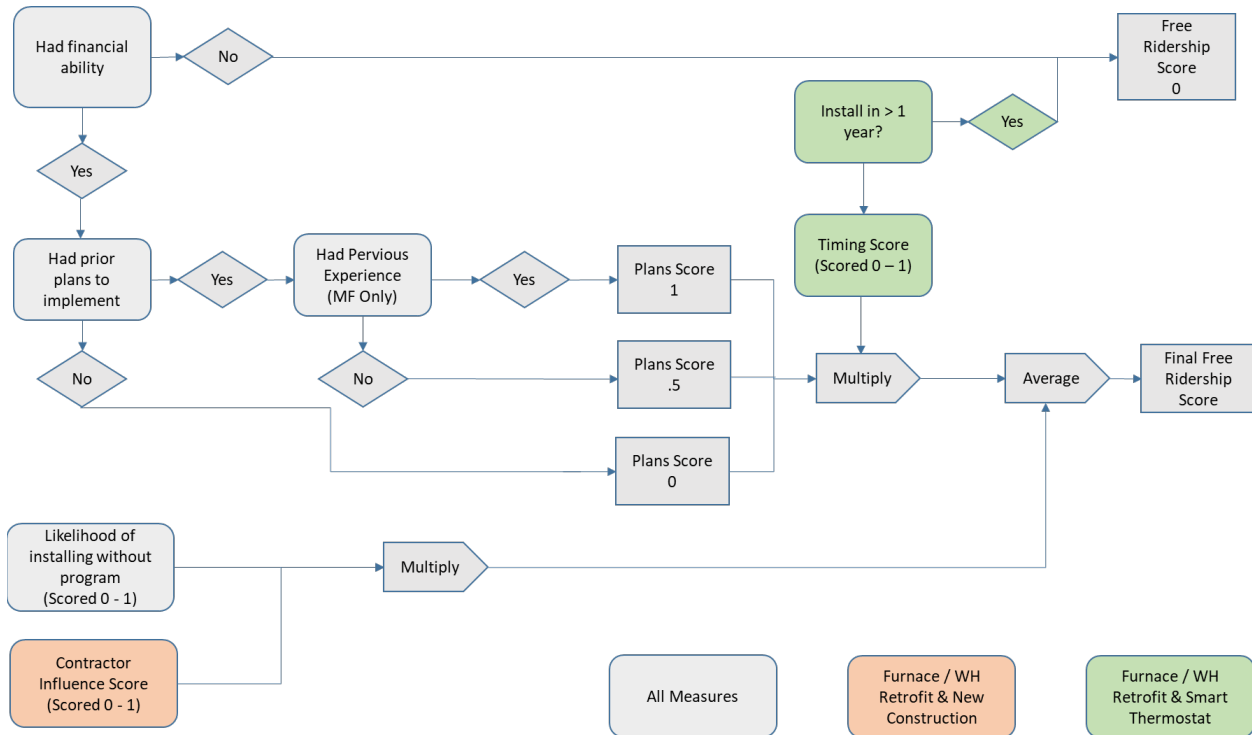


Figure 4-17: RSP FR Diagram

Table 4-15 summarizes the estimated free-ridership, spillover, and net-to-gross ratios for the estimates developed through self-report.

Table 4-12: RSP Summary of Free-ridership, Spillover, and NTGRs

Pathway & Measure	Free Ridership	Spillover	NTG Ratio
Equipment Rebates Pathway			
■ Furnace - Retrofit	22.0%	0.0%	78.0%
■ Furnace – NC - Builder	9.0%	0.0%	91.0%
■ Furnace – NC - Owner	35.6%	0.0%	64.4%
■ Smart Thermostat	35.0%	0.0%	65.0%
■ Water Heater - Retrofit	0.0%	0.0%	100.0%
■ Water Heater – Housing Authority	0.0%	0.0%	100.0%
■ Water Heater - NC – Builder	9.0%	0.0%	91.0%
■ Water Heater – NC - Owner	35.6%	0.0%	64.4%
HES Pathway			
■ Duct sealing, air sealing, ceiling insulation	6.7%	0.0%	93.3%
■ Aerators, showerheads, pipe wrap, tank wrap	0.0%	0.0%	100.0%

The approach was based on survey self-reports, using the following questions:

Q15. Prior to learning about the [PROGRAM], did you have plans to install a [MEASURE]?

- 1. Yes
- 2. No
- 98. DON'T KNOW
- 99. REFUSED

Q16. Just to be clear, did you have plans to install a [MEASURE] as opposed to a standard efficiency [BASELINE]?

- 1. Yes
- 2. No
- 98. DON'T KNOW
- 99. REFUSED

Q17. Would you have been financially able to purchase the [MEASURE] if there was not a rebate available through the [UTILITY_SHORT] program?

- 1. Yes
- 2. No
- 98. DON'T KNOW
- 99. REFUSED

Q18. How likely is it that you would have purchased and installed the same [MEASURE] that you had rebated through the program if the rebate was not viable? Would you say [READ. MARK ONE.]

1. Very likely
2. Somewhat likely
3. Neither particularly likely nor unlikely
4. Somewhat unlikely
5. Very unlikely
98. DON'T KNOW
99. REFUSED

Q19. How influential was your contractor in helping you finalize the selection of your equipment? [READ. MARK ONE.]

1. Very influential
2. Somewhat influential
3. Neither particularly influential nor uninformal
4. Somewhat uninformal
5. Very uninformal
98. DON'T KNOW
99. REFUSED

Q20. Did you install the [MEASURE] sooner than you otherwise would have because of the rebate available through the [UTILTIY_SHORT] program?

1. Yes
2. No
98. DON'T KNOW
99. REFUSED

Q21. When would you have installed the [MEASURE] if rebates through the [UTILITY_SHORT] program were not available?

1. Within 6 months of when you installed it
2. Between 6 months and one year
3. 1-2 years
4. 2-3 years
5. More than 3 years
98. DON'T KNOW
99. REFUSED

The plans score was factored by the programs impact on timing. Specifically,

- If the respondent stated that they would have installed the measure more than one year after the measure was installed, the prior plan score reduced to zero.
- If the respondent stated that they would have installed the measure in 6 months to one year, then the prior plans score was reduced by one-half.
- If the respondent stated that they would have installed the measure at the same time or within 6 months of when it was installed, the prior plans score was not adjusted.

A likelihood of installing the measure in the absence of the program was developed based on respondents stated likelihood of installing a measure. Specifically, responses to this question were scored as follows:

- Very likely: 1
- Somewhat likely: .75
- Neither particularly likely nor unlikely: .5
- Somewhat unlikely: .25
- Very unlikely: 0

Contractor Influence: This score is first determined via respondent answers to Question 18. The scores are as follows:

- Very influential: .5
- Somewhat influential: .25
- All other answers: .00

This value is then scaled by .667 due to contractor estimates that the rebate assisted them in upselling to a high efficiency model two-thirds of the time.

4.4.4.1 HES Pathway – Gross Savings Analysis

The Evaluators conducted field verification at 70 homes in the HES Pathway. Measures included in this sample were as follows:

- Air Infiltration: 55 homes
- Ceiling Insulation: 14 homes
- Duct Sealing: 49 homes, 56 HVAC systems

The Evaluators conducted duct blaster and blower door tests at all homes that received duct sealing and air sealing (respectively).

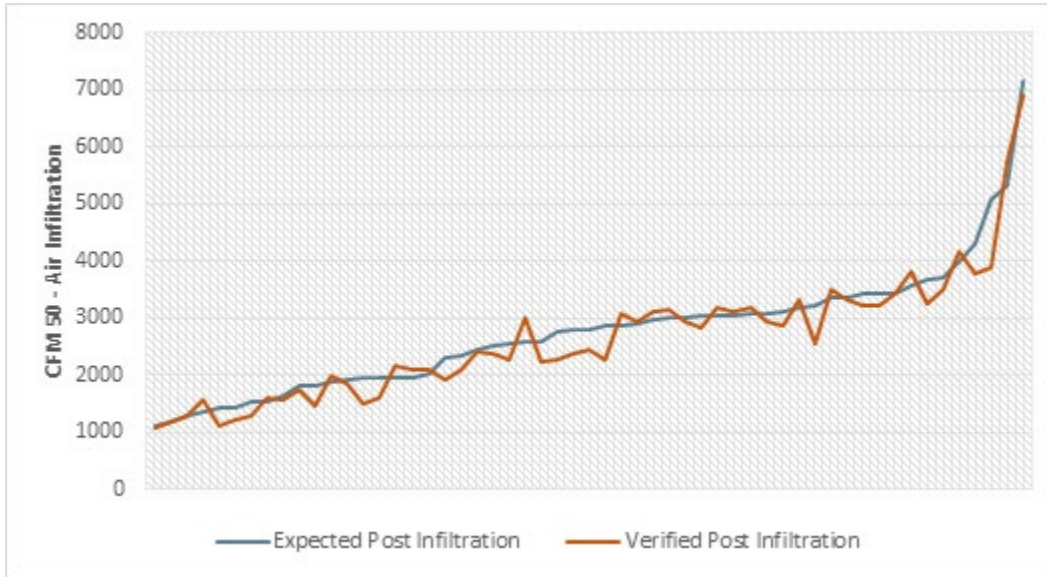


Figure 4-18: Air Infiltration Field Data Collection Results (n=55)

The Evaluators lower infiltration than shown in ex ante estimates. This resulted in an overall in-service rate (ISR) of 110.0%.

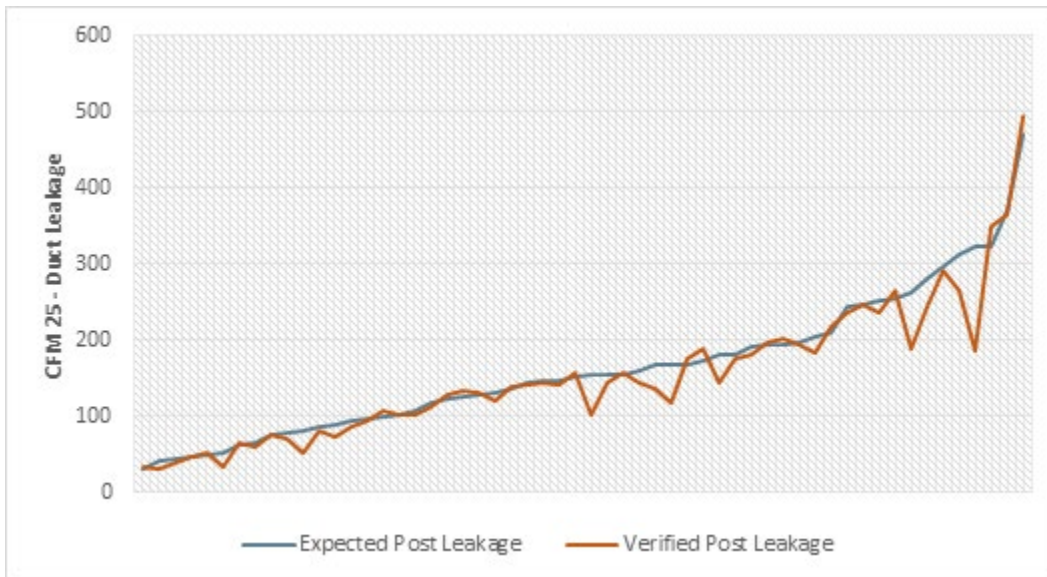


Figure 4-19: Duct Sealing Field Data Collection Results (n=56)

The Evaluators lower leakage than shown in ex ante estimates. This resulted in an overall in-service rate (ISR) of 102.9%.

Ceiling insulation projects inspected showed no deviations from project tracking and had a 100.0% ISR.

The HES Pathway had overall realization of 105.8%, driven by the lower leakage levels found on-site for air infiltration and duct sealing projects.

4.4.4.2 Energy Savings Calculations - Furnaces

Gross savings for furnaces applied TRM V9.0 protocols. The Evaluators verified heat load estimates based on home age and square footage, all of which was provided in BHE program tracking data.

One key parameter addressed in the PY2020 gross impact analysis was verification of early retirement. Early retirement is estimated based off survey findings with BHE participants. Surveys were not completed in PY2021 so values from the PY2020 survey were applied to PY2022 projects. The survey findings addressed:

- Extent to which furnaces that are in working condition have been replaced; and
- Age of the preexisting furnace in instances of qualifying early retirement.

As per the TRM V9.0, and the procedures for calculating the impact of early replacement for residential furnaces, early retirement AFUE is calculated by a degradation factor of a 78 AFUE unit. This is calculated as:⁷

$$AFUE_{base_early} = (Base\ AFUE) \times (1 - M)^{age}$$

Where:

Base AFUE = efficiency of the existing equipment when new, 78% AFUE.

*M*⁸ = maintenance factor, 0.01.

age = the age of the existing equipment, in years.

Following this, lifetime savings are determined based on the Remaining Useful Life (RUL) of the old equipment. The RUL table is presented in Table 4-16.⁹

⁷ Arkansas TRM V9.0 Volume 2, Pg. 44

⁸ Maintenance factor of 0.01 is the average maintenance factor for gas furnaces taken from the October 2010 National Renewable Energy publication "Building America House Simulation Protocols", table 30.

⁹ AR TRM V9.0, Volume 2, Pg. 46

Table 4-13: Residential Furnace RUL

Unit Age	RUL	Unit Age	RUL
5	14.7	19	3.6
6	13.7	20	3.2
7	12.7	21	2.9
8	11.8	22	2.6
9	10.9	23	2.4
10	10.0	24	2.1
11	9.1	25+	0.0
12	8.3		
13	7.5		
14	6.8		
15	6.2		
16	5.5		
17	4.5		
18	4.0		

To assess whether a unit qualified for early retirement, the Evaluators examined the following survey questions:

7. Was the replaced [BASELINE]....(READ LIST)?

- 1. Fully functional and not in need of repair?
- 2. Functional, but needed minor repairs?
- 3. Functional, but needed major repairs?
- 4. Not functional?
- 98. DON'T KNOW
- 99. REFUSED

8. How old was the [BASELINE] at the time you replaced it?

- 1. ___ # Years
- 98. DON'T KNOW
- 99. REFUSED

9. How long do you think your [BASELINE] would have lasted if you had not replaced it?

- 1. ___ # Years
- 98. DON'T KNOW

Figure 4-26 summarizes the scoring for early retirement based on these three questions.

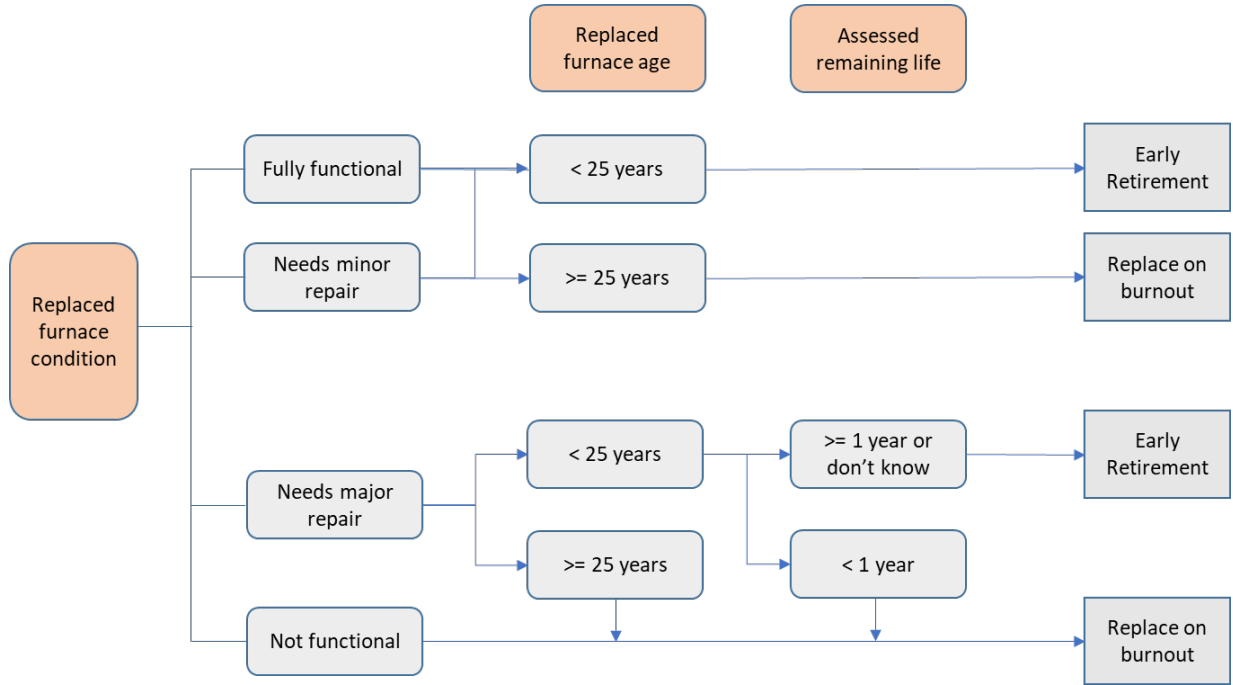


Figure 4-20: Residential Furnace Early Retirement Flowchart

In total, the Evaluators found that 78.26% of BHE furnace retrofits were early retirement.

The average age of functioning and failed units was as follows:

- 14.12 for functioning units
- 20.33 for failed units

Based on the degradation equation from TRM V9.0¹⁰, this leads to an Early Retirement AFUE of:

$$AFUE_{base_{early}} = (.78) \times (1 - .01)^{14.12} = .6942$$

Further, based on the values in Table 4-16, the RUL of the early replacement units is seven years. For years 8-20 of the unit EUL, the normal replacement baseline applies. The savings for each residential retrofit unit were calculated using both the normal and early replacement baselines, and final savings reflect a weighted average of these two values based on participant survey data findings. These values were then applied on a weighted basis to the residential retrofit units using weights of 78.26% early replacement and 21.74% normal replacement. The resulting weighted average baseline is:

$$AFUE_{base_{early_weighted}} = 78.26\% \times .6492 + 21.74\% \times .80 = .7172$$

¹⁰ TRM V9.0 Vol. 2 Pg. 44

4.4.4.3 Energy Savings Calculations – Water Heaters

Savings from tankless water heaters were calculated using protocols from Arkansas TRM V9.0 Vol. 2 Section 2.3.1. For sample calculations, see Appendix C.

Gross realization for water heater was 120.7%. The Evaluators attribute this to the following:

- **Correction of the water heater setpoint.** The calculations performed by CLEAResult used 120 degrees Fahrenheit for water heater replacements. This was updated to 124 based off water heater setpoint research conducted by the Evaluators that had been incorporated into TRM V9.0. In Weather Zone 9, this increases savings by 7.4%.
- **Aligning DHW load to match baseline sizing.** Though the direct formula is not visible in the spreadsheet tracking data provided to the Evaluators (as calculations are performed in a back-end system with an Excel export then sent for review), the Evaluators suspect that the DHW load is aligning with 40-gallon systems. The Evaluators were able closely recreate ex ante calculations (to within 3.0% of ex ante estimates) when the baseline was established to align with a high-draw pattern (50-gallon equivalent) tankless system while aligning the DHW load to a medium draw pattern (40-gallon equivalent) system.

4.4.4.4 Energy Savings Calculations – Smart Thermostats

Gross savings were calculated for smart thermostats using protocols AR TRM V9.0 Vol 2 2.1.12. For sample calculations, see Appendix C.

BHE tracked the baseline thermostat on their program application. The Evaluators applied the appropriate baseline for each line item. There were 38 smart thermostats installed in new construction projects. Within this, program tracking data showed 16 using manual thermostat baseline and 22 using programmable thermostat. The Evaluators overwrote this and applied the programmable thermostat baseline to all new construction projects in accordance with IECC2009 guidelines.

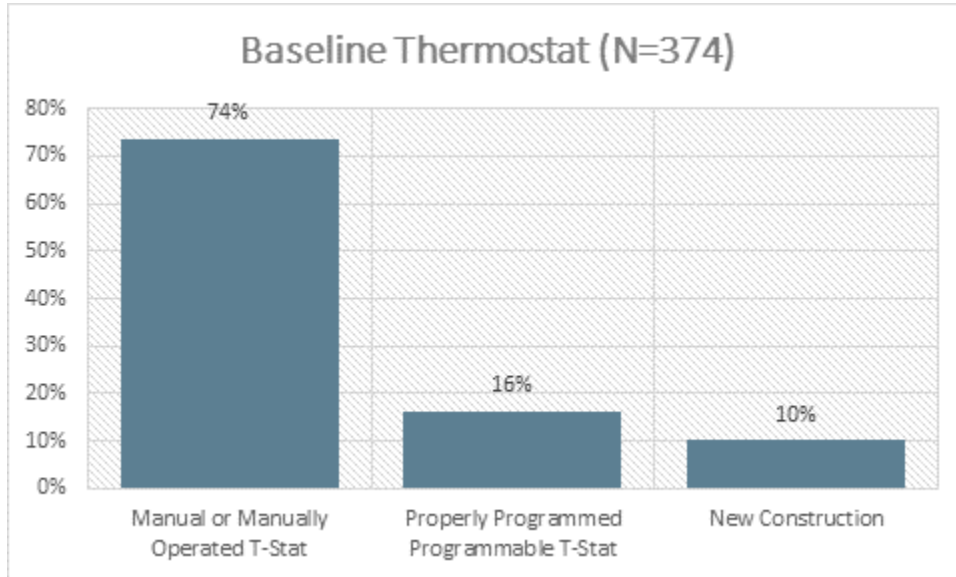


Figure 4-21: Equipment Rebates Pathway - Baseline Thermostat for Smart Thermostat Rebates

To evaluate attributable energy savings for smart thermostats, the tracking data from the BHE program was compared to SWECPO tracking data in order to identify premises that received rebates from both utilities. The Evaluators did not identify any instances of multiple utility rebates, and kWh from smart thermostats were assigned to the program as a NEB.

When estimating savings using TRM protocols, the Evaluators found inconsistencies in how square footage was entered in instances of multiple thermostats. In some instances, the tracking data showed the square feet 'pre-divided' (i.e., a 2,500 square foot home with two thermostats would show two 1,250 square foot line items). In other instances, there were two line items each showing the full square footage. This inconsistency was often driven by whether a customer applied for multiple rebates at once versus more than one rebate application distributed throughout the year. The Evaluators used a formula that divided square footage for each line item by the number of instances of the address occurring in program tracking. High and low outliers were then reconciled based on internet searches on Zillow.com to validate square footage.

4.4.5 Analysis of Savings by Tracking System Type

The RSP migrated from the Catalyst tracking system to the DSMT tracking system during PY2022. The Evaluators received datasets in both formats and reconciled them to a single dataset for analysis. In doing so, projects were then analyzed to address whether realization rates differed across tracking systems.

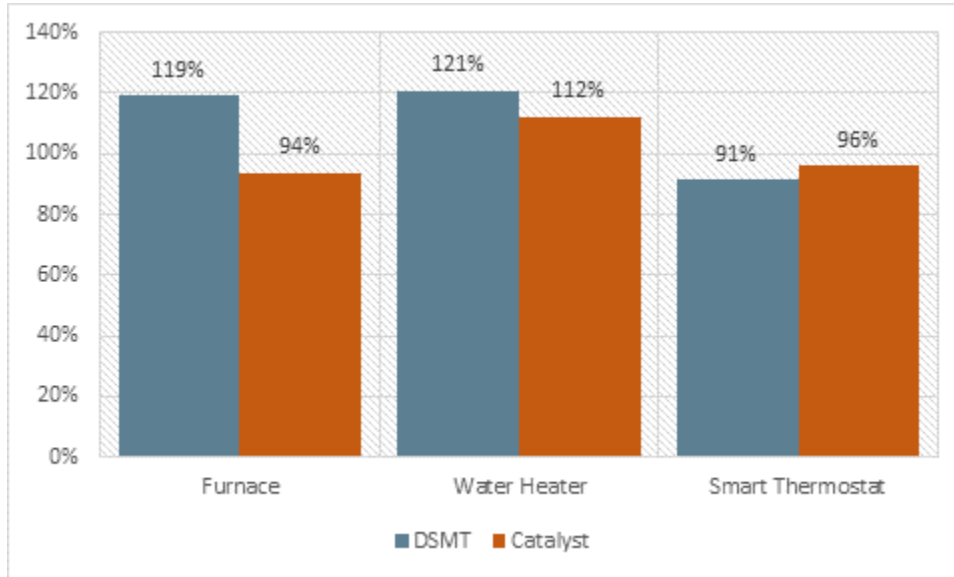


Figure 4-22: Realization Rate by Tracking System: ERP

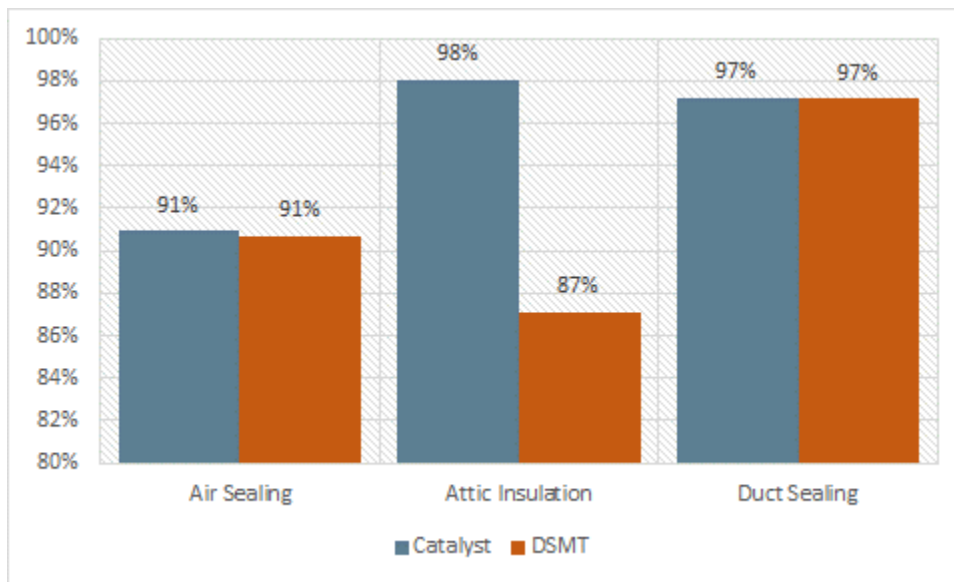


Figure 4-23: Realization Rate by Tracking System: HES

The Evaluators found that there were significant differences in realization rates cross the two tracking systems for the following measures:

- Furnaces
- Tankless water heaters
- Attic insulation

4.4.6 Ex Post Savings

Table 4-14 presents the gross savings results of the evaluation of the PY2022 Residential Solutions Program. Total gross savings summarizes the savings calculations performed by TRM V9.0 protocols.

Table 4-14: RSP Ex Post Gross Therms Savings

Pathway	Measure Category	Ex Ante Therms Savings	Ex Post Therms Savings	Gross Realization Rate	EUL	Lifetime Therms Savings
ERP	Furnace Retrofit	39,181	44,753	114.2%	15.53	695,175
	Furnace NC: Builder	379	1,220	321.9%	20	24,393
	Furnace NC: Owner	838	1,405	167.7%	20	28,102
	Tankless Water Heater Retrofit	4,100	4,864	118.6%	20	97,271
	Tankless Water Heater: NC Builder	2,768	3,352	121.1%	20	67,032
	Residential Tankless Water Heater NC: Owner	310	380	122.6%	20	7,598
	Tankless Water Heater - Housing Authority	560	745	133.0%	20	14,905
	Smart Thermostat	22,305	20,609	92.4%	11	226,703
HES	Home Energy Savings	704,872	745,620	105.8%	16.98	12,658,846
	Total Gross Savings	775,873	822,948	106.1%	16.79	13,820,025

The resulting net savings are presented in Table 4-15.

Table 4-15: RSP Net Savings Summary

Project Category	Free-Ridership Rate		Net Annual Savings		Net Realization Rate	Net Lifetime Therms Savings
	Ex Ante	Ex Post	Ex Ante	Ex Post		
Furnace Retrofit	21.27%	22.00%	30,847	34,907	89.77%	542,236
Furnace NC: Builder	8.90%	9.00%	345	1110	99.89%	22,198
Furnace NC: Owner	35.50%	35.60%	541	905	99.84%	18,098
Tankless Water Heater Retrofit	0.00%	0.00%	4,100	4864	82.65%	97271
Tankless Water Heater NC: Builder	0.00%	0.00%	2,768	3050	125.25%	60,999
Tankless Water Heater NC: Owner	8.90%	9.00%	282	245	121.09%	4,893
Tankless Water Heater Housing Auth.	35.50%	35.60%	361	745	117.19%	14,905
Smart Thermostat	35.00%	35.00%	14,498	13,396	99.74%	147,357
Home Energy Savings	8.79%	6.70%	642,914	695,917	107.85%	11,814,794
Overall	10.21%	8.24%	696,657	755,139	108.39%	12,722,752

4.4.7 Non-Energy Benefits Summary

Per Protocol L of the Arkansas TRM V9.0, Evaluators calculated non-energy benefits (NEBs) from each program. Program measures provide the following categories of NEBs:

- Benefits of electricity and liquid propane energy savings as in other fuel savings;
- Benefits of public water and wastewater savings¹¹; and
- Benefits of avoided and deferred replacement costs.

The Evaluators identified potential NEBs associated with each measure category.

4.4.7.1 RSP NEBs: Other Fuel

Table 4-16: RSP Ex Post Net Electric Savings

Measure Category	Net Annual kWh	Net Peak kW	Lifetime Net kWh
Smart Thermostat	163,078	0	1,793,863
Air Sealing	122,361	73	1,345,967
Ceiling Insulation	231,294	193	4,625,881
Duct Sealing	1,121,867	524	20,193,600
Faucet Aerators	0	0	0
Low Flow Showerheads	0	0	0
Total	1,638,600	791	27,959,311

4.4.7.2 RSP NEBs: Water Savings

Table 4-17: RSP Ex Post Net Water Savings

Pathway	Net Annual Water Saving (Gallons)	Lifetime Net Water Savings (Gallons)
Equipment Rebates	0	0
Home Energy Savings	102,365	1,023,653
Total	102,365	1,023,653

4.4.7.3 RSP NEBs: Avoided Replacement Costs (ARCs)

Residential tankless water heaters have an EUL of 20 years. The baseline system has an EUL of 11 years. This makes the systems eligible for the Deferred Replacement Cost Non-Energy Benefit. This NEB was calculated using the IEM calculation tool¹². The input assumptions were as follows:

- Full installed cost of tankless system: \$1,219
- Full installed cost of baseline storage tank system: \$614

¹¹ Though water savings were zero (0) in PY2020, we include this here to provide a comprehensive description of the measure offerings.

¹² Protocol L Avoided & Deferred Replacement Cost_08_31_16.xlsx

- Nominal Discount Rate: 5.62%
- Inflation Rate: 2.04%
- Real Discount Rate: 3.50%

The resulting gross deferred replacement cost is \$355.33 per unit. The calculator for this is provided in Appendix B of this report. For individual line items in the BHE program, this value was scaled by the appropriate NTGR.

There were 171 residential tankless systems rebated in PY2022, and the resulting ARC value is \$57,861.92.

4.4.7.4 RSP NEBs: Deferred Replacement Costs (DRCs)

Fifty-two percent of furnace retrofits were early retirement (51.8%), with a Remaining Useful Life (RUL) of seven years. This produces a DRC benefit in that it defers the normal replacement schedule in perpetuity. This NEB was calculated using the IEM calculation tool¹³. The input assumptions were as follows:

- Full installed cost of efficient furnace: \$2,548
- Full installed cost of baseline furnace: \$2,011
- Nominal Discount Rate: 5.62%
- Inflation Rate: 2.04%
- Real Discount Rate: 3.50%

The resulting gross DRC is \$1,145.67 per early retirement. When scaling this to the prevalence of early replacement versus normal replacement, the weighted average gross DRC is \$710.32 per retrofit. The calculator for this is provided in Appendix B of this report. For individual line items in the BHE program, this value was scaled by the appropriate NTGR.

There were 193 furnace replacements rebated in PY2022, and the resulting net DRC value is \$113,579.89.

¹³ Protocol L Avoided & Deferred Replacement Cost_08_31_16.xlsx

4.5 Conclusions

The program significantly increased savings and exceeded program goal.	Savings are similar to PY2021, and the program met 115.2% of its filed net savings goal.
Realization rates were high across most measure categories.	The overall realization rate was 106.1%. Realization was high for all measure groups other than smart thermostats
The Virtual Energy Audit tool was removed from program operations.	Program staff elected to remove the VEA tool as restrictions related to COVID-19 eased. In PY2021, the VEA produced 619 smart thermostat projects.
Savings discrepancies found in some measures.	Smart thermostats installed in New Construction projects were shown with a mix of manual and programmable thermostat baselines.
Savings calculations differed after the database migration.	Calculation of deemed savings differed across the Catalyst and DSMT systems. The new system (DSMT) appear to be more conservative in estimates of savings, and higher realization rates were found for furnaces, water heaters, and attic insulation. Though the realization rate is a positive finding, it nonetheless warrants investigation into assumptions used in the new system.

4.6 Recommendations

Conduct an audit of deemed inputs in DSMT for measures that differed significantly after the migration.	This audit should focus on furnaces, water heaters, and attic insulation calculations.
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5 Commercial & Industrial Solutions Program (CISP)

CISP is directed at developing and incenting energy efficiency measures for commercial and industrial customers. It is implemented by CLEAResult Consulting on behalf of BHE. CLEAResult handles program administration, marketing and outreach, direct install of energy savings measures, and technical review of custom efficiency projects. Program participants are offered:

- (1) No-cost direct installation of low flow faucet aerators, showerheads, and pre-rinse spray valves (PRSVs), if the participant has natural gas water heating;
- (2) No-cost direct installation of door air infiltration sealing if the participant has natural gas space heating;
- (3) Prescriptive incentives for commercial furnaces, water heaters, commercial boilers, boiler controls, and Prescriptive incentives for commercial kitchen equipment;
- (4) \$.75 per therm for custom projects;
- (5) \$.20 per therm for Strategic Energy Management (SEM) projects; and
- (6) Incentives to trade allies for steam system surveys.

5.1 CISP Overview

CISP's historical performance is summarized in Table 5-1.

Table 5-1: CISP Historical Performance against Goals

Program Year	# Participants		Budget			Net Therms		
	Actual	Goal	Spent	Allocated	%	Achieved	Goal	%
2011	404	790	\$486,284	\$637,926	76.2%	500,906	451,808	110.9%
2012	518	773	\$836,388	\$1,012,822	82.6%	560,574	536,810	104.4%
2013	417	723	\$1,382,015	\$1,410,997	97.9%	954,191	805,150	118.5%
2014	215	762	\$1,331,924	\$1,525,075	87.3%	789,523	694,577	113.7%
2015	385	800	\$1,520,715	\$1,698,848	89.5%	811,600	766,630	105.9%
2016	185	2,817	\$1,638,167	\$1,832,824	89.4%	851,581	798,455	106.7%
2017	157	2,344	\$1,331,689	\$1,374,482	96.9%	714,913	713,150	100.2%
2018	153	2,344	\$1,247,349	\$1,374,482	90.8%	713,833	713,150	100.0%
2019	42	2,344	\$1,296,563	\$1,380,696	93.6%	719,575	713,150	100.9%
2020	58	1,569	\$1,325,452	\$1,501,198	88.3%	745,692	629,741	118.4%
2021	80	1,569	\$1,526,265	\$1,501,198	101.7%	705,541	629,741	112.0%
2022	54	1,569	\$1,617,667	\$1,552,279	104.2%	723,540	629,741	114.8%

CISP participants fall into one of four categories:

- Direct install;
- Prescriptive furnace, water heater, boiler, and food service rebates;
- Custom audit recipients;¹⁴ and
- Closed custom projects.

Total net Therms by pathway are summarized in Figure 5-1.

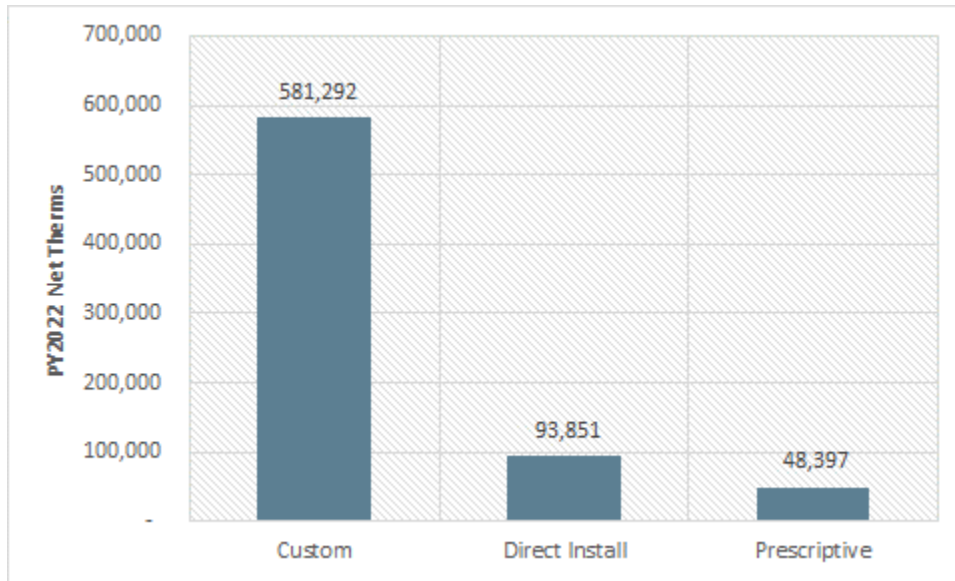


Figure 5-1: Total Net Therms by Program Pathway

These participants are detailed in the subsections to follow.

5.2 Direct Install Participation Summary

In PY2022, there were 45 direct install measures¹⁵ installed at 10 unique premises. The summary of participation by facility type and the relative share of program therms savings are summarized in Figure 5-2.

¹⁴ The Evaluators tally audit recipients but do not count them towards BHE’s participation goal.

¹⁵ “Measure” in this context means “measure category”; i.e., if a facility received showerheads and aerators it is counted as two measures.

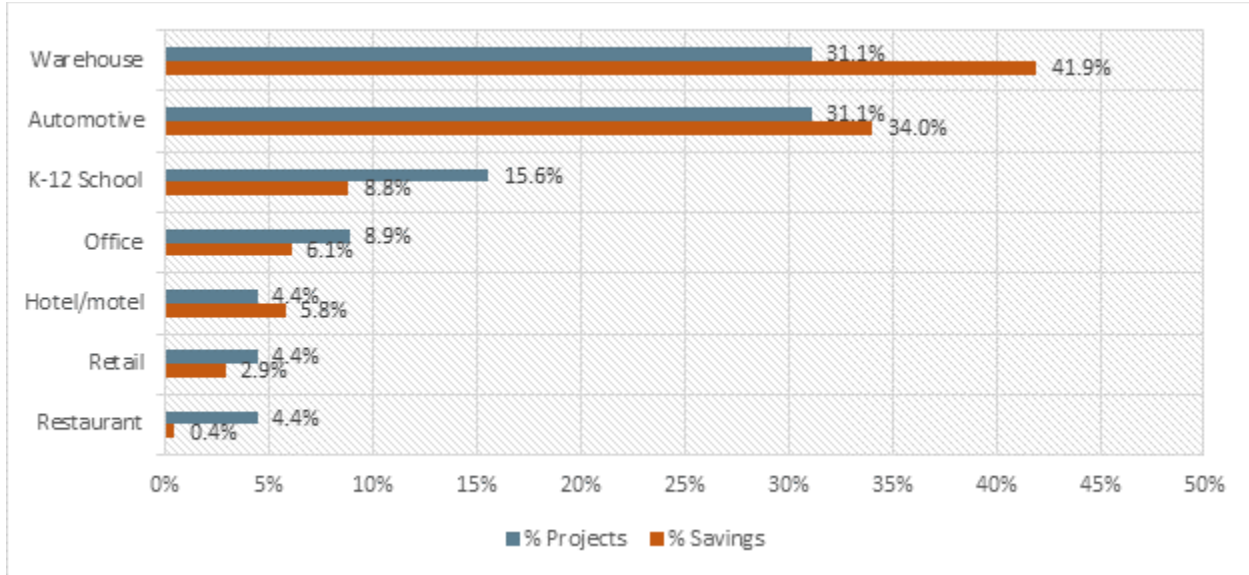


Figure 5-2: Direct Install Participation Summary

5.3 Prescriptive Rebate Summary

Beginning in PY2020, commercial prescriptive furnaces and water heaters were moved from the former Equipment Rebates Program to CISP, fully separating residential and non-residential rebates into discrete programs. Figure 5-4 summarizes CISP PY2022 prescriptive participation and net savings.

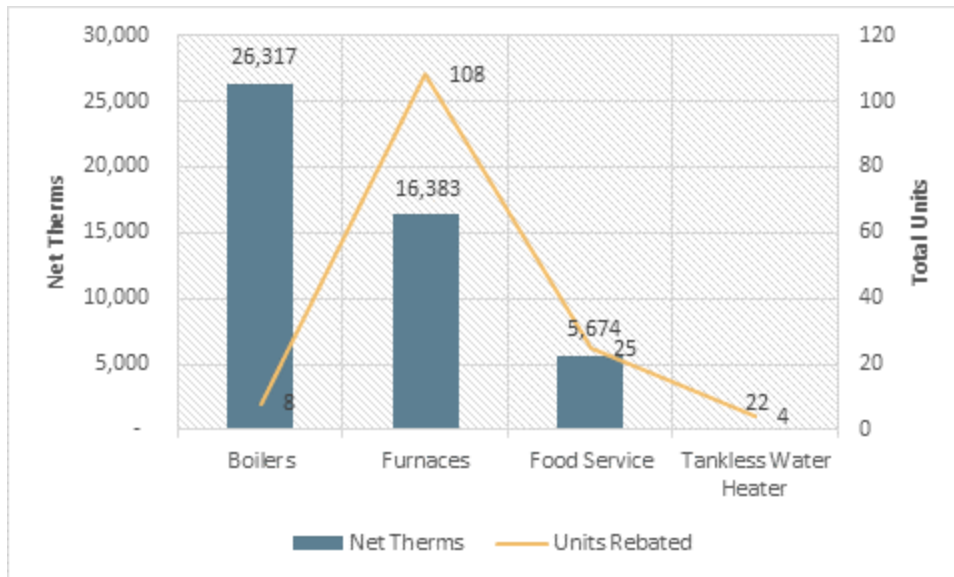


Figure 5-3: CISP Prescriptive Participation Summary

5.4 Closed Custom Project Participation Summary

Table 5-2 summarizes the completed custom projects for the program. Closed custom projects are projects that have been verified by the Evaluators and an incentive has been issued by BHE.

Table 5-2: Custom Project Participation Summary

Facility Type	Project ID	Measure	Ex Post Savings
Medical	EA-0000886352	Steam Trap Replacement	73,459
Medical	EA-0000639254	Steam Trap Replacement, Steam Leak Repair, Insulation, Condensate Return	49,053
Medical	EA-0000709785	Condensate Return	10,583
Food Processing	EA-0000886351	Boiler Replacement, Boiler Controls	33,409
Food Processing	EA-0000918156	SEM	35,141
Industrial	EA-0000466038	Steam Leak Repair	12,165
College / University	EA-0000918061	Steam Trap Replacement, Steam Leak Repair	85,061
Medical	EA-0000706905	Retrocommissioning	19,560
Medical	EA-0000696227	Steam Trap Replacement, Steam Leak Repair, Insulation	51,008
Industrial	EA-0000925866	SEM	25,366
Industrial	EA-0000925869	SEM	27,462
Food Processing	EA-0000821482	Boiler Replacement, Boiler Controls	50,435

5.5 CISP Process Evaluation

The Evaluators conducted a formal process evaluation of the CISP in PY2021 and found that the program was successful in meeting participation, savings, and satisfaction goals. Table 5-3 and Table 5-4 summarize the Evaluators’ review of the CISP in comparison to TRM V9.0 Protocol C for timing and conditions of conducting a process evaluation.

Table 5-3: Determining Appropriate Timing to Conduct a Process Evaluation

Component	Determination
New and Innovative Components	No. The program is unchanged from PY2021.
No Previous Process Evaluation	No. The program received a process evaluation in PY2021.
New Vendor or Contractor	No. The restructured program continues to be implemented by CLEAResult.

Table 5-4: Determining Appropriate Conditions to Conduct a Process Evaluation

Component	Determination
Are program impacts lower or slower than expected?	No. The program met savings goals in PY2021.
Are the educational or informational goals not meeting program goals?	No. The program has an established trade ally network.
Are the participation rates lower or slower than expected?	No. The program met participant goals in PY2021.
Are the program’s operational or management structure slow to get up and running or not meeting program administrative needs?	No. The PY2Y2021 process evaluation found that operational and management structure to be up to speed and efficient in administering the program.
Is the program’s cost-effectiveness less than expected?	No. The program’s cost-effectiveness exceeded expectations.
Do participants report problems with the programs or low rates of satisfaction?	No. Participant surveys found high satisfaction levels.
Is the program producing the intended market effects?	Yes. Interviews with participants and trade allies have shown market transformation is occurring.

Based on these findings, process evaluation activities were limited to a review of prior recommendations.

5.5.1 Data Collection Activities

The process evaluation of the CISP included the following data collection activities:

- *Program Actor In-Depth Interviews.* The Evaluators conducted in-depth interviews with a series of program actors. These interviews covered a range of topics, including marketing efforts, feedback on program delivery, an assessment of barriers to program implementation and success, and recommendations for program improvement. Program actors interviewed include:
 - *BHE Program Staff.* The Evaluators interviewed staff at BHE involved in the administration of the CISP. These interviews built upon interviews conducted in PY2020, keeping apprised of BHE’s involvement as the CISP develops.
 - *Third Party Implementation Staff Interviews.* The Evaluators conducted interviews with CLEAResult involved with the CISP. These interviews addressed the development of the program over the PY2022 program year as well as CLEAResult’s perspective on a variety of implementation issues, including conversion of audits to completed projects and the process flow for direct install and custom projects.
- *Participant Surveying.* A census of custom participants was surveyed for this evaluation effort. These surveys included net-to-gross and process issues. The surveys provided valuable data for this process evaluation effort, providing participant feedback as to

their program participation, recommendations for program improvement, and insight into the decision-making process.

Table 5-5 summarizes the data collection for this process evaluation effort. This includes the titles, roles, and sample sizes for data collection.

Table 5-5: BHE CISP Data Collection Summary

Target	Component	Activity	n	Precision	Role
BHE Program Staff	Manager, Energy Efficiency	Interview	1	N/A	Overall administration of BHE the larger strategic decisions associated with the EE portfolio. They are also involved with the CISP in the overall coordination of utility resources.
CLEAResult Staff	Program Manager	Interview	2	N/A	The Program Managers handle day-to-day operations, including tracking of outreach and implementation activities, payments for direct installation, and interfacing with Evaluation staff.
Participants	Custom	Survey	6	±0%	Custom participants received a semi-structured interview at the beginning of a project and a structured survey at the close. The Evaluators interviewed a census of participants.

5.5.2 Process Results & Findings

This section presents the results and key findings from the data collection activities. These findings are based upon interviews with utility staff, implementation staff, surveys with participants, and thorough and in-depth literature review.

5.5.2.1 Response to Program Recommendations

Table 5-6 summarizes the PY2021 recommendation and BHE’s response.

Table 5-6: CISP Response to PY2020 Recommendations

Recommendation	BHE Response	Status of Issue
Estimate water impacts in customer audit report payback calculations/ROI for relevant projects. Projects that save water can have significantly more rapid payback periods than just based solely on their gas savings. CLEAResult should factor this into audit report calculations when the opportunity presents itself (steam leak repair, condensate return, etc.).	Accepted and in progress for implementation.	In Progress

5.5.2.2 Program Theory & Design

The CISP was designed to provide outreach in hard-to-reach sectors of the C&I markets. The bullets below list program activities and their expected outcomes.

- **Direct installation of high-return measures.** The CISP provides no-cost direct installation of weather stripping, low flow faucet aerators, PRSVs, and showerheads. These measures have a high return of savings relative to their cost and as such can be provided free-of-charge and remain cost-effective. The resulting savings are unlikely to occur absent the program; generally, if a respondent does not already have the equipment in place, the direct install activities induce an action that was not planned. These activities are also intended to serve as an introduction to energy efficiency for the recipients, and that they will then be further interested in participating in the custom component of the program.
- **Energy audits to medium and large customers.** These audits are conducted by CLEARResult staff, providing recommendations for energy efficiency improvements and an audit report. These audits are intended to generate the bulk of the program savings, yielding high-return custom projects.
- **Steam system survey incentives.** These incentives defray the cost of steam system surveys for participating trade allies, allowing them to provide detailed project scoping at no upfront cost to them or to the customer.
- **Incentives for custom measures.** The CISP provides \$0.75 per Therm for verified savings from custom projects (\$.20 per therm in the case of Strategic Energy Management). These projects may be driven by a program-funded audit, generated by a trade ally, or be customer-directed.
- **Incentives for prescriptive measures.** This includes furnaces, water heaters, boilers, and food service equipment at fixed incentive rates.

5.5.2.3 Program Administration

The CISP is overseen by the Manager of Energy Efficiency at BHE. This manager's responsibilities primarily include interfacing with CLEARResult, who directly implements the program. Other activities by this manager include providing updated customer lists to CLEARResult to better-facilitate their implementation, review of custom applications, and at times assisting CLEARResult in customer interactions.

For CLEARResult, the program overall is led by the Program Manager, who oversees the implementation of the CISP from CLEARResult's Fayetteville, AR office. This manager handles high-level issues across the programs, including regulatory compliance and reporting, as well as some level of intervention on the larger projects.

Much of the day-to-day activity is handled by the Program Manager, who reviews direct install and audit activity, and coordinates with the Evaluators in facilitating EM&V activities.

Audit activities are run by engineering staff at CLEAResult. Titles for staff that engage in this activity may vary depending upon the complexity of the facility¹⁶. These engineers conduct the energy audits. Additionally, their responsibilities include development of the audit report and recommendations. The Direct Install Program Manager oversees crews that perform direct installation. Further, the Associate Account Manager follows up with customers to gauge interest in completing a project.

There were no major changes to program design in 2022. Staff have focused on building the SEM program, which finally seems to be picking up steam. Staff noted that the SEM projects are only successful when the customer is fully engaged and on-board. That being said, they have seen large saving improvements across some of the participants. Moreover, the SEM program teaches customers about various behavioral changes they can make that can result in long-term, sustainable, savings, that can sometimes be hard to quantify. The SEM program is slated to run through the end of 2023; staff plan to evaluate the cost-benefit analysis of the program during the upcoming gap year.

Supply chain issues remained a concern in 2022. Although availability of products has improved, higher efficiency equipment can be difficult to acquire. Moreover, contractors struggle to employ staff, thereby slowing down their project turnover time. Additionally, the cost of insulation materials has increased dramatically.

5.5.2.4 Program Implementation and Delivery

CLEAResult provides the Evaluators with updates regarding their pipeline of custom projects. These updates listed the full scope of facility audits, expected savings with associated recommended measures, and what stage the project was in. These stages are:

- *Pipeline*. Projects listed as Pipeline are in the first phase of involvement in the CISP. These participants are customers that have discussed the possibility of a facility audit and indicated interest to CLEAResult. These facilities will receive a Pre-Inspection at a later date and have not signed a project application.
- *Pre-Inspected*. Projects listed as Pre-Inspected are in the phase where CLEAResult has completed a facility audit. During these audits, CLEAResult conducts a comprehensive review of the facility's systems and operational practices. On this basis, CLEAResult then formulates initial recommendations for energy efficiency improvements. These are

¹⁶ Examples include (but are not limited to) Energy Engineer, Senior Energy Engineer, and Senior Program Consultant.

discussed with facility staff during the audit in order to address the feasibility of recommended measures.

- *Pre-Installation Calculation.* At this phase, CLEAResult is compiling high-level data needed to provide an initial estimate of energy savings. This step of the process compiles the information collected in the site audit, which are then used in the development of an Audit Report.
- *Audit Report Complete.* In this phase, feasible measures from the Pre-Inspection are compiled into a formal audit report, providing the participant with further detail as to the scope of the project, initial savings estimates, associated incentives, expected project costs, and the payback period of the measure. Additionally, should the measure provide operational benefits to the facility (such as improved comfort or product reliability), these are included as well to provide the customer with a full scope of the benefits of the project. This report is provided at no cost to the participant.
- *Project Agreement.* At this point, the customer has informed CLEAResult and BHE that they intend to install a program-recommended measure. When this occurs, CLEAResult then involves the Evaluators. CLEAResult provides the Evaluators with an M&V plan for the facility, detailing the project scope and proposed data collection and analysis. The Evaluators' engineering staff then reviews the M&V plan and makes recommendations for any changes needed. If this revises the savings amount, the reserved incentive amount in the application is revised. A project agreement is then signed, in which the reserved incentive amount is detailed and reflects edits made by the Evaluators.
- *Post-Inspection.* This phase marks the completion of post-inspection for an installed measure. CLEAResult has, at this point, post-inspected a measure and revised savings accordingly if the installed project differs from the proposed project. In some rare instances, the participant may then be paid out for 60% of the reserved incentive, with the remainder held in reserve to true-up the final incentive amount after M&V is completed. There are times when this may occur for a project with an M&V period at extends across the calendar year. This occurs for a small number of projects overall; two facilities with three measures had a project that installed in PY2021 and carried into PY2022. No projects installed in PY2022 with ongoing M&V have partial savings claims applied in this report.
- *M&V.* M&V marks the phase when post-installation data is collected for an installed project to allow for calculation of a final savings estimate, from which the remaining incentive to the customer is determined. There are some measures that do not require post-retrofit data; for such measures, the M&V phase is short and requires completion of calculations based upon inputs verified during the Post-Inspection. For facilities that

require post-installation data, the data collection period can range from 30 days to 6 months.

- *Complete*. Facilities marked as Complete have received their full incentive.

The process flow for the CISP is displayed in the figure below.

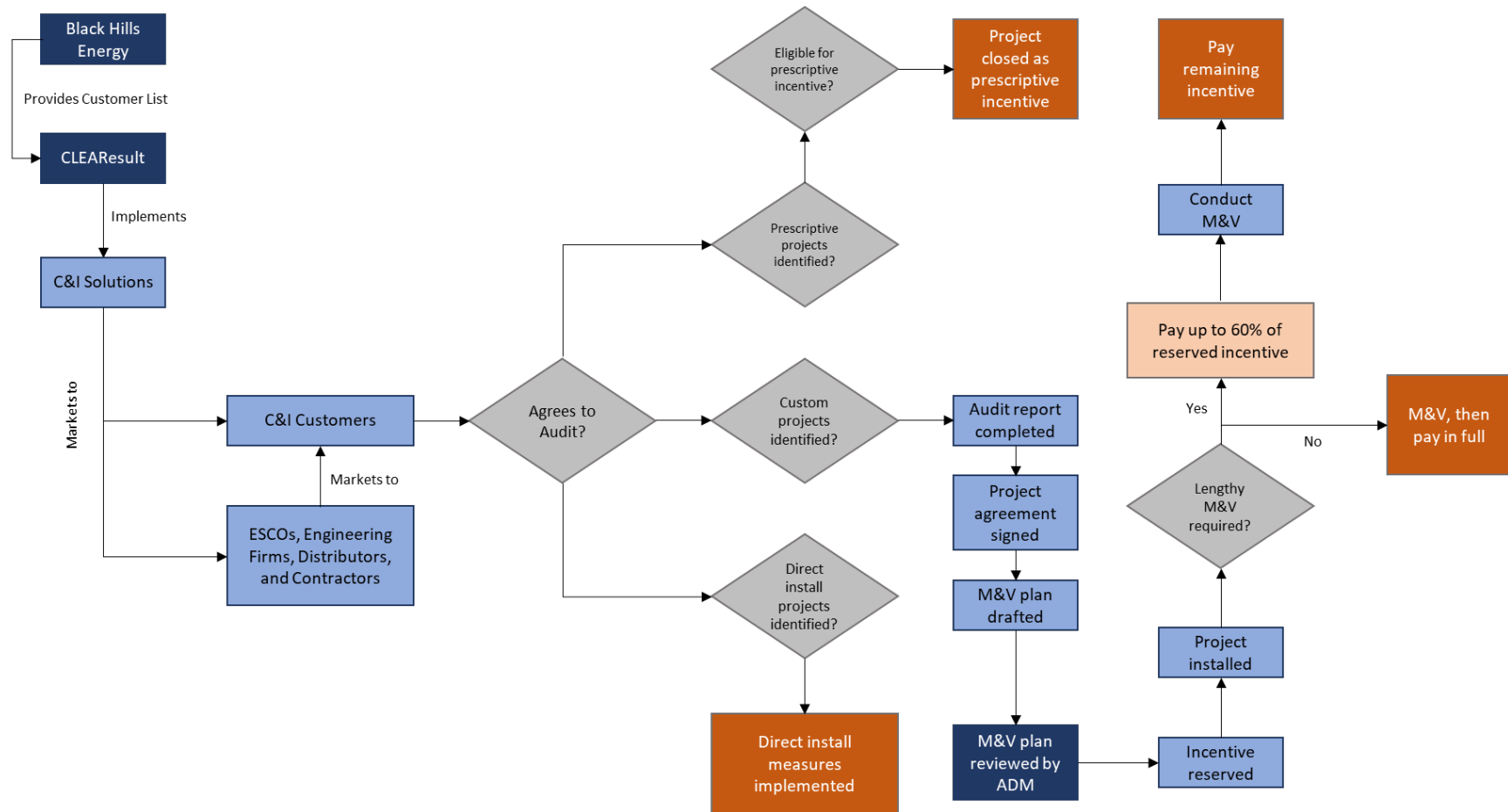


Figure 5-4: C&I Solutions Process Flow

5.5.2.5 Trade Allies

C&I customers can use any licensed contractor for their equipment upgrades. BHE does have a list of 15-20 pre-approved and recommended trade allies for various install types. Staff are trying to diversify their trade ally list to ensure certain install types, such as steam traps, are not solely dependent on one to two trade allies.

5.5.3 Adherence to Protocol A

The CLEAResult tracking system contained full detail with project addresses, contact information, and measure inputs. Further, the tracking system provided the Therms savings for each line item.

During PY2022, the Evaluators received monthly tracking data updates as well as final tracking exports. The tracking system included necessary inputs per TRM V9.0. Other than these updates, there were no major updates to the structure or content of program tracking data. The Evaluators previously reviewed program tracking data in PY2020 to assess its compliance with Protocol A of the TRM V9.0 which specifies that tracking data should be checked for:

- Participating Customer Information;
- Measure Specific Information;
- Vendor Specific Information;
- Program Tracking Information;
- Program Costs; and
- Marketing & Outreach Activities.

The Evaluators conducted a review of each of the above factors within PY2022 tracking data except for marketing and outreach activities as these are outside the scope of the tracking system’s reporting.

5.5.3.1 Customer, Premise, Cost, and Vendor Information

Each of these factors was assessed individually based on the guidelines stated in TRM V9.0. Overall, the Evaluators conclude the following regarding tracking data completeness:

- Participating customer information was complete for nearly all participants.
- Custom and prescriptive projects contained complete information on the contractor that completed the installation. This was not needed for direct install as this is done in-house with CLEAResult staff.
- Tracking data included the measure and project costs for each project.
- Weather zones were provided in the tracking data, though entries were blank for 44% of Direct Install projects.
- All inputs needed to re-calculate savings according to TRM V9.0 protocols were present in the direct install database.

5.5.3.2 Measure Specific Information

The tracking data was found to include sufficient information for all measures in PY2022.

5.6 CISP Impact Evaluation

The impact evaluation of the CISP included the following:

- *Custom Project M&V.* The Evaluators conducted project-specific M&V on a census of custom projects completed through the CISP. Each project included an M&V plan and a project-specific report. The reports are provided in Appendix A.
- *Free-Ridership Estimation.* A free ridership rate for DI participants was estimated through participant surveying. Respondents were asked a series of questions related to their past experience with the appropriate measures, whether they had ever installed similar equipment at the participating premise or at other premises within their organization, and whether they knew of the potential savings from the DI measures prior to participating. Given the types of measures covered by the DI component, the free ridership rate is essentially focused on to what extent participating organizations had policies in place to install such equipment anyway. If such policies were not in place, then the installation of the equipment is generally considered to be program-induced.

5.6.1 Summary of Non-Energy Benefits

Table 5-10 summarizes the non-energy benefits by measure that are credited to the CISP.

Table 5-7: CISP Non-Energy Benefits

Measure	Electric Savings	Water Savings	Propane Savings	Avoided Replacement Cost
Steam Leak Repair		✓		
Condensate Return		✓		
Faucet Aerators		✓		
Low Flow Showerheads		✓		
Low Flow PRSVs		✓		
Weather Stripping	✓			
Tankless Water Heaters				✓

5.6.1.1 Water Savings Calculation Procedure

The TRM V9.0 provides detail for calculation of water savings for the following measures:

- Faucet Aerators (3.3.2);
- PRSVs (3.8.11); and
- Low Flow Showerheads (3.3.5).

The deemed savings procedures for these measures require calculation of water savings, and the water savings claims comply with TRM protocols.

5.6.2 CISP Direct Install Impact Evaluation

5.6.2.1 Deemed savings calculations

For sample TRM calculations, see Appendix C.

5.6.2.2 Direct Install Free-Ridership

In prior evaluations, the methodology for DI Free-Ridership was focused on the participants' past experiences with the appropriate equipment and whether they had organizational policies in place to install such equipment. Respondents were asked:

- Q22. Before to participating in the C&I Solutions Program, did you have plans to install [LIST MEASURE]?
- Q23 Would you have gone ahead with this planned project even if you had not participated in the program?

Twenty percent of respondents stated that they were aware of the savings potential from such equipment.

- Q27 If the [PROGRAM] program representative had not recommended installing the [PROJECT_DESCRIPTION], how likely is it that you would have installed it anyway?
1. Definitely would have installed
 2. Probably would have installed
 3. Probably would not have installed
 4. Definitely would not have installed
 98. Don't know

These are combined into the following factors:

- A. **Prior Plans:** If the respondent indicated plans to install prior to participation, they receive a "1" for this metric.
- B. **Installation counterfactual:** If they respondent states that they would have gone ahead with this project without the program, they receive a "1" for this factor.
- C. **Program Influence:** If a respondent states that they "Definitely would have" or "probably would have" installed this equipment without the program, they receive a "1" for this factor.

To be found a free rider, a respondent must receive a "1" score for all three factors. The direct install pathway was found to have 100% NTGR.

5.6.3 CISP Prescriptive Projects Impact Evaluation

The CISP processed 145 prescriptive rebates in PY2022. These projects included:

- 108 furnaces;
- 4 water heaters;
- 8 boilers;
- 22 convection ovens; and
- 3 fryers.

The Evaluators found applied TRM V9.0 protocols and calculated savings by measure. Savings are summarized in Table 5-11.

Table 5-8: BHE CISP Prescriptive Project Summary

Measure	Ex Ante Gross Savings	Ex Post Gross Savings	Gross Realization Rate	Gross Lifetime Savings
Furnaces	21,148	21,494	101.6%	429,872
Water Heaters	21	29	138.1%	582
Food Service	7,350	7,350	100.0%	88,195
Boilers	32,782	32,782	100.0%	655,641
Total	61,300	61,654	100.6%	1,174,291

Causes for revision in savings included:

- **Water heaters:** The Evaluators cannot discern the source of the discrepancy, other than it is derived from the DHW load lookup value (this being the only input that can affect savings to this magnitude).
- **Furnaces:** The Evaluators made corrections for facility type on a small number of projects.

5.6.4 CISP Custom Project Impact Evaluation

The Evaluators opted for a census of custom projects in order to capture the full variability associated with these projects; the measures are often unique with idiosyncratic issues, and as such extrapolation from the M&V of other projects would be inappropriate. Table 5-12 summarizes the custom projects completed and evaluated in PY2022. “Ex Ante Savings” is the value calculated by CLEAResult after M&V. “Ex Post Savings” is the savings calculation completed by the Evaluators.

Table 5-9: BHE CISP Custom Project Summary

Facility Type	Project ID	Measure	Ex Ante Savings	Ex Post Savings	M&V Protocol
Medical	EA-0000886352	Steam Trap Replacement	73,459	73,459	Deemed
Medical	EA-0000639254	Steam Trap Replacement, Steam Leak Repair, Insulation, Condensate Return	49,053	49,053	Option A
Medical	EA-0000709785	Condensate Return	10,583	10,583	Option A
Food Processing	EA-0000886351	Boiler Replacement, Boiler Controls	33,409	33,409	Option A
Food Processing	EA-0000918156	SEM	35,141	35,141	Option C
Industrial	EA-0000466038	Steam Leak Repair	12,165	12,165	Option A
College / University	EA-0000918061	Steam Trap Replacement, Steam Leak Repair	85,061	85,061	Deemed, Option A
Medical	EA-0000706905	Retrocommissioning	19,560	19,560	Option C
Medical	EA-0000696227	Steam Trap Replacement, Steam Leak Repair, Insulation	51,008	51,008	Deemed, Option A
Industrial	EA-0000925866	SEM	25,366	25,366	Option C
Industrial	EA-0000925869	SEM	27,462	27,462	Option C
Food Processing	EA-0000821482	Boiler Replacement, Boiler Controls	50,435	50,435	Option A
Food Processing	EA-0000696230	Steam Trap Replacement, Steam Leak Repair	108,590	108,590	Deemed, Option A
Total			581,292	581,292	

5.6.4.1 Custom Project Free-Ridership

The Evaluators conducted interviews with nine decision-makers responsible for the completed custom projects in the CISP program in PY2022. Given the small number of interviews, reporting data in terms of percent response by question does not adequately present the participant response to the program. The methodology used by the Evaluators in determining the free ridership rates for custom projects examined the following factors:

- Knowledge gained from program outreach.* If the project originated from program outreach (which may include program-sponsored training courses or facility audits), the respondent is asked if they had prior knowledge of the energy-saving opportunity recommended and eventually installed. If the respondent learned of the measure through the program audit or program-sponsored training, then they are considered to not have been free riders, in that in the absence of the program, the likelihood of the

facility receiving a similarly detailed audit are low. Questions used in evaluating this criterion include:

- FI-1 Prior to participating in the C&I Solutions Program, did your organization install any equipment similar to [EQUIPMENT/MEASURE] at your facility without financial incentives or rebates?
- Yes
 - No

FI-1a Did you learn of this measure through your participation in the Commercial & Industrial Solutions Program?

- Yes [IF YES, ASK FI-1b] Do you recall how you learned of the measure?
- No

- *Prior plans for a similar measure.* This component is examined in instances where the respondent knew of the measure prior to receiving and technical assistance through the C&I Solutions Program. Respondents are asked a series of questions related to whether they had plans for installing this equipment prior to having learned of the available financial incentives from the C&I Solutions program. Questions used in this component include:

- FI-1 Prior to participating in the C&I Solutions Program, did your organization install any equipment similar to [EQUIPMENT/MEASURE] at your facility without financial incentives or rebates?
- Yes
 - No

FI-2 Did you have plans to install the [EQUIPMENT/MEASURE] that was upgrades through C&I Solutions before participating in the program?

- Yes
- No

If Yes: FI-2a Would you have gone ahead with this planned installation without the program rebates?

- Yes
- No

FI-2b Would this installation have included the same equipment without the program rebates?

- Yes
- No

- *Analysis of measure payback.* Respondents are asked to indicate what their required payback period is for energy efficiency improvements. This value is compared against the measure payback with and without the program incentive. If the financial incentive

brings the project from over the threshold to under the threshold, then the project is considered to have been sufficiently influenced by the program incentive. This includes the following questions:

DM-5 Does your organization require a specific payback period in order to implement energy efficiency improvements?

- Yes [ASK DM-5A]
- No [SKIP TO DM-6]
- Don't know [DON'T READ]

DM-5a What **payback length of time** do you normally require in order to consider an energy investment cost effective?

___ Years

- Don't know

The stated payback requirement by the respondent is then compared against the payback of the recommended project with and without the program incentive.

- *Modification of the project.* Respondents are asked a series of questions addressing whether they modified the project as a result of their program participation. This includes changes in equipment quantity and/or efficiency level (where appropriate for the measure) and a change in project timing. Questions used to analyze this component include:

FI-5 If the C&I Solutions through C&I Solutions Program were not available, would you have installed the...

- Same quantity of energy efficient equipment,
 - A lower quantity, or
 - No energy efficient equipment at all?
- [IF FI-5 = "Lower Quantity"]: FI-5a: By percentage, how much lower?

FI-6 If the C&I Solutions program were not available, would you have installed ...

- The same equipment with the same efficiency level,
- The same equipment with a lower energy efficiency level, but still above minimum code, or
- standard efficiency equipment?

[IF FI-6 = "Lower efficiency level, but still above minimum code"]: FI-6a: By percentage, how much lower?

FI-7 Did the C&I Solutions rebate allow you to install [EQUIPMENT/MESURE] sooner than you otherwise would have?

- Yes

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IF YES: FI-7a When would you otherwise have installed the equipment? (READ IF NEEDED)

- In less than 6 months later
- In 6-12 months later
- In 1-2 years later
- In 3-5 years later
- In more than 5 years later
- No, did not affect timing of purchase and installation

The scoring mechanism for custom projects is presented in Figure 5-8.

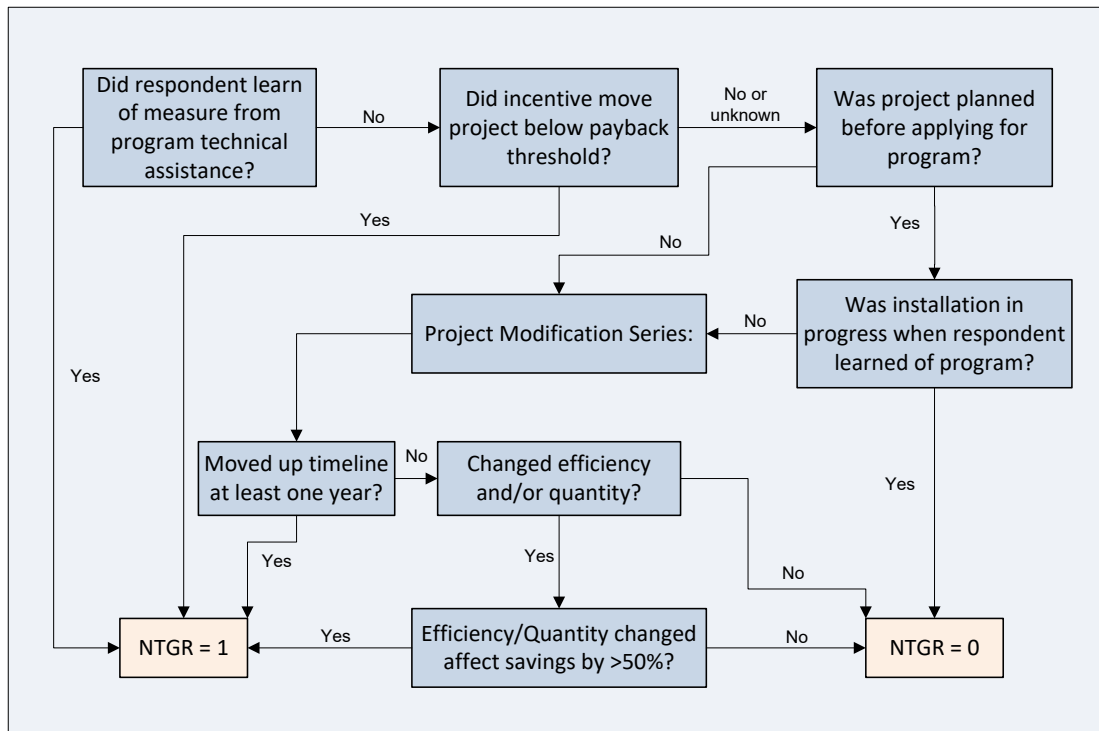


Figure 5-5: CISP Custom Project Free-Ridership Diagram

The resulting NTGRs by project are presented in Table 5-10.

Table 5-10: CISP Custom Project Free-Ridership Results

Facility Type	Project ID	Measure	Ex Post Savings	NTGR
Medical	EA-0000886352	Steam Trap Replacement	73,459	100.0%
Medical	EA-0000639254	Steam Trap Replacement, Steam Leak Repair, Insulation, Condensate Return	49,053	100.0%
Medical	EA-0000709785	Condensate Return	10,583	100.0%
Food Processing	EA-0000886351	Boiler Replacement, Boiler Controls	33,409	100.0%
Food Processing	EA-0000918156	SEM	35,141	100.0%
Industrial	EA-0000466038	Steam Leak Repair	12,165	100.0%
College / University	EA-0000918061	Steam Trap Replacement, Steam Leak Repair	85,061	100.0%
Medical	EA-0000706905	Retrocommissioning	19,560	100.0%
Medical	EA-0000696227	Steam Trap Replacement, Steam Leak Repair, Insulation	51,008	100.0%
Industrial	EA-0000925866	SEM	25,366	100.0%
Industrial	EA-0000925869	SEM	27,462	100.0%
Food Processing	EA-0000821482	Boiler Replacement, Boiler Controls	50,435	100.0%
Food Processing	EA-0000696230	Steam Trap Replacement, Steam Leak Repair	108,590	100.0%
Total			581,292	100.0%

Given the small number of participants, the free rider assessments were a series of case studies as opposed to an extrapolated survey. The individual free rider assessments are contained within the survey narrative responses detailed in Section 5.1.8.

5.6.4.2 Participant Spillover

Participant spillover is defined as savings from program participants that was not incentivized by the BHE programs. During participant surveying, both DI and Custom participants are asked questions addressing whether their participation had led to the installation of equipment that was not rebated by BHE. The estimated savings from these projects are tallied and added to the program savings as Participant Spillover.

OS-3 Has your organization’s participation in the C&I Solutions Program led you to buy any energy efficient equipment for which you did not apply for a financial incentive?

Yes

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If Yes: OS-3a What type of equipment? _____

No

- Don't know [DON'T READ]

The Evaluators did not identify any participant spillover.

5.6.4.3 Partial-Participant Spillover

Partial-participant spillover are savings resulting from projects that were recommended to recipients of audits through the CISP that were completed without filing for program incentives. Respondents are asked:

Have you since implemented any of the recommendations from your facility audit?

- a. If Yes: Why didn't you install these measures through the available incentive program?

It is then clarified as to whether the respondent installed the project as specified in the audit or made modifications to the project. This is combined in providing an estimate of non-incentivized savings, which constitutes the Partial Participant Spillover.

5.6.5 Ex Post Savings

Table 5-14 presents the gross savings results of the evaluation of the PY2022 CISP. Total gross savings summarizes the savings calculations performed by TRM protocols for direct install measures as well as the project-specific M&V of custom measures.

Table 5-11: CISP Ex Post Therms Savings

Measure Category	Ex Ante Therms Savings	Ex Post Therms Savings	Gross Realization Rate	EUL	Lifetime Therms Savings
Direct Install	96,996	97,589	96.02%	10.97	1,070,972
Prescriptive	61,300	61,654	160.77%	19.05	1,174,291
Custom	581,292	581,292	99.82%	7.36	4,280,925
Total	739,589	740,536	100.94%	8.81	6,526,188

Net savings for the CISP were calculated using survey data of direct install and custom participants. The resulting net savings are presented in Table 5-15.

Table 5-12: CISP Net Savings Summary

Measure Category	Free-Ridership Rate		Net Annual Savings		Net Realization Rate	Net Lifetime Therms Savings
	Ex Ante	Ex Post	Ex Ante	Ex Post		
Direct Install	3.83%	3.83%	93,282	93,851	100.61%	1,029,861
Prescriptive	21.50%	21.50%	48,119	48,397	100.58%	922,540
Custom	0.00%	0.00%	581,292	581,292	100.00%	4,280,925
Total	2.29%	2.29%	722,693	723,540	100.12%	6,233,327

The Evaluators applied TRM V9.0 Volume 1, Section II, Protocol L1 to calculated water savings from faucet aerators and low-flow showerheads. Avoided costs for water savings is calculated

using TRM V9.0 Volume 1, Section II, Protocol L2.¹⁷ The Evaluators relied on the TRM-calculated marginal water rates. The corrected marginal water rates below are reported both for PY2022.

Table 5-13: Total Marginal Water Rates

Customer Class	Marginal Water Rates (per 1,000 gallons)	Marginal Sewage Rates (per 1,000 gallons)	Total Combined Marginal Water Rates (per 1,000 gallons)
Residential	\$3.51	\$4.74	\$8.24
Commercial	\$2.84	\$4.27	\$7.11
Average Cost \$/Gallon	\$3.20	\$4.50	\$7.70

Table 5-17 summarizes water savings from the CISP.

Table 5-14: Commercial & Industrial Solutions Ex Post Net Water Savings

Measure Category	Net Annual Water Saving (Gallons)	Lifetime Net Water Savings (Gallons)
Custom	40,941,063	409,410,632
Direct Install	74,351	371,751
Prescriptive	0	0
Total	41,015,414	409,782,381

5.6.6 Avoided & Deferred Replacement Cost

With commercial tankless water heaters being moved from the former Equipment Rebates Program to CISP, the CISP now has avoided replacement cost benefits. The Evaluators estimated net ARC of \$109.48 for commercial tankless systems. With four systems rebated in PY2022, total ARC for the CISP is \$437.91.

¹⁷ These avoided costs were updated through the 'TRM Clarification Memo' distributed by the IEM on July 22, 2019.

5.7 Conclusions

<p>The program met savings goals and was highly cost-effective.</p>	<p>Though savings decreased by 2.5% compared to PY2021, and the program met 114.8% of its net savings goal</p> <p>Participation increased significantly in the Prescriptive Pathway for the second straight year. Savings by year from this pathway for the program cycle were:</p> <ul style="list-style-type: none"> • PY2020: 24,400 • PY2021: 36,398 • PY2022: 48,397
<p>NEBs have increased significantly.</p>	<p>Water savings increased significantly for the second straight year. Savings by year from this pathway for the program cycle were:</p> <ul style="list-style-type: none"> • PY2020: 435,401 • PY2021: 16,312,350 • PY2022: 41,015,414 <p>This is a volatile value year-over-year as it is heavily driven by the relative prevalence of custom projects that save water. The three highest water-saving projects accounted for 85% of total PY2022 water savings.</p>
<p>SEM is growing in prevalence in the Custom Pathway.</p>	<p>SEM constituted 15% of CISP Custom Pathway savings in PY2022. The one-year EUL for this measure as contributed largely to the decline in Custom EUL (declining from 11.09 in PY2021 to 8.81 in PY2022) but this is an anticipated side-effect of encouraging this measure.</p> <p>BHE plays a lower incentive per therm for SEM projects to account for this difference.</p>

6 Low Income Pilot Program

The Low Income Pilot Program (LIPP) was designed to comply with Act 1102. LIPP is an extension of the Consistent Weatherization Approach (CWA), and it is targeted to customers who meet the income eligibility requirements of the Low Income Home Energy Assistance Program (LIHEAP).

The program provides energy assessments, along with direct installation of low-cost measures and pre-qualification for building envelope improvements.

- Direct install measures include:
- Faucet aerators; and
- Low flow showerheads.

Weatherization measures include:

- Air infiltration;
- Duct sealing; and
- Ceiling insulation.

Additionally, the program offers a maximum of \$500 per participating residence to meet the health code standards required to weatherize the residence. Health and safety funding may be used to provide carbon monoxide detectors, smoke detectors, or other required measures.

6.1 Program Overview

Table 6-1 summarizes the historical performance of LIPP.

Table 6-1: LIPP Historical Performance against Goals

Program Year	# Participants		Budget		Net Therms	
	Actual	Goal	Spent	Allocated	Achieved	Goal
2020	41	123	\$80,675	\$81,904	21,782	19,596
2021	39	123	\$76,619	\$81,904	25,244	19,596
2022	40	123	\$100,189	\$83,696	31,698	19,596

6.2 Participation Summary

The LIPP had 40 participants in PY2022. Figure 6-1 summarizes savings by measure for PY2022.

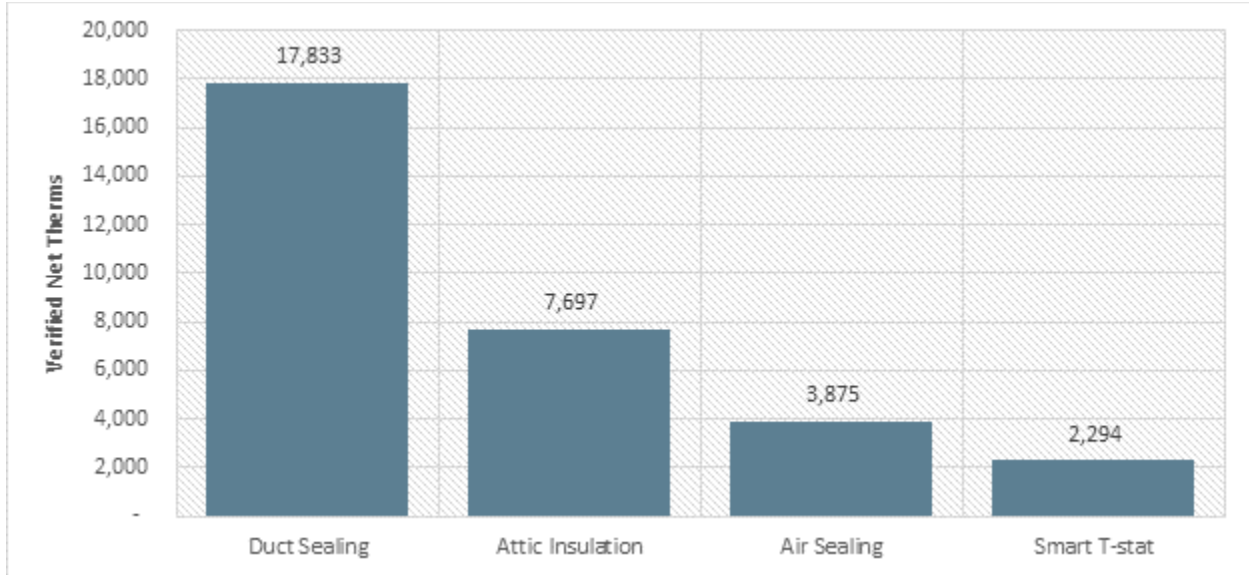


Figure 6-1: Program Savings Share by Measure

In addition, incentives were provided for 40 assessments and health and safety spending at all 40 participant homes.

6.2.1 Contractor Participation

The LIPP had one trade ally assigned to the program, who had also been assigned to the program in PY2020-PY2021. This was an established trade ally in the HES Pathway. Given the small size of the pilot, BHE and CLEAResult chose to focus the funds on one contractor rather than incurring expenses associated with program training for multiple HES Pathway contractors. As shown in Figure 6-2, the LIPP provided comprehensive services, with 100% of PY2022 homes receiving duct sealing, 95% receiving air sealing, 65% receiving smart thermostats and 63% receiving ceiling insulation.

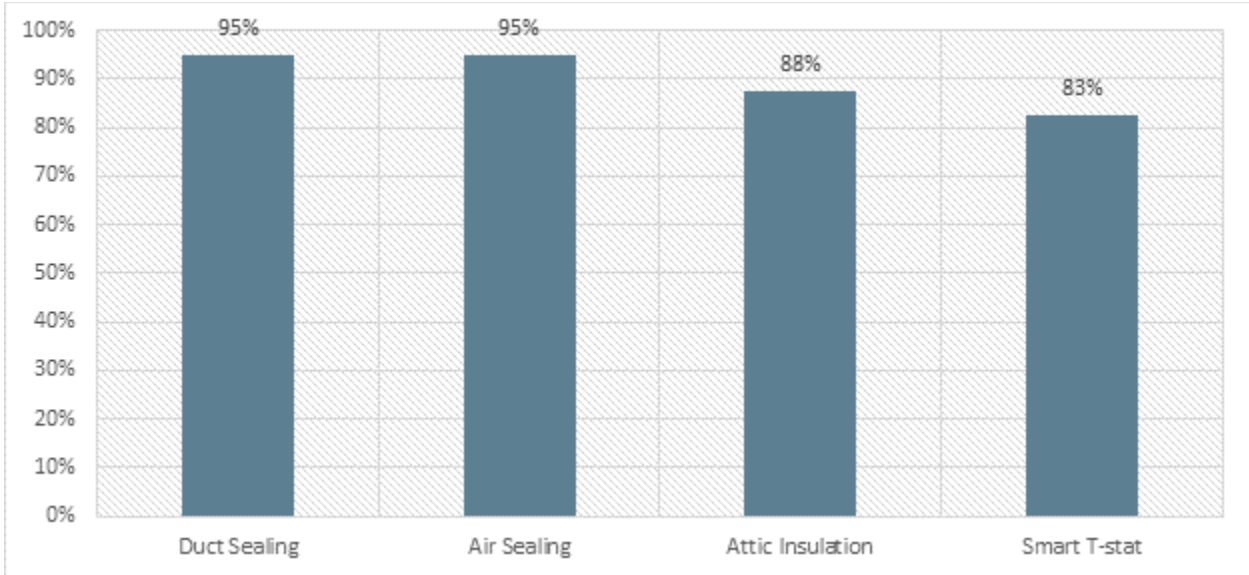


Figure 6-2: Percent of Homes Receiving LIPP Measures

6.3 LIPP Process Evaluation

Table 6-2 and Table 6-3 summarize the Evaluators’ review of the LIPP in comparison to TRM V9.0 Protocol C for timing and conditions of conducting a process evaluation.

Table 6-2: Determining Appropriate Timing to Conduct a Process Evaluation

Component	Determination
New and Innovative Components	No. The program is implemented in the same manner as in PY2021.
No Previous Process Evaluation	No. The program received a process evaluation in PY2020 and PY2021.
New Vendor or Contractor	No. The program is still implemented by CLEARResult .

Table 6-3: Determining Appropriate Conditions to Conduct a Process Evaluation

Component	Determination
Are program impacts lower or slower than expected?	No. The program met savings goals in PY2021.
Are the educational or informational goals not meeting program goals?	No. The achieved educational goals in PY2021.
Are the participation rates lower or slower than expected?	No. The achieved participation goals in PY2021.
Are the program’s operational or management structure slow to get up and running or not meeting program administrative needs?	No. Administration has been effective, providing both energy efficiency and health & safety measures.
Is the program’s cost-effectiveness less than expected?	No. Cost-effectiveness exceeded plan expectations.
Do participants report problems with the programs or low rates of satisfaction?	Unknown. Participants not yet surveyed,
Is the program producing the intended market effects?	Premature to fully determine, but program has thus far achieved all Pilot goals.

The Evaluators conducted a limited process evaluation emphasizing collection of participant feedback and satisfaction levels.

6.3.1 CWA Metrics Summary

This section presents the required metrics for BHE’s LIPP program. Though not explicitly required under Act 1102, the Evaluators have provided this for the purpose of comparability to the HES Pathway.

Table 6-4: CWA Required Process Evaluation Metrics

Metric	Value
Program Name	Low Income Pilot Program
CWA Implementation	Yes
Total Audits Completed	40
Total Submitted Projects	40 homes, 325 measures
Conversion Rate	100.0%
Measures installed per-project	Energy-saving: 3.60 Health & Safety (no energy savings): 4.80
Cost per participant	\$1,276.84
Percent of contractors promoting program	100% (1 Contractor)

Table 6-5: LIPP Alignment with CWA Requirements

Requirement	Alignment with Requirement	Percent of Participants Receiving
Includes Applicable DI Measures	Yes	82.5%
Aerators	Yes	0%
Showerheads	Yes	0
Smart Thermostat	Yes	82.5%
Efficient lighting	Yes	N/A
Smart strips	Yes	N/A
Prequalifies homes based on year of construction or energy costs	Yes, the customer must have had a bill in the last twelve months that exceeded. Five cents per square foot or the home’s age is 10 years or greater.	Not in tracking data
TRC is used to assess program cost-effectiveness	Yes	N/A
Measures screened using SIR or comparable metric	Program uses TRC	N/A
Includes Core No Cost Measures	Yes	100.0%
Audit (walk through)	Yes	100.0%
Audit (virtual)		N/A
Ceiling insulation	Yes	87.5%
Duct sealing	Yes	95.0%
Air infiltration reduction	Yes	95.0%
Safety testing and/or measures	Yes	Not in tracking data
Offers other utility measures	Yes	82.5%
Contractors are certified BPI Building Analyst or RESNET HERS Rater	Yes, for duct sealing, air infiltration, and assessments. Insulation requires Arkansas Home Improvement Specialty License.	N/A

Figure 6-3 summarizes expenditures per-home by measure group. Overall spending per home increased by 9.9% from PY2021 to PY2022.

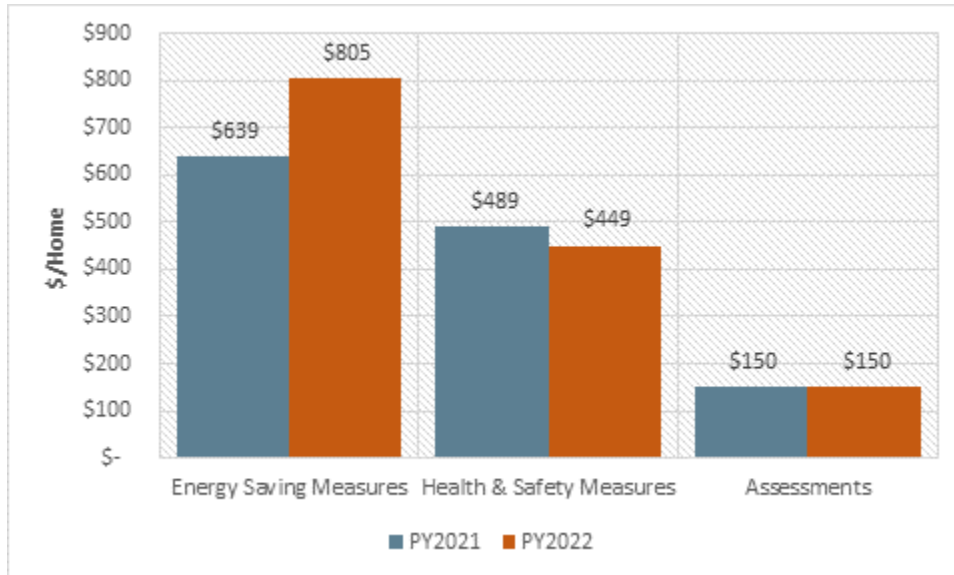


Figure 6-3: LIPP Spending Per-Home

6.3.2 Act 1102 Eligibility Summary

Figure 6-4 summarizes the extent to which LIPP participants were age-eligible, income-eligible or eligible on both criteria (as a cross-tabulation of the first two categories).

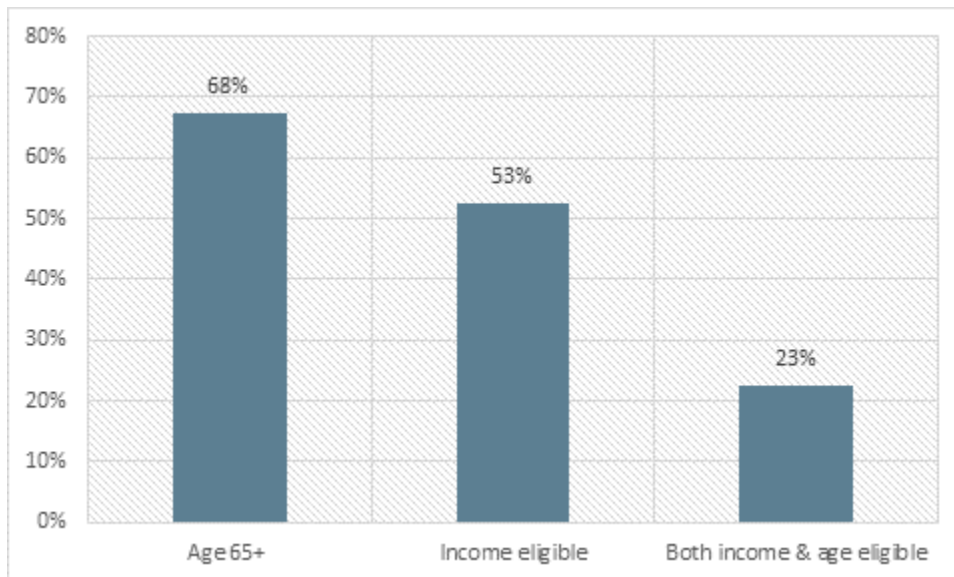


Figure 6-4: BHE LIPP Act 1102 Eligibility Summary

6.3.3 Response to Program Recommendations

Table 6-6 summarizes the PY2021 recommendation and BHE’s response.

Table 6-6: LIPP Response to PY2020 Recommendations

<i>Recommendation</i>	<i>BHE Response</i>	<i>Status of Issue</i>
<p>Formalize “electrician” and “AC tech” supplementary infrastructure work as H&S categories.</p> <p>All instances of “Other” spending were for work from electricians or AC technicians to complete installations of H&S measures in homes where preexisting infrastructure was insufficient. This is a good strategy to meet Act 1102 requirements and complete H&S installations. As all “Other” spending fell into these readily delineable categories, establishing them as standard H&S categories (albeit with variable incentive values) could simplify their use by program trade allies in future program years</p>	<p>BHE has formalized this measure category.</p>	<p>Completed</p>

6.3.4 Data Collection Activities

The process evaluation of LIPP included the following activities:

- *Program Actor In-Depth Interviews.* The Evaluators conducted in-depth interviews with a series of program actors. These interviews covered a range of topics, including marketing efforts, feedback on program delivery, an assessment of barriers to program implementation and success, and recommendations for program improvement. Program Actors interviewed include:
 - *BHE Program Staff.* The Evaluators interviewed staff at BHE involved in the administration of the LIPP.
 - *Third Party Implementation Staff Interviews.* The Evaluators conducted interviews with CLEAResult involved with the LIPP.

Table 6-7 summarizes the data collection for this process evaluation effort. This includes the titles, role, and sample sizes for data collection.

Table 6-7: BHE LIPP Data Collection Summary

Target	Component	Activity	n	Precision Met	Role
BHE Program Staff	Manager of Energy Efficiency	Interview	1	NA	Overall administration of BHE EE programs. This manager is involved in the larger strategic decisions associated with the EE portfolio and is involved with the LIPP and in the overall coordination of utility resources.
CLEAResult Staff	Program Manager	Interview	1	NA	Handles day-to-day operations, application review, billing, and logistics.
Participants	Participants	Survey	20	-	The Evaluators conducted a multi-utility survey of BHE, SUA, and AOG participants. The cross-cutting results are presented in this chapter. The survey encompassed multiple utilities due to the small participant population available for individual utilities.

6.3.5 Program Theory & Design

LIPP was created in response to Act 1102 and targets low income BHE customers. The program follows the design of RSP HES Pathway and includes enhanced health and safety measures.

6.3.5.1 Program Administration

The LIPP is overseen by the Manager of Energy Efficiency at BHE. This manager’s responsibilities primarily include interfacing with CLEAResult, who directly implements the program. Other activities by this manager include providing updated customer lists to CLEAResult to better facilitate their implementation, participation in outreach events, and at times assisting CLEAResult in customer interactions.

For CLEAResult, the roles and responsibilities of program staff are as follows:

- **Program Manager.** The Program Manager oversees day-to-day activities, supervises program staff, and handles complaints from customers or contractors.
- **Program Coordinator/Specialist.** This staff member coordinates tracking data, develops samples for quality assurance inspection, and supports reporting and invoicing requirements.
- **QA Verification Specialist.** The QA Verification Specialist conducts post inspections and communicates inspection results to contractors.

6.3.5.2 Program Implementation & Delivery

The key components of LIPP implementation are as follows:

- **Customer verification:** Potential customers interested in the program are confirmed as a BHE customer by program staff.
- **A comprehensive assessment of the customer's home:** Once the customer is prequalified by the contractor as residing in a home that fits the program requirements, the contractor schedules a comprehensive audit of the home and develop a recommended action plan of weatherization upgrades for the participant.
- **Direct installation of immediate energy savings measures:** While performing the comprehensive audit, the contractor installs energy efficient measures throughout the home, including low-flow aerators and showerheads.
- **Installation of a set of weatherization and H&S measures:** The contractor and customer will decide on what upgrades will be undertaken for the home. Based on review of the plan, the customer and contractor will develop an installation plan, and upgrades.

6.3.5.3 Marketing

CLEAResult is the implementer for the LIPP and oversees marketing efforts. In PY2022, LIPP marketing was largely confined to customer referral based on eligibility assessment.

6.3.5.4 Quality Assurance

In the HES Pathway, staff at CLEAResult conducts post inspections at a minimum of 10% of the projects completed by each trade ally. For the LIPP, QA inspections were performed at 50% of PY2022 projects.

6.3.6 Protocol A Database Review

The CLEAResult tracking system contained full detail with project addresses, contact information, and measure inputs. Further, the tracking system provided the therms savings for each line item.

During PY2022, the Evaluators received monthly tracking data updates as well as final tracking exports. The tracking system was updated quarterly include necessary inputs as per TRM V9.0. Protocol A of the TRM specifies that tracking data should be checked for:

- Participating Customer Information;
- Measure Specific Information;
- Vendor Specific Information;
- Program Tracking Information;
- Program Costs; and
- Marketing & Outreach Activities.

The Evaluators conducted a review of each of the above factors within PY2022 tracking data except for marketing and outreach activities as these are outside the scope of the tracking system's reporting.

6.3.6.1.1 Customer, Premise, Cost, and Vendor Information

Each of these factors was assessed individually based on the guidelines stated in TRM V9.0. Overall, the Evaluators conclude the following regarding tracking data completeness:

- Participating customer information was nearly complete for all participants. This included telephone numbers, addresses, full names, and utility account numbers for BHE. LIPP tracking was missing project record numbers ("PRJs" in CLEAResult's tracking for other programs).
- All participant records included the name of the installation contractor who performed the implementation as well as the invoice date and weatherization date.
- Tracking data included the measure and project costs for each home.
- Tracking data included the weather zone for each project.
- Heating type, cooling type, and ceiling square footage were present for all participants where appropriate and needed.

6.3.6.1.2 Measure Specific Information

The content of tracking data was found to include sufficient information for all measures in PY2021. All data fields needed to recreate TRM V9.0 calculations were present.

The tracking data delineated between energy saving versus health and safety measures by denoting the latter with an "H&S" prefix.

6.3.7 Health and Safety Measures

Act 1102 specifies required spending on health and safety improvement in LIPP homes. The LIPP had the following H&S measures:

- Air Purifier
- Air Cyclor Fan Controller
- CO Detector
- New Bath Fan with Venting to Outside
- Venting for Existing Bath Fan
- Plumbing Services
- Electrical Services
- Smoke Detector

Figure 6-5 summarizes H&S measure spending and percent of homes receiving each measure.

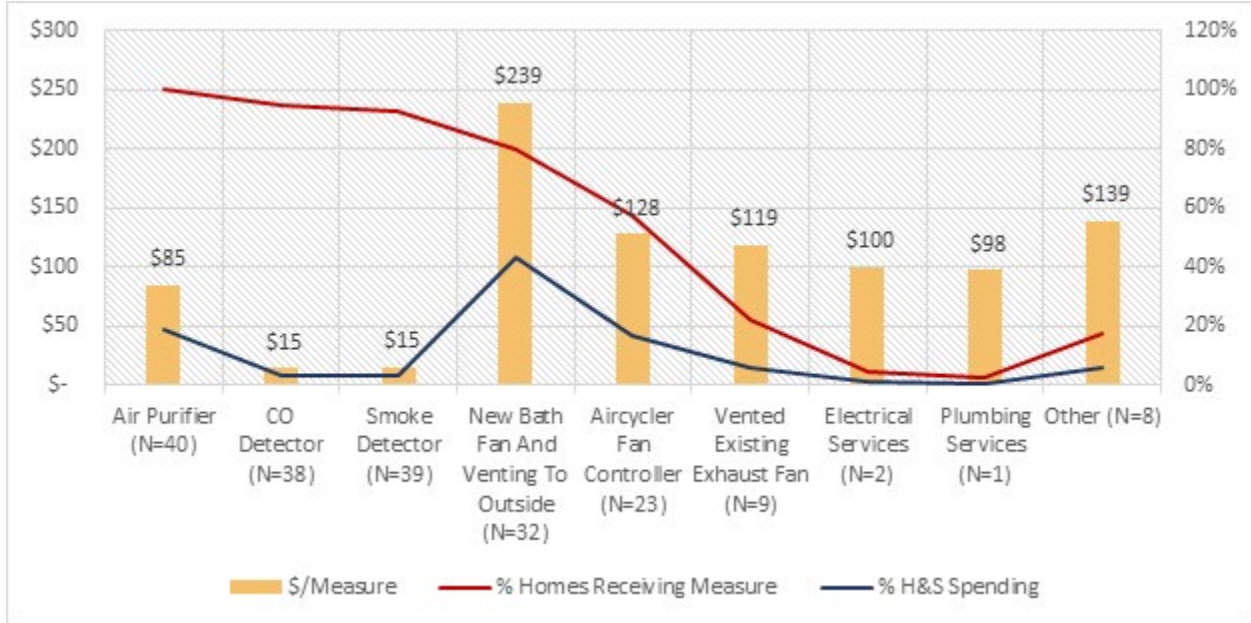


Figure 6-5: Summary of H&S Measure Spending

6.3.8 LIPP Survey Responses

The Evaluators surveyed 20 participants across three Arkansas gas-utility low-income weatherization programs (Table 6-8). These surveys sought to collect data on participant experience with the program including sources of program awareness, motivations for participating, and satisfaction with the program. Furthermore, the evaluators collected demographic information on the respondents during the survey.

Table 6-8: Respondents by Utility (n=20)

	Respondents
Arkansas Oklahoma Gas	2
Black Hills Energy	7
Summit Utilities Arkansas	11

Respondents were more limited than observed in prior years. Due to the small number of responses, evaluators have combined all three utilities’ respondents into one summary.

6.3.8.1 Respondent Profile

The majority of respondents own their home (90.0%, n=18), and over half of respondents live with one to two other people (55.0%, n=11). Eighty percent of respondents were at least 35 years old (n=16), and just over half worked or attended school (55.5%, n=11).

6.3.8.2 Program Awareness

Respondents learned about the program through indirect outreach avenues (60.0%, n=12) and direct outreach avenues (35.0%, n=7) (Figure 6-6).

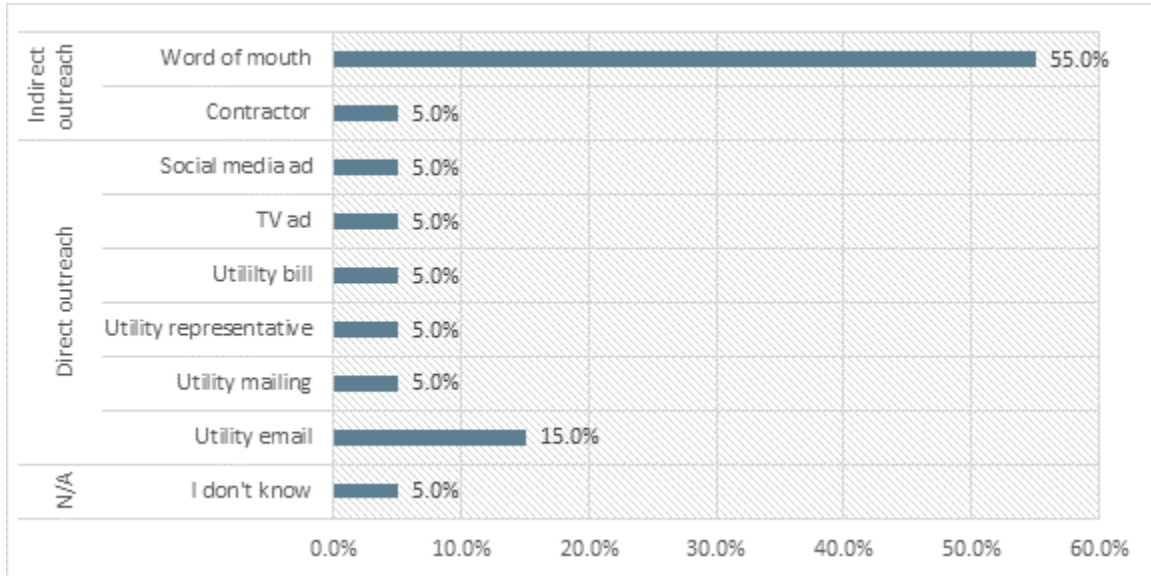


Figure 6-6: Program Awareness (n=20)

Three-quarters of respondents (n=15) were interested in participating in the program to save money on utility bills (Figure 6-7) and just under two-thirds of respondents make improvements to their home to increase the efficiency of their equipment in order to save energy (65.0%, n=13) (Figure 6-8).

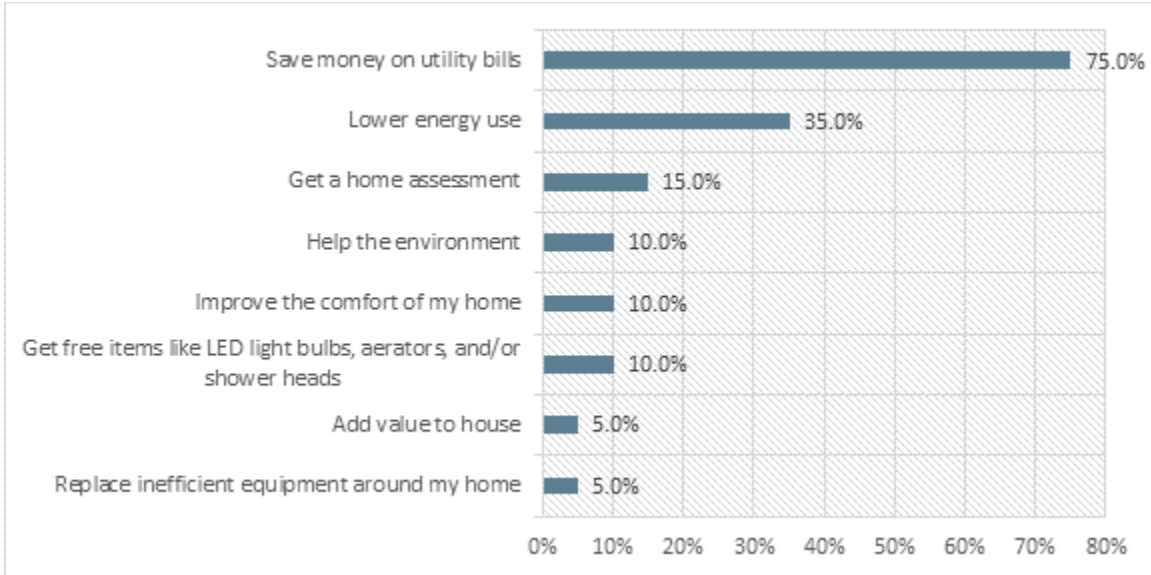


Figure 6-7: Participation Motivation (n=20)

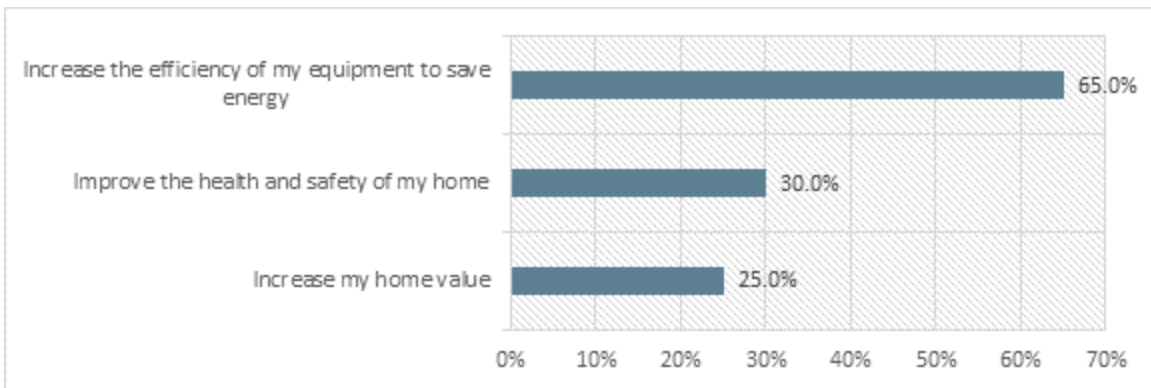


Figure 6-8: Home Improvement Motivations (n=20)

6.3.8.3 Home Energy Assessment

The majority of respondents remember receiving a home energy assessment as part of their participation in the program (80.0%, n=16). Among the respondents who remember receiving a home energy assessment, just under two-thirds were interested in the assessment to save energy to save money (64.3%, n=9) (Figure 6-8).

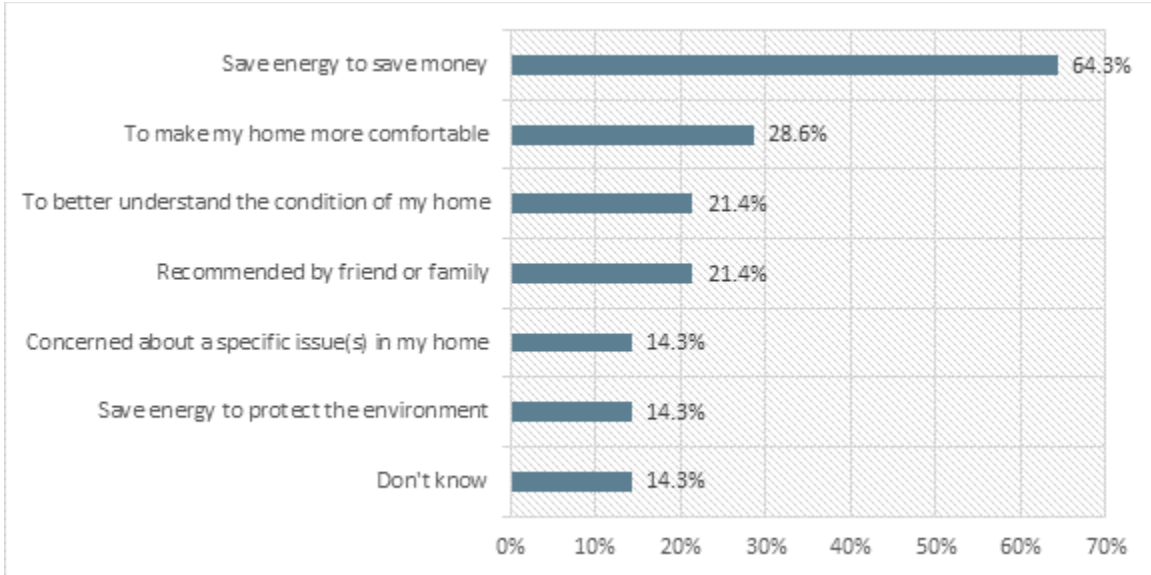


Figure 6-9: Home Energy Assessment Motivation (n=14)

All but one of the respondents who were home for the energy assessment indicated the assessment occurred in-person (n=14) and almost all of them noted that the assessor discussed the assessment findings with them (86.7%, n=14). Just under three-quarters of respondents who were home for the assessment noted they received an energy report with recommendations following the assessment (73.3%, n=11); Two respondents (13.3%) indicated there were recommendations in their assessment report that they did not act on; both of them indicated they did not replace the shower head.

Respondents were pleased with the home energy assessment (Figure 6-9) and found the information provided in to be useful (Figure 6-10).

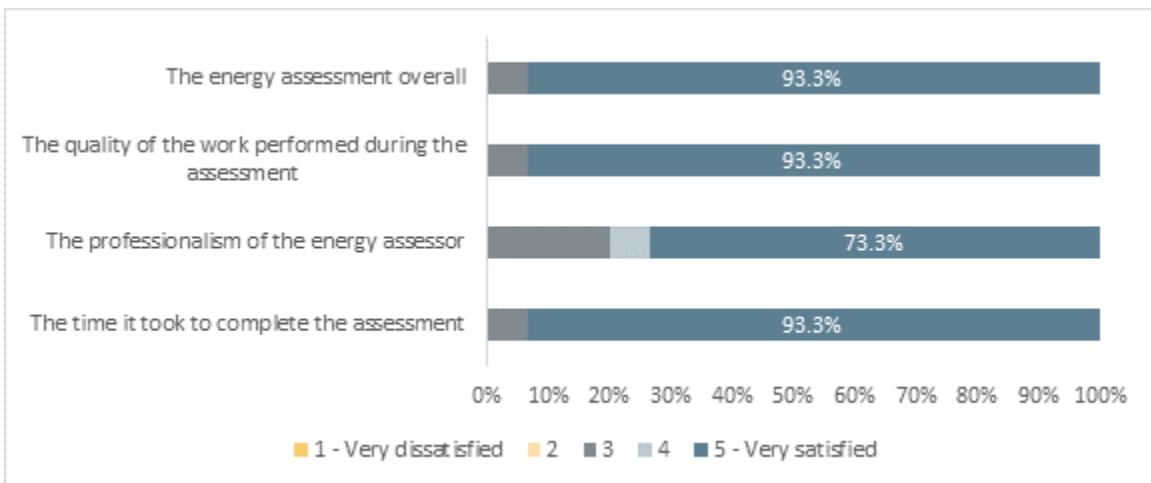


Figure 6-10: Home Energy Assessment Satisfaction (n=15)

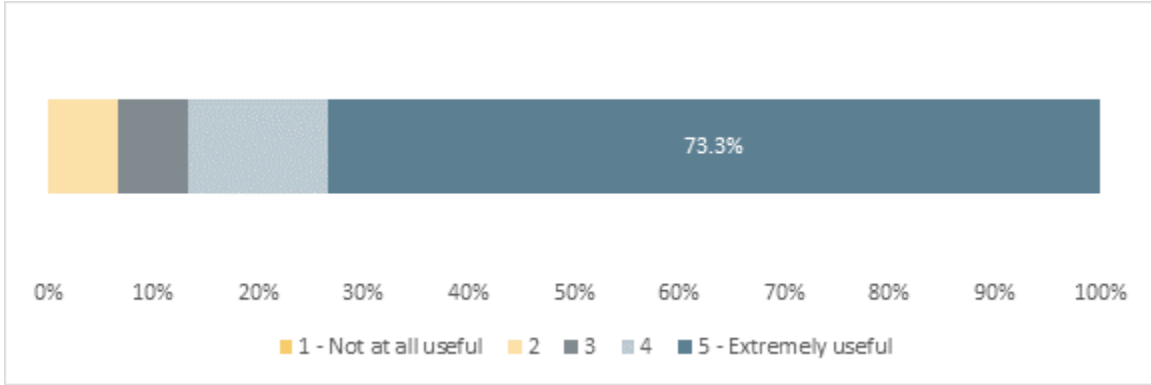


Figure 6-11: Home Energy Assessment Usefulness (n=15)

6.3.8.4 Program Participation

One-third of respondents completed the program application themselves (35.3%, n=6); some of these respondents found the application difficult to complete (66.6%, n=4). Respondents found their contractor through past experience (n=4), utility recommendation (n=3), and word of mouth (n=2).

Just under two-thirds of respondents have noticed a decrease in their energy bill since their participation in the program (Figure 6-11). Twenty percent of respondents have noticed benefits of the energy efficient equipment installed (n=4). Some respondents (n=4) reached out to the utility staff for assistance or questions while participating in the program.

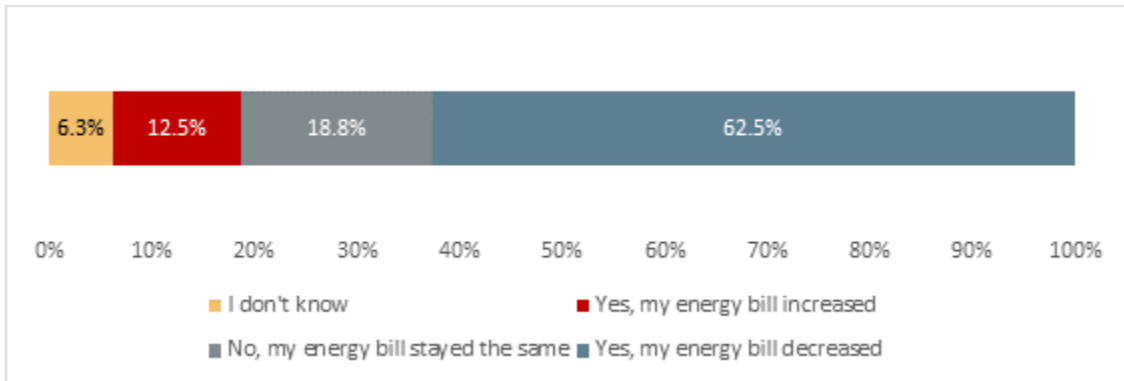


Figure 6-12: Changes in Energy Bill (n=16)

Since participating in the program, one respondent indicated they have installed additional energy efficient items in their home.

6.3.8.5 Program Satisfaction

Respondents were generally satisfied with the program (Figure 6-12) and 80.0% of respondents have recommended the program to other people (n=16). One-quarter of respondents indicated

that participating in the program increased their satisfaction with the utility as their energy provider (n=41).

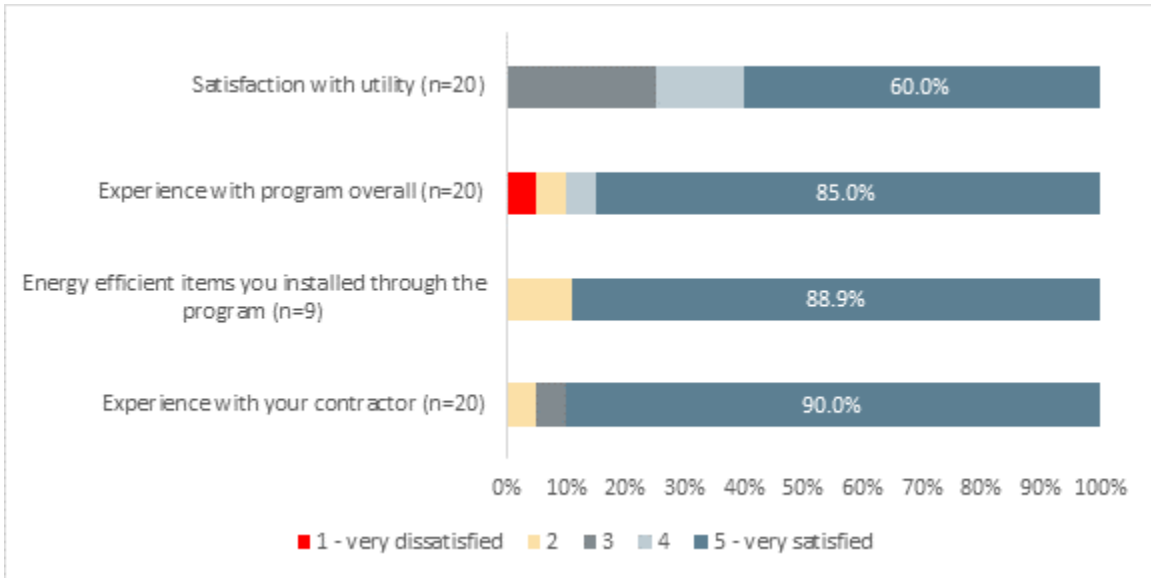


Figure 6-13: Program Satisfaction (n varies)

6.3.9 Measure Offerings

The Evaluators benchmarked BHE’s LIWP program offerings with other measures on the following categories:

- 1) Deemed savings supported in AR TRM
- 2) Implemented by other AR utilities
- 3) Potential cost-effectiveness

The measure summaries are as follows:

- **Floor Insulation**

Floor insulation is not installed as part of any utilities’ CWA or LIWP. It is included in supplementary programs for market-rate housing administered by OG&E and SWEPCO, installed with customer co-pay.

For Zone 9, floor insulation produces a net present value of \$.51 per square foot in gas benefits. The program currently pays an average of \$.43 per square foot for ceiling insulation, which is in most instances easier to install than floor insulation. As such, this measure is unlikely to be cost-effective.

Recommendation: Investigate the feasibility of this measure with CLEAResult and program Trade Allies.

- **Wall Insulation**

Wall insulation is not installed as part of any utilities’ CWA or LIWP. It is included in supplementary programs for market-rate housing administered by OG&E and SWEPCO, installed with customer co-pay.

For Zone 9, this measure produces a net present value of \$2.31 per square foot in gas benefits when adding R-13 wall insulation. The program currently pays an average of \$.51 per square foot for ceiling insulation, though ceiling insulation is a simpler installation.

Recommendation: Investigate the feasibility of this measure with CLEAResult and program Trade Allies.

- **Low-E Storm Windows**

This is a newer measure in the AR TRM and has not to-date been implemented by the AR gas utilities. The Evaluators screened the measure based on weighted-average baseline of single-pane and dual-pane preexisting window for aluminum and wood frames. The NPV natural gas benefits per square foot is:

- Aluminum frame: \$.66
- Wood frame: \$.44

The Illinois TRM V.10 specifies an installed cost of \$37.50 per square foot. Though this measure would obtain more benefits from kWh and kW NEBs, it is unlikely to meet cost-effectiveness.

Recommendation: reject measure

6.4 LIPP Impact Evaluation

The evaluation effort of the LIPP included the following:

- *Desk Review of Residential Calculations.* The Evaluators utilized TRM V9.0 values in assessing savings from measures included in the program.

6.4.1 Tracking Review

The impact evaluation began with a review of program tracking data, which included a separate row for each measure installed. Table 6-8 summarizes ex ante savings by measure for the LIPP.

Table 6-9: LIPP Ex Ante Summary

<i>Measure</i>	<i>Ex Ante Therms</i>
Duct Sealing	17,330
Ceiling Insulation	7,447
Air Sealing	3,523
Smart Thermostat	2,094
Total	30,393

The tracking data provided measured values for duct pressurization testing and blower door tests, allowing for the recreation of ex ante calculations based on leakage reduction. Ceiling insulation included an indicator for baseline R-value. Program specifications are to bring the home’s insulation level up to R-38. The maximum allowed baseline insulation in the program is R-15. The TRM V9.0 allows for up to a minimum of R-22 but the program allows a max of R-15 due to cost-effectiveness issues with preexisting insulation above that level.

- First, the program tracking database was reviewed to determine the scope of the program and to ensure there were no duplicate project entries.
- Next, a detailed desk review was conducted for a census of projects in the tracking system. The desk review process entails recalculation of therms and non-energy benefits for each measure and for each participant.
- Field verification rates from the HES pathway were applied to the LIPP.

After determining the ex post savings impacts for each sampled project, the ex post savings were combined with the ex-ante savings from the projects not included in the sample to determine program level savings

6.4.2 Net Savings Estimates

The Evaluators assigned a NTG of 100% to the LIPP, keeping with industry best practices for low income weatherization programs as specified in the Department of Energy Uniform Methods Project¹⁸.

6.4.3 Ex Post Savings

Table 6-9 presents the gross savings results of the evaluation of the PY2022 LIPP. Total Gross Savings summarizes the savings calculations performed by TRM protocols for program measures.

Table 6-10: LIPP Ex Post Savings Summary

<i>Measure</i>	<i>Ex Ante Therms</i>	<i>Ex Post Therms</i>	<i>Gross Realization Rate</i>	<i>EUL</i>	<i>Lifetime Therms</i>
Duct Sealing	17,330	17,833	102.9%	18	320,986
Ceiling Insulation	7,447	7,697	103.4%	20	153,941
Air Sealing	3,523	3,875	110.0%	11	42,622
Smart Thermostat	2,094	2,294	109.6%	11	25,229
Total	30,393	31,698	104.3%	17.12	542,778

¹⁸ https://www.energy.gov/sites/prod/files/2015/02/f19/UMPChapter23-estimating-net-savings_0.pdf

With a 100% NTGR due to the income requirements of the program, net impacts equal gross impacts.

6.4.3.1 Water & Electric NEBs

In PY2022, the LIPP had 100% overlap with SWEPCO. As a result, all homes received electric utility co-funding and there are no claimable kWh or kW NEBs for BHE. Further, no showerheads or faucet aerators were installed in PY2022 so there are no water NEBs.

6.5 Conclusions

<p>The program met savings goals and was highly cost-effective.</p>	<p>Savings increased by 25.8% from PY2021 to PY2022, after having already increased by 15.8% from PY2020 to PY2021.</p>
<p>Survey respondents indicated high satisfaction.</p>	<p>Respondents noted high satisfaction across all categories, including 85% reporting being “very satisfied” with the program overall.</p>
<p>The program successfully completed comprehensive H&S retrofits with thorough documentation, meeting all Act 1102 requirements.</p>	<p>The LIPP spent \$449 per home on H&S retrofits, and thoroughly documented the equipment installed. In response to PY2021 recommendations, BHE formalized categories for electric and plumbing repair.</p>

6.6 Recommendations

<p>Screen additional weatherization measures for joint cost-effectiveness with the current program bundle.</p>	<p>Wall and floor insulation are potentially cost-effective for the program and should be screened for potential inclusion for the next program cycle.</p>
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7 Appendix A: Site Reports

This appendix contains the individual site reports for CISP.

Program C&I Solutions
Facility SIC Code 8062 General Medical and Surgical Hospitals
Measures Condensate Return

Project Background

The participant is a hospital that received incentives from Black Hills Energy for implementing the following energy efficient conservation measure (ECM):

- ECM #1 – Condensate Return

Savings come from reducing the amount of makeup water needed for the boiler by replacing a portion of makeup water with returned condensate. The condensate is returned to a condensate return unit (CRU) instead of directly back into the system.

M&V Methodology

The M&V effort for this project follows the guidelines of the 2022 International Performance Measurement and Verification Protocol (IPMVP) Option A - Retrofit Isolation: Key Parameter Measurement.

Condensate Return

Measurement and verification activities are based on the following assumptions:

- Spot condensate flow reading representative of annual loss rate
- Condensate return temperature in CRU averaged 187°F
- Average condensate flow in system is 8 GPM
- Boiler efficiency rate is 81%
- Facility operates 50 weeks per year
- Annual hours of operation are 8,760 hours/year

The following table shows the parameters that were used for the energy savings calculations.

Condensate Return Parameters

<i>Boiler Efficiency</i>	<i>Condensate Flow Rate (GPM)</i>	<i>Condensate Temperature (°F)</i>	<i>Makeup Water Temperature (°F)</i>	<i>Pump Annual Hours of Operation</i>
81%	8	187	65.6	8,760

The heat loss from the condensate is estimated with the formula:

Calculation for Condensate Heat Loss

$$\frac{Btu}{hr} = \frac{1 Btu}{lb \times F} \times \frac{8.34 lb}{gal} \times \frac{60 min}{hr} \times \frac{gal}{min} \times (T_{makeup\ water} - T_{condensate})$$

Energy Savings
Condensate Return

The heat loss determined by the flow and temperature difference of the makeup water and condensate temperature is an input to the following equation to determine the boiler gas savings.

$$\frac{CCF}{year} = \frac{Heat\ Loss\ \left(\frac{BTU}{hr}\right) \times AOH}{Boiler\ efficiency\ (\%) \times 100,000 \frac{BTU}{CCF}}$$

Where:

- Heat Loss* = 363,274.02 BTU/hr
- AOH* = Annual Operation Hours (8,760 hours)
- Eff_{post}* = Efficiency of the steam boiler = 81.3%

Measure Life

Estimated Useful Life by Measure

<i>Measure</i>	<i>EUL</i>
Condensate Return	15 years

Calculated Savings:

Condensate Return

Condensate Return Savings

<i>Condensate Return</i>	<i>Annual operating hours</i>	<i>Make up water Temp(°F)</i>	<i>Condensate Temp(°F)</i>	<i>Heat Loss (Btu/hr)</i>	<i>Therms Savings</i>
CRU	8,760	65.6	187	363,274	34,392
Total:					34,392

Overall project savings are as follows:

Overall Project Savings

<i>Measure</i>	<i>Expected Annual therms Savings</i>	<i>Realized Annual therms Savings</i>	<i>Realization Rate</i>	<i>Annual Water Savings</i>	<i>Lifetime therms Savings</i>
Condensate Return	34,392	34,392	100%	1,376,700	515,880
TOTAL	34,392	34,392	100%	1,376,700	515,880

Measure Cost, Incentive, & Payback

The Evaluators reviewed the invoices associated with this project and verified a cost of \$32,000. Measure payback is summarized in the table below.

Cost, Incentive, and Payback

<i>Annual Therms Savings</i>	<i>Cost per Therm</i>	<i>Annual Energy Cost Savings</i>	<i>Incremental Cost</i>	<i>Base Incentive</i>	<i>Adjusted Incentive</i>	<i>Payback w/Incentive</i>	<i>Payback w/o Incentive</i>
34,392	\$0.49	\$16,852	\$32,000	\$7,937	\$7,937	1.29	1.89

Program	C&I Solutions
Facility SIC Code	8062 General Medical and Surgical Hospitals
Measures	Steam Trap Replacement Steam Leak Repairs Pipe Insulation

Project Background

The participant is a Medical Center that received incentives from Black Hills Energy for:

- ECM #1 - Steam leak repairs
- ECM #2 - Steam trap replacement
- ECM #3 – Pipe Insulation

The steam system serves the hospital’s typical systems, including space heat, sanitization, and laundry.

M&V Methodology

The M&V effort for this project follows the guidelines of the 2022 International Performance Measurement and Verification Protocol (IPMVP) Option A - Retrofit Isolation: Key Parameter Measurement.

Measurement and verification activities are based on the following assumptions:

- Supply water temperature is 66°F based on the AR TRM 9.0
- Annual operating hours for the site are 8,760 hours
- Combustion efficiency is 81.0% (for both pre-retrofit and post-retrofit condition)

Steam Leak Repairs

An alternative method was used to calculate the steam loss before steam leak repairs. The more traditional method equates the orifice diameter flow rate, using the orifice diameter of the leak and the system’s absolute pressure. Due to the difficulty in determining the exact diameter of an orifice leak, the alternate method was used. Calculations follow the methods established by G.G. Rajan for a steam leak rate as a function of the length of an active steam plume.

Equating Steam Plume Length to Flow Rate

$$\text{Leak Rate} \left(\frac{kg}{hr} \right) = 2.5678 \times \exp[1.845 \times \text{Plume Length (m)}]$$

$$Leak\ Rate\ \left(\frac{lb}{hr}\right) = 5.661 \times \exp [0.562 \times Plume\ Length\ (ft)]$$

Equation 1. Calculation for Heat Loss

$$Heat\ Loss\ \left(\frac{Btu}{hr}\right) = Leak\ Rate\ \left(\frac{lb}{hr}\right) \times \left[Steam\ Enthalpy\ \left(\frac{Btu}{lb}\right) - MW\ Enthalpy\ \left(\frac{Btu}{lb}\right) \right]$$

Where:

Leak Rate = calculated value using the equation above

Steam Enthalpy = saturated steam region based on system steam pressure

MW Enthalpy = steam look up table based on makeup water temperature, derived from average temperature of water main in each zone (34.2 BTU/lb)

The following table shows relevant steam leak parameters required for annual energy savings calculations.

<i>Steam Leak #</i>	<i>Description</i>	<i>Quantity of Leaks</i>	<i>Plume Length (ft)</i>	<i>Steam Pressure (psig)</i>	<i>Leak Rate (lbs/hr)</i>	<i>Boiler Efficiency</i>
1	Steam Leak	1	1	15	9.9	81%
2	Trap 108 Gate Valve	1	6	100	164.9	81%

Energy Savings

The annual energy savings from repairing a steam leak is calculated with the following equation:

Steam Leak Repair Annual Energy Savings

$$Annual\ Energy\ Savings\ (therms) = \frac{Heat\ Loss\ \left(\frac{Btu}{hr}\right) \times Annual\ Operating\ Hours\ \left(\frac{hrs}{yr}\right)}{Boiler\ Efficiency(\%) \times 100,000\ \frac{Btu}{therm}}$$

Where:

Annual Operating Hours = number of hours facility operates annually = 8,760 hours

Boiler Efficiency = 81.0%

100,000 Btu/CCF = conversion factor (BTU/yr to CCF/yr)

Steam Trap Replacement

The following table shows relevant failed steam traps parameters required for annual energy savings.

Steam Trap Parameters

Steam Trap #	Orifice Size (in.)	Inlet Pressure (psig)	Outlet Pressure (psig)	Service (Drip/Process)	Feedwater Temperature (°F)	Boiler Efficiency	Operating Hours
1	1/8	60	1	Drip	180	81%	8760
2	1/8	60	1	Drip	180	81%	8760
3	1/8	60	1	Drip	180	81%	8760
4	1/8	60	1	Drip	180	81%	8760
5	7/32	60	1	Drip	180	81%	8760
6	1/8	60	1	Drip	180	81%	8760
7	5/32	60	1	Drip	180	81%	8760
8	1/8	100	1	Drip	180	81%	8760
9	5/32	60	1	Drip	180	81%	8760
10	1/8	60	1	Drip	180	81%	8760
11	5/32	60	1	Drip	180	81%	8760
12	1/8	100	1	Drip	180	81%	8760
13	5/32	100	1	Drip	180	81%	8760
14	1/8	60	1	Drip	180	81%	8760
15	1/8	60	1	Drip	180	81%	8760
16	1/8	125	1	Drip	180	81%	8760
17	7/32	60	1	Drip	180	81%	8760

Calculations for the annual therms savings use the following equation:

$$\text{Annual therms Savings} = \frac{\text{Steam Trap Discharge Rate} \times \text{OpHrs} \times h_{fg}}{EC_{Base} \times \text{Therm Conversion Factor}}$$

Where:

Steam Trap Discharge Rate = steam loss from the system (lb/hr)

OpHrs = annual hours the system is pressurized (hrs/yr) = 8,760 annual hours

H_{fg} = latent heat of evaporation (BTU/lb) found in the table above

EC_{Base} = combustion efficiency of boiler (%), 81%

Therm Conversion Factor = 100,000 (BTU/therm)

The discharge rate (lb/hr) was calculated using Armstrong’s “Steam Loss Through Failed Trap Calculator” (found here: <https://www.armstronginternational.com/knowledge/resources-library/calculators/steam-loss>)

Pipe Insulation

Through this method, energy savings are calculated using key data and through the North American Insulation Manufacturers Association’s 3E Plus software:

(<http://www.pipeinsulation.org/>).

Measurement and verification activities are based on the following assumptions:

- Insulation thickness: 2 in
- Insulation material type: 850°F Min. Fiber Pipe and Tank, Type IIIB, C1393-14, 850°F Min. Fiber Blanket, Type IV, C55-13
- Process temperature is 195°-380°F
- The average annual ambient air temperature 91°F

The 3E Plus software was used to calculate heat loss (btu/hr/ft) for bare piping (pre-retrofit) and piping with 1.5-in insulation (post-retrofit). The software required these inputs: process temperature, ambient temperature, pipe size, base metal, insulation, and jacket material. Annual therms savings was calculated using the following equation:

Pipe Insulation Installation Annual Energy Savings

$$\text{Annual Therms Savings} = \frac{\text{Heat Loss} \left(\frac{\text{Btu}}{\text{hr}} \right) \times \text{Annual Operating Hours} \left(\frac{\text{hrs}}{\text{yr}} \right)}{\text{Boiler Efficiency} \times 100,000 \left(\frac{\text{BTU}}{\text{CCF}} \right)}$$

Where:

Annual Operating Hours = number of hours facility operates annually

Boiler Efficiency

100,000 Btu/CCF = conversion factor (BTU/yr to CCF/yr)

Water Savings

In addition to energy savings, water savings were calculated for the Steam Leak Repair ECM. These savings are considered as Non-Energy Benefits (NEBs).

Annual Energy Savings Unit Conversion (therms/year to BTU/year)

$$\text{Annual Energy Savings} \left(\frac{\text{Btu}}{\text{yr}} \right) = \text{Annual Energy Savings} \left(\frac{\text{therm}}{\text{yr}} \right) \times 100,000 \frac{\text{Btu}}{\text{therm}}$$

Equation 2. Calculation for Pounds of Steam Produced per Year

$$Steam_{Trap} \left(\frac{lb}{yr} \right) = \left(\frac{Annual\ Energy\ Savings\ (Btu)}{Steam\ Enthalpy\ \left(\frac{Btu}{lb} \right) - FW\ Enthalpy\ \left(\frac{Btu}{lb} \right)} \right) \times Eff_{Boiler}\ (%)$$

$$Steam_{Leak} \left(\frac{lb}{yr} \right) = \left(\frac{Annual\ Energy\ Savings\ (Btu)}{Steam\ Enthalpy\ \left(\frac{Btu}{lb} \right) - MW\ Enthalpy\ \left(\frac{Btu}{lb} \right)} \right) \times Eff_{Boiler}\ (%)$$

Equation 3. Annual Water Savings Calculation

$$Annual\ Water\ Savings\ \left(\frac{gal}{yr} \right) = \frac{Steam\ \left(\frac{lb}{yr} \right)}{8.33\ \left(\frac{lb}{gal} \right)}$$

Measure Life

Estimated Useful Life by Measure

<i>Measure</i>	<i>EUL</i>
Steam Leak Repairs	10 years
Steam Trap Replacement	5 years
Pipe Insulation	20 years

Calculated Savings:

Steam Leak Repairs

Steam Leak Repairs Savings

<i>Steam Leak #</i>	<i>Description</i>	<i>Quantity of Leaks</i>	<i>Plume Length (ft)</i>	<i>Steam Enthalpy (BTU/lb)</i>	<i>System Enthalpy (BTU/lb)</i>	<i>Therms Savings</i>
1	Steam Leak	1	1	1,164	1,131	1,216
2	Trap 108 Gate Valve	1	6	1,191	1,157	20,668
Total:						21,884

Steam Trap Replacement

. Steam Trap Replacement Savings

<i>Steam Trap #</i>	<i>Discharge Rate (lbs/hr)</i>	<i>Steam Enthalpy (BTU/lb)</i>	<i>Feedwater Enthalpy (BTU/lb)</i>	<i>Latent Heat of Evaporation, H_{fg} (BTU/lb)</i>	<i>Therms Savings</i>
1	31	1,182	148	970	3,473
2	31	1,182	148	970	3,473
3	31	1,182	148	970	3,473
4	31	1,182	148	970	3,473
5	95	1,182	148	970	10,643
6	95	1,182	148	970	10,643
7	48	1,182	148	970	5,377
8	48	1,182	148	970	5,420
9	31	1,182	148	970	3,473
10	31	1,182	148	970	3,473
11	31	1,182	148	970	3,473
12	48	1,182	148	970	5,420
13	75	1,182	148	970	8,469
14	31	1,182	148	970	3,473
15	31	1,182	148	970	3,473
16	58	1,182	148	970	6,571
17	95	1,182	148	970	10,643
Total:					94,442

Pipe Insulation

Pipe Insulation Annual Energy Savings

Entry #	Description	Pipe or Valve	Temperature (°F)	Pre Heat Loss	Post Heat Loss	Therms Savings
1	6" 300# GV	Valve or Fitting	326	1,164	107	819
2	4" 300# AV	Valve or Fitting	326	805	75	274
3	6" 300# flanges	Valve or Fitting	326	1,164	107	410
4	6" P/3	Pipe	326	1,164	107	343
5	6" x 4" REDUCER	Cylindrical Tank	326	640	49	59
6	3/4" P.5/GV/P3/	Valve or Fitting	243	117	18	59
7	1" 4WAY/P1/UN/P1	Valve or Fitting	243	147	19	90
8	1" UN/P.5/4WAY/P.1	Valve or Fitting	243	147	19	83
9	1" 4WAY/P.5/UN/P1	Valve or Fitting	243	147	19	83
10	LWCO Valve (8" T x 6" W x 6" D)	Rectangular Tank	243	351	28	52
11	LWCO Valve (8" T x 6" W x 6" D)	Rectangular Tank	243	351	28	52
12	1 1/4" TRR/P0.5/TRR/P1	Valve or Fitting	243	176	21	109
13	1 1/4" 4WAY/4WAY/P1/UN/P3/4WAY	Valve or Fitting	243	176	21	235
14	LR UR GAUGE 17" T x 7" W x 7" D	Rectangular Tank	243	351	28	110
15	1 1/4" 4WAY/UJI/P1	Valve or Fitting	243	176	21	101
16	1 1/4" P0.5/4WAY/P/TRR/P/UN/P3	Valve or Fitting	243	176	21	201
17	HAND HOLD 6" DIA	Valve or Fitting	243	641	62	899
18	LIFT LUGS (1 1/2" W x 13" L x 6" T)	Rectangular Tank	280	471	37	63
19	LIFT LUGS (1 1/2" W x 13" L x 6" T)	Rectangular Tank	280	471	37	63
20	3" PRV COUPLING	Valve or Fitting	280	469	47	306
21	MANWAY 18" x 15" DIA	Cylindrical Tank	280	471	37	393
22	WATSON PRV HD SERIES 3"	Valve or Fitting	280	460	46	300
23	6" x 150" Y-STRAINER BOTTOM	Valve or Fitting	280	842	80	591
24	1 1/2" GV/STR/UN/RL/P0.5	Valve or Fitting	254	213	26	234
25	LEVEL GAUGE (17" T x 7" W x 7" D)	Rectangular Tank	380	857	64	271
26	LWCO Valve (8" T x 6" W x 6" D)	Rectangular Tank	380	857	64	129
27	LWCO Valve (8" T x 6" W x 6" D)	Rectangular Tank	380	857	64	129
28	1" P0.5/4WAY/PUN/P1	Valve or Fitting	380	341	43	210
29	1" P0.5/4WAY/P0.5/UN/P2	Valve or Fitting	380	341	43	242
30	1" P0.5/4WAY/P0.5/TRR/P1/UN/P2/4WAY	Valve or Fitting	380	341	43	419
31	1" P1/4WAY/P/UN/P3	Valve or Fitting	380	341	43	306
32	LIFT LUGS (6" T x 5" L x 1" W)	Rectangular Tank	380	857	64	46
33	MANWAY 18" x 15" DIA	Cylindrical Tank	380	857	64	717
34	2" PRV COUPLINGS	Valve or Fitting	380	588	62	171
35	1" P/CAP	Valve or Fitting	380	341	43	89
36	2" P/CAP	Valve or Fitting	380	588	62	199
37	SIGHT GLASS MANWAY 22" DIA	Cylindrical Tank	343	698	53	409
38	1" EL/BV/STR	Valve or Fitting	220	126	17	80
39	1" UN/B	Valve or Fitting	220	126	17	53
40	1 1/2" P/TRR/BV	Valve or Fitting	220	176	21	138
41	1" P0.5/TRR/P/BV/P/STR/P	Valve or Fitting	220	126	17	104

42	1" P0.5/R1/P/BV/P/STR/P	Valve or Fitting	220	126	17	89
43	P/L/Water Head 9" Dia FLG x 3" x 15" FLG	Cylindrical Tank	220	309	25	44
44	3/4" PRV	Valve or Fitting	225	105	16	19
45	1" STR/P0.5/TRR/P0.5/UH/P3	Valve or Fitting	225	145	19	146
46	1" Control Valve	Valve or Fitting	225	145	19	31
47	1" P0.5/1" x 2" RED/GV	Valve or Fitting	225	145	19	68
48	2" UN/P/R2/P	Valve or Fitting	225	248	28	191
49	HEAT EXCH HEAD 10" DIA	Cylindrical Tank	213	319	26	43
50	HEAT-EXCH 6" DIA x 23" LONG	Cylindrical Tank	213	319	26	108
51	1" UN/TRR/P/CAP	Valve or Fitting	213	131	17	89
52	1" P1/RL/P	Valve or Fitting	213	131	17	46
53	1" x 1 1/2" RED TRR	Valve or Fitting	213	131	17	28
54	1 1/2" RL/P	Valve or Fitting	213	182	22	65
55	3/4" GV/BV	Valve or Fitting	213	107	16	39
56	3/4" P0.5/UN/P0.5/TRST VLV	Valve or Fitting	213	107	16	49
57	PK Heater HRADS (12" DIA FLG x 3 1/4" FLG)	Cylindrical Tank	254	369	30	89
58	1 1/4" 150# SIEMENS Control Vlv	Valve or Fitting	254	188	22	45
59	1" EL/BV/STR/RL/RL	Valve or Fitting	254	150	20	158
60	1" RL/BV/STR/UN/RL	Valve or Fitting	254	150	20	158
61	1" UN/CK/BV	Valve or Fitting	254	150	20	95
62	1" STR/UN	Valve or Fitting	254	150	20	63
63	2" P2/BV/UN	Valve or Fitting	320	438	47	339
64	2" P3.5/RL	Valve or Fitting	320	438	47	275
65	2" P2	Pipe	320	438	47	85
66	2" 300# FLANGES	Valve or Fitting	320	438	47	127
67	2" TRR/P3/TRR	Valve or Fitting	320	438	47	381
68	2" P1/300# FLANGES	Valve or Fitting	320	438	47	169
69	2" P0.5/UN/P2/FL	Valve or Fitting	295	374	40	307
70	2" Gate Valve	Valve or Fitting	295	374	40	109
71	3" TRR/RL/TRR/CAP	Valve or Fitting	295	538	53	703
72	7" GV/P/BV/P	Valve or Fitting	295	1,126	100	948
73	4" 300# Gate Valve	Valve or Fitting	270	579	55	197
74	1 1/2" RL/P2/UN/P0.5/RL/P	Valve or Fitting	235	197	24	211
75	1 1/2" SARCO Control Valve	Valve or Fitting	235	197	24	52
76	1 1/2" UN/ON	Valve or Fitting	235	197	24	103
77	9" 150# DIA FLG x 3" 150# FLG H/EXCH HEAD	Cylindrical Tank	235	347	28	51
78	1 1/2" x 1" SWAGE RRD/BV/STR/RL/UN/RL	Valve or Fitting	235	197	24	310
79	1" CK/BV/BL/TRR	Valve or Fitting	235	141	19	119
80	1" RL/RL/UR	Valve or Fitting	235	141	19	90
81	1 1/2" P0.5/TRR/P/CAP	Valve or Fitting	230	197	24	164
82	1" GV/BV	Valve or Fitting	230	141	19	60
83	2" P3	Pipe	260	268	30	78
84	1 1/2" RRD	Valve or Fitting	260	219	26	57
85	1 1/2" BV/STR/P/TRR/UN	Valve or Fitting	260	219	26	240
86	1 1/2" SHRLD Regulator	Valve or Fitting	260	219	26	57
87	1 1/2" UN/TRR/	Valve or Fitting	260	219	26	115

88	1" Globe Valve	Valve or Fitting	260	156	21	33
89	8" 300# Gate Vlv	Valve or Fitting	300	1,382	119	540
90	GRSTRA FPS-14 PUMP	Cylindrical Tank	195	229	19	657
91	3" 150# Gate Valve	Valve or Fitting	195	230	25	74
92	3" Elbow	Valve or Fitting	195	230	25	74
93	3" 150# FLG w/ CHRCK	Valve or Fitting	195	230	25	74
94	2" 150# FLG w/ CHRCK	Valve or Fitting	195	161	19	46
95	2" RL/P3/RL	Valve or Fitting	195	161	19	138
96	2" x 1 1/2" Bell RRD	Cylindrical Tank	195	229	19	2
97	1 1/2" P/RL/P0.5/RL/UN	Valve or Fitting	212	157	19	138
98	1" P0.5/UN/P5	Valve or Fitting	212	113	15	82
99	1/2" BV/UN/TRR/P/RL/P/UN/P	Valve or Fitting	235	94	15	77
100	1/2" RL/1/2"	Valve or Fitting	235	94	15	13
101	3/4" SWAGR	Valve or Fitting	235	114	17	21
102	3/4" RL/TRR/P0.5/UN	Valve or Fitting	203	84	13	50
					Total:	18,674

Overall project savings are as follows:

Overall Project Savings

<i>Measure</i>	<i>Expected Annual therms Savings</i>	<i>Realized Annual therms Savings</i>	<i>Realization Rate</i>	<i>Lifetime therms Savings</i>	<i>Annual Water Gallons Savings</i>	<i>Lifetime Water Gallons Savings</i>
Steam Leak Repair	21,884	21,884	100%	218,840	183,901	1,839,006
Steam Trap Replacement	94,442	94,442	100%	472,210	N/A	N/A
Pipe Insulation	18,674	18,674	100%	373,480	N/A	N/A
TOTAL	135,000	135,000	100%	1,064,530	183,901	1,839,006

Measure Cost, Incentive, & Payback

The Evaluators reviewed the invoices associated with this project and verified a cost of \$101,152. Measure payback is summarized in the table below.

Cost, Incentive, and Payback

<i>Annual Therms Savings</i>	<i>Cost per Therm</i>	<i>Annual Energy Cost Savings</i>	<i>Incremental Cost</i>	<i>Base Incentive</i>	<i>Adjusted Incentive</i>	<i>Payback w/Incentive</i>	<i>Payback w/o Incentive</i>
135,000	\$0.490	\$66,150	\$101,152	\$101,250	\$101,250	0.6	1.529

Program	C&I Solutions
Facility SIC Code	8062 General Medical and Surgical Hospitals
Measures	Steam Trap Replacement Steam Leak Repairs Pipe Insulation

Project Background

The participant is a Medical Center that received incentives from Black Hills Energy for:

- ECM #1 - Steam leak repairs
- ECM #2 - Steam trap replacement
- ECM #3 – Pipe Insulation

The steam system serves the hospital’s typical systems, including space heat, sanitization, and laundry.

M&V Methodology

The M&V effort for this project follows the guidelines of the 2022 International Performance Measurement and Verification Protocol (IPMVP) Option A - Retrofit Isolation: Key Parameter Measurement.

Measurement and verification activities are based on the following assumptions:

- Supply water temperature is 65.60°F based on the AR TRM 9.0
- Annual operating hours for the site are 8,760 hours
- Combustion efficiency is 83% (for both pre-retrofit and post-retrofit condition)

Steam Leak Repairs

An alternative method was used to calculate the steam loss before steam leak repairs. The more traditional method equates the orifice diameter flow rate, using the orifice diameter of the leak and the system’s absolute pressure. Due to the difficulty in determining the exact diameter of an orifice leak, the alternate method was used. Calculations follow the methods established by G.G. Rajan for a steam leak rate as a function of the length of an active steam plume.

Equating Steam Plume Length to Flow Rate

$$\text{Leak Rate} \left(\frac{kg}{hr} \right) = 2.5678 \times \exp[1.845 \times \text{Plume Length (m)}]$$

$$Leak\ Rate\ \left(\frac{lb}{hr}\right) = 5.661 \times \exp [0.562 \times Plume\ Length\ (ft)]$$

Calculation for Heat Loss

$$Heat\ Loss\ \left(\frac{Btu}{hr}\right) = Leak\ Rate\ \left(\frac{lb}{hr}\right) \times \left[Steam\ Enthalpy\ \left(\frac{Btu}{lb}\right) - MW\ Enthalpy\ \left(\frac{Btu}{lb}\right) \right]$$

Where:

Leak Rate = calculated value using the equation above

Steam Enthalpy = saturated steam region based on system steam pressure

MW Enthalpy = steam look up table based on makeup water temperature, derived from average temperature of water main in each zone (34.2 BTU/lb)

The following table shows relevant steam leak parameters required for annual energy savings calculations.

<i>Steam Leak #</i>	<i>Description</i>	<i>Quantity of Leaks</i>	<i>Plume Length (ft)</i>	<i>Steam Pressure (psig)</i>	<i>Leak Rate (lbs/hr)</i>	<i>Boiler Efficiency</i>
1	Trap #47	1	1	60	9.93	83%
2	Trap #46	1	1	60	9.93	83%
3	Trap #62	1	1	60	9.93	83%
4	Trap #67	1	2	60	17.42	83%
5	Trap #112	1	1	15	9.93	83%
6	Trap #136	1	3	60	30.56	83%
7	4in Flange	1	1	60	9.93	83%
8	Union leak on roof	1	5	15	94.03	83%
9	Trap 96 north penthouse surgery	1	6	15	164.94	83%

Energy Savings

The annual energy savings from repairing a steam leak is calculated with the following equation:

Equation 4. Steam Leak Repair Annual Energy Savings

$$Annual\ Energy\ Savings\ (therms) = \frac{Heat\ Loss\ \left(\frac{Btu}{hr}\right) \times Annual\ Operating\ Hours\ \left(\frac{hrs}{yr}\right)}{Boiler\ Efficiency(\%) \times 100,000 \frac{Btu}{therm}}$$

Where:

Annual Operating Hours = number of hours facility operates annually = 8,760 hours

Boiler Efficiency = 83%

100,000 Btu/CCF = conversion factor (BTU/yr to CCF/yr)

Steam Trap Replacement

The following table shows relevant failed steam traps parameters required for annual energy savings.

Steam Trap Parameters

<i>Steam Trap #</i>	<i>Inlet Pressure (psig)</i>	<i>Feedwater Temperature (°F)</i>	<i>Boiler Efficiency</i>	<i>Operating Hours</i>
1	60	148	83%	8,760
2	60	148	83%	8,760
3	60	148	83%	8,760
4	60	148	83%	8,760
5	60	148	83%	8,760
6	60	148	83%	8,760
7	60	148	83%	8,760
8	60	148	83%	8,760
9	15	148	83%	8,760
10	15	148	83%	8,760
11	15	148	83%	8,760
12	15	148	83%	8,760
13	15	148	83%	8,760
14	60	148	83%	8,760

Calculations for the annual therms savings use the following equation:

$$\text{Annual therms Savings} = \frac{\text{Steam Trap Discharge Rate} \times \text{OpHrs} \times H_{fg}}{EC_{Base} \times \text{Therm Conversion Factor}}$$

Where:

Steam Trap Discharge Rate = steam loss from the system (lb/hr)

OpHrs = annual hours the system is pressurized (hrs/yr) = 8,760 annual hours

H_{fg} = latent heat of evaporation (BTU/lb) found in the table above

EC_{Base} = combustion efficiency of boiler (%), 83%

Therm Conversion Factor = 100,000 (BTU/therm)

The discharge rate (lb/hr) was calculated using Armstrong’s “Steam Loss Through Failed Trap Calculator” (found here: <https://www.armstronginternational.com/knowledge/resources-library/calculators/steam-loss>)

Pipe Insulation

Through this method, energy savings are calculated using key data and through the North American Insulation Manufacturers Association’s 3E Plus software:

(<http://www.pipeinsulation.org/>).

Measurement and verification activities are based on the following assumptions:

- Insulation thickness: 1.5 in
- Insulation material type: 850°F Min. Fiber Pipe and Tank, Type IIIB, C1393-14
- Process temperature is 307°F
- The average annual ambient air temperature 75°F

The 3E Plus software was used to calculate heat loss (btu/hr/ft) for bare piping (pre-retrofit) and piping with 1.5-in insulation (post-retrofit). The software required these inputs: process temperature, ambient temperature, pipe size, base metal, insulation, and jacket material. Annual therms savings was calculated using the following equation:

Equation 5. Pipe Insulation Installation Annual Energy Savings

$$\text{Annual Therms Savings} = \frac{\text{Heat Loss} \left(\frac{\text{Btu}}{\text{hr}} \right) \times \text{Annual Operating Hours} \left(\frac{\text{hrs}}{\text{yr}} \right)}{\text{Boiler Efficiency} \times 100,000 \left(\frac{\text{BTU}}{\text{CCF}} \right)}$$

Where:

Annual Operating Hours = number of hours facility operates annually

Boiler Efficiency

100,000 Btu/CCF = conversion factor (BTU/yr to CCF/yr)

Pipe/Valve Insulation Parameters

<i>Entry #</i>	<i>Description</i>	<i>Pipe or Valve</i>	<i>Quantity</i>	<i>Pipe Length / Valve Equivalent Length (ft)</i>	<i>Diameter (in)</i>
1	2" THRD 3 Fitting Assembly	Valve or Fitting	3	9	
2	1.25" THRD 3 Fitting Assembly	Valve or Fitting	3	7.5	
3	1.25" THRD 3 Fitting Assembly	Valve or Fitting	3	7.5	
4	6" Flange	Valve or Fitting	1	3.6	
5	1.5" THRD 3 Fitting Assembly	Valve or Fitting	3	8.3	
6	1" Union	Valve or Fitting	1	2.3	
7	1.5" Elbow	Valve or Fitting	1	2.8	
8	3" GV	Valve or Fitting	1	3.4	
9	2" Flange	Valve or Fitting	1	3	
10	2" Union	Valve or Fitting	1	3	
11	2" Elbow	Valve or Fitting	1	3	
12	2" THRD 3 Fitting Assembly	Valve or Fitting	3	9	
13	2" THRD 4 Fitting Assembly	Valve or Fitting	4	12	
14	3" Elbow	Valve or Fitting	1	3.4	
15	17" dia x 9" HX head	Cylindrical Tank		0.8	1.4
16	1.5" THRD 2 Fitting Assembly	Valve or Fitting	2	5.5	
17	1.5" Steam Trap	Valve or Fitting	1	2.8	
18	.5" THRD PRV	Valve or Fitting	1	1.5	
19	2" THRD 4 Fitting Assembly	Valve or Fitting	4	12	
20	4" Flange	Valve or Fitting	1	3.5	
21	3" reducer	Valve or Fitting	1	3.4	
22	1.5" Elbow	Valve or Fitting	1	2.8	
23	2" THRD 3 Fitting Assembly	Valve or Fitting	3	9.0	
24	2" THRD 4 Fitting Assembly	Valve or Fitting	4	12.0	
25	1" THRD 2 Fitting Assembly	Valve or Fitting	2	4.5	
26	4" pipe	Pipe		0	4
27	4" THRD 2 Fitting Assembly	Valve or Fitting	2	6.9	
28	4" THRD 3 Fitting Assembly	Valve or Fitting	3	10.4	
29	4" Elbow	Valve or Fitting	1	3.5	
30	6" Flange	Valve or Fitting	1	3.6	
31	4" Elbow	Valve or Fitting	1	3.5	
32	3" Pipe	Pipe		3	3
33	3" Flange	Valve or Fitting	1	3.4	
34	.75" THRD PRV	Valve or Fitting	1	2	
35	8" Flange	Valve or Fitting	1	4	
36	11" dia x 6" HX head	Cylindrical Tank		0.5	0.2
37	4" GV	Valve or Fitting	1	3.5	
38	2" GV	Valve or Fitting	1	3	
39	2" PRV	Valve or Fitting	1	3	
40	2" THRD 3 Fitting Assembly	Valve or Fitting	3	9	
41	3" GV	Valve or Fitting	1	3.4	

Water Savings

In addition to energy savings, water savings were calculated for ECM #1 and #2. These savings are considered as Non-Energy Benefits (NEBs).

Annual Energy Savings Unit Conversion (therms/year to BTU/year)

$$\text{Annual Energy Savings} \left(\frac{\text{Btu}}{\text{yr}} \right) = \text{Annual Energy Savings} \left(\frac{\text{therm}}{\text{yr}} \right) \times 100,000 \frac{\text{Btu}}{\text{therm}}$$

Equation 6. Calculation for Pounds of Steam Produced per Year

$$\text{Steam}_{\text{Trap}} \left(\frac{\text{lb}}{\text{yr}} \right) = \left(\frac{\text{Annual Energy Savings (Btu)}}{\text{Steam Enthalpy} \left(\frac{\text{Btu}}{\text{lb}} \right) - \text{FW Enthalpy} \left(\frac{\text{Btu}}{\text{lb}} \right)} \right) \times \text{Eff}_{\text{Boiler}} (\%)$$

$$\text{Steam}_{\text{Leak}} \left(\frac{\text{lb}}{\text{yr}} \right) = \left(\frac{\text{Annual Energy Savings (Btu)}}{\text{Steam Enthalpy} \left(\frac{\text{Btu}}{\text{lb}} \right) - \text{MW Enthalpy} \left(\frac{\text{Btu}}{\text{lb}} \right)} \right) \times \text{Eff}_{\text{Boiler}} (\%)$$

Equation 7. Annual Water Savings Calculation

$$\text{Annual Water Savings} \left(\frac{\text{gal}}{\text{yr}} \right) = \frac{\text{Steam} \left(\frac{\text{lb}}{\text{yr}} \right)}{8.33 \left(\frac{\text{lb}}{\text{gal}} \right)}$$

Measure Life

Table 11. Estimated Useful Life by Respective Measure

<i>Measure</i>	<i>EUL</i>
Steam Leak Repairs	10 years
Steam Trap Replacement	5 years
Pipe Insulation	20 years

Calculated Savings:

Steam Leak Repairs

Steam Leak Repairs Savings

<i>Steam Leak #</i>	<i>Description</i>	<i>Quantity of Leaks</i>	<i>Plume Length (ft)</i>	<i>Steam Enthalpy (BTU/lb)</i>	<i>System Enthalpy (BTU/lb)</i>	<i>Therms Savings</i>
1	Trap #47	1	1	1,182	1,149	1,204
2	Trap #46	1	1	1,182	1,149	1,204
3	Trap #62	1	1	1,182	1,149	1,204
4	Trap #67	1	2	1,182	1,149	2,112
5	Trap #112	1	1	1,182	1,149	1,185
6	Trap #136	1	3	1,182	1,149	3,705
7	4in Flange	1	1	1,182	1,149	1,204
8	Union leak on roof	1	5	1,182	1,149	11,221
9	Trap 96 north penthouse surgery	1	6	1,182	1,149	19,684
Total:						42,723

Steam Trap Replacement

Steam Trap Replacement Savings

Steam Trap #	Discharge Rate (lbs/hr)	Steam Enthalpy (BTU/lb)	Feedwater Enthalpy (BTU/lb)	Therms Savings
1	80.0	1,182	148	9,699
2	80.0	1,182	148	5,819
3	80.0	1,182	148	4,850
4	48.0	1,182	148	2,620
5	31.0	1,182	148	2,538
6	39.0	1,182	148	3,406
7	31.0	1,182	148	2,369
8	17.0	1,182	148	1,485
9	31.0	1,182	148	1,995
10	48.0	1,182	148	2,574
11	27.0	1,182	148	2,317
12	31.0	1,182	148	3,325
13	7.0	1,182	148	526
14	12.0	1,182	148	393
			Total:	43,917

Pipe Insulation

Pipe Insulation Annual Energy Savings

Entry #	Description	Pipe or Valve	Temperature (°F)	Pre Heat Loss	Post Heat Loss	Therms Savings
1	2" THRD 3 Fitting Assembly	Valve or Fitting	307	419	75	327
2	1.25" THRD 3 Fitting Assembly	Valve or Fitting	307	302	63	188
3	1.25" THRD 3 Fitting Assembly	Valve or Fitting	307	302	63	188
4	6" Flange	Valve or Fitting	307	1103	181	349
5	1.5" THRD 3 Fitting Assembly	Valve or Fitting	307	341	64	241
6	1" Union	Valve or Fitting	307	244	49	46
7	1.5" Elbow	Valve or Fitting	307	341	64	80
8	3" GV	Valve or Fitting	307	602	102	177
9	2" Flange	Valve or Fitting	307	419	75	109
10	2" Union	Valve or Fitting	307	419	75	109
11	2" Elbow	Valve or Fitting	307	419	75	109
12	2" THRD 3 Fitting Assembly	Valve or Fitting	307	419	75	327
13	2" THRD 4 Fitting Assembly	Valve or Fitting	307	419	75	436
14	3" Elbow	Valve or Fitting	307	602	102	177
15	17" dia x 9" HX head	Cylindrical Tank	307	605	85	356
16	1.5" THRD 2 Fitting Assembly	Valve or Fitting	307	341	64	161
17	1.5" Steam Trap	Valve or Fitting	307	341	64	80
18	.5" THRD PRV	Valve or Fitting	307	164	40	20
19	2" THRD 4 Fitting Assembly	Valve or Fitting	307	419	75	436

20	4" Flange	Valve or Fitting	307	763	122	235
21	3" reducer	Valve or Fitting	307	602	102	177
22	1.5" Elbow	Valve or Fitting	307	341	64	80
23	2" THRD 3 Fitting Assembly	Valve or Fitting	307	419	75	327
24	2" THRD 4 Fitting Assembly	Valve or Fitting	307	419	75	436
25	1" THRD 2 Fitting Assembly	Valve or Fitting	307	244	49	92
26	4" pipe	Pipe	307	763	122	68
27	4" THRD 2 Fitting Assembly	Valve or Fitting	307	763	122	470
28	4" THRD 3 Fitting Assembly	Valve or Fitting	307	763	122	704
29	4" Elbow	Valve or Fitting	307	763	122	235
30	6" Flange	Valve or Fitting	307	1103	181	349
31	4" Elbow	Valve or Fitting	307	763	122	235
32	3" Pipe	Pipe	307	602	102	53
33	3" Flange	Valve or Fitting	307	602	102	177
34	.75" THRD PRV	Valve or Fitting	307	199	48	32
35	8" Flange	Valve or Fitting	307	1420	216	502
36	11" dia x 6" HX head	Cylindrical Tank	307	605	85	151
37	4" GV	Valve or Fitting	307	763	122	235
38	2" GV	Valve or Fitting	307	419	75	109
39	2" PRV	Valve or Fitting	307	419	75	109
40	2" THRD 3 Fitting Assembly	Valve or Fitting	307	419	75	327
41	3" GV	Valve or Fitting	307	602	102	177
					Total:	9,193

Overall project savings are as follows:

Overall Project Savings

<i>Measure</i>	<i>Expected Annual therms Savings</i>	<i>Realized Annual therms Savings</i>	<i>Realization Rate</i>	<i>Lifetime therms Savings</i>	<i>Annual Water Gallons Savings</i>	<i>Lifetime Water Gallons Savings</i>
Steam Leak Repair	42,723	42,723	100.0%	427,228	375,009	3,750,087
Steam Trap Replacement	43,917	43,917	100.0%	219,583	176,672	883,361
Pipe Insulation	9,193	9,193	100.0%	183,862	N/A	N/A
TOTAL	95,833	95,832	100.0%	830,673	551,681	4,633,448

Program C&I Solutions
Facility SIC Code 3052 – Rubber and Plastics Hose and Belting
Measures Steam Trap Replacement

Project Background

The participant is a large manufacturing facility that received incentives from Black Hills Energy AR for implementing the following:

- ECM #1: Steam trap replacement

The site uses steam throughout the facility primarily for three process needs: space heating, domestic water heating, and other process heating loads such as sterilization. Savings come from repairing the failed steam traps throughout the site's steam system.

M&V Methodology

The M&V effort for this project follows the guidelines of the 2022 International Performance Measurement and Verification Protocol (IPMVP) Option A - Retrofit Isolation: Key Parameter Measurement.

Measurement and verification activities are based on the following assumptions:

- Feedwater temperature is 200°F
- Annual operating hours for the on-site steam system are 8,440 hours
- Combustion efficiency is 82% (for both pre-retrofit and post-retrofit condition)

Steam Trap Replacement

The following table shows relevant failed steam traps parameters required for annual energy savings.

Steam Trap Parameters

Steam Trap #	Orifice Size (in.)	Inlet Pressure (psig)	Outlet Pressure (psig)	Service (Drip/Process)	Feedwater Temperature (°F)	Boiler Efficiency	Operating Hours
1	0.11	190	0	Drip	200	82%	8,440
2	0.18	190	0	Drip	200	82%	8,440
3	0.08	220	0	Drip	200	82%	8,440
4	0.44	190	0	Drip	200	82%	8,440
5	0.11	160	0	Drip	200	82%	8,440
6	0.11	190	0	Drip	200	82%	8,440
7	0.11	120	0	Drip	200	82%	8,440

Calculations for the annual therms savings use the following equation:

Steam Trap Replacement Annual Energy Savings

$$Annual\ therms\ Savings = \frac{Steam\ Trap\ Discharge\ Rate \times OpHrs \times h_{fg}}{EC_{Base} \times Therm\ Conversion\ Factor}$$

Where:

Steam Trap Discharge Rate = steam loss from the system (lb/hr)

OpHrs = annual hours system is pressurized (hrs/yr) = 8,440 annual hours

H_{fg} = latent heat of evaporation (BTU/lb)

EC_{Base} = combustion efficiency of boiler (%), 82%

Therm Conversion Factor = 100,000 (BTU/therm)

The discharge rate (lb/hr) was calculated using Armstrong’s “Steam Loss Through Failed Trap Calculator” (found here: <https://www.armstronginternational.com/knowledge/resources-library/calculators/steam-loss>)

Measure Life

Estimated Useful Life by Measure

Measure	EUL
Steam Trap Replacement	5 years

Calculated Savings:

Steam Trap Replacement

Steam Trap Replacement Savings

<i>Steam Trap #</i>	<i>Discharge Rate (lbs/hr)</i>	<i>Percent Failed</i>	<i>Steam Enthalpy (BTU/lb)</i>	<i>Feedwater Enthalpy (BTU/lb)</i>	<i>Latent Heat of Evaporation, H_{fg} (BTU/lb)</i>	<i>Therms Savings</i>
1	65	80%	1,199.80	168.13	1,032	5,508
2	192	80%	1,199.80	168.13	1,032	16,271
3	38	80%	1,201.50	168.13	1,033	3,226
4	1,047	80%	1,199.80	168.13	1,032	88,725
5	56	80%	1,197.50	168.13	1,029	4,735
6	65	80%	1,199.80	168.13	1,032	5,508
7	75	80%	1,193.30	168.13	1,025	6,316
Total:						130,289

Overall project savings are as follows:

Overall Project Savings

<i>Measure</i>	<i>Expected Annual therms Savings</i>	<i>Realized Annual therms Savings</i>	<i>Realization Rate</i>	<i>Lifetime therms Savings</i>	<i>Annual Water Gallons Savings</i>	<i>Lifetime Water Gallons Savings</i>
Steam Trap Replacement	130,289	130,289	100%	651,443	N/A	N/A
TOTAL	130,289	130,289	100%	651,443	N/A	N/A

Measure Cost, Incentive, & Payback

The Evaluators reviewed the invoices associated with this project and verified a cost of \$23,388. Measure payback is summarized in the table below.

Cost, Incentive, and Payback

<i>Annual Therms Savings</i>	<i>Cost per Therm</i>	<i>Annual Energy Cost Savings</i>	<i>Incremental Cost</i>	<i>Base Incentive</i>	<i>Adjusted Incentive</i>	<i>Payback w/Incentive</i>	<i>Payback w/o Incentive</i>
130,289	\$0.55	\$71,658	\$23,388	\$23,388	\$23,388	0.0	0.32

8 Appendix B: Deferred Replacement Cost Calculations

This appendix presents the calculations of deferred replacement costs for residential and commercial tankless water heaters as well as residential furnace early retirement.

Inputs		
Measure Type=	Res Tankless (ROB + NC)	
Nominal Discount Rate=	5.62%	
Inflation Rate=	2.04%	
Real Discount Rate=	3.5%	
	Program	Baseline
Equipment Type=	Tankless WH	Storage WH
Effective Useful Life=	20	11
Remaining Useful Life=		
PW(EUL)=	14.21	9.00
PW(RUL)=		
Installed Cost=	\$1,219	\$614
Deferred Replacement Cost=		\$ 355.33
PWF Formula=		\$ 355.33
Incremental Cost=	\$ 249.67	

Figure 8-1: Residential Tankless WH Avoided Replacement Cost Calculation

Inputs		
Measure Type=	C&I Tankless (ROB + NC)	
Nominal Discount Rate=	5.62%	
Inflation Rate=	2.04%	
Real Discount Rate=	3.50%	
	Program	Baseline
Equipment Type=	Tankless WH	Storage WH
Effective UsefulLife=	20	15
Remaining Useful Life=		
PW(EUL)=	14.21	11.51
PW(RUL)=		
Installed Cost=	\$1,219	\$614
Deferred Replacement Cost=		\$ 143.63
PWF Formula=		\$ 143.63
Incremental Cost=	\$ 461.37	

Figure 8-2: C&I Tankless WH Avoided Replacement Cost Calculation

Inputs		
Measure Type=	Furnace Early Replacement	
Nominal Discount Rate=	5.62%	
Inflation Rate=	2.04%	
Real Discount Rate=	3.5%	
	Program	Baseline
Equipment Type=	HE Furnace	SE Furnace
Effective UsefulLife=	20	20
Remaining Useful Life=		7
PW(EUL)=	20.00	20.00
PW(RUL)=		\$6.11
Installed Cost=	\$ 2,548	\$ 2,011
Deferred Replacement Cost=		\$ 1,145.67
PWF Formula=		\$ 1,396

Figure 8-3: Furnace Early Retirement Deferred Replacement Cost Calculation

9 Appendix C: Sample TRM Calculations

9.1 Residential Furnaces (TRM V9.0 Section 2.1.3)

According to Arkansas TRM V9.0, savings for residential furnaces are calculated as follows:¹⁹

$$\text{Annual Therm Savings} = \text{Heat load} \times \left(\frac{1}{AFUE_{base}} - \frac{1}{AFUE_{eff}} \right)$$

$$\text{Heat load} = \text{therms}/\text{site area}/\text{year} \times \text{site area}$$

Site area = ft.² of the project site. If unknown, use installed capacity (BTUh)/30 (BTUh/ft²).

$AFUE_{base}$ = baseline efficiency of the furnace, 80% AFUE.

$AFUE_{eff}$ = efficiency of the new furnace installed, in AFUE.

Table 9-1 summarizes the heating load multipliers per square foot from the TRM V9.0.

Table 9-1: TRM V9.0 Annual Furnace Heating Load

Vintage	Heating Load (Therms/Ft.2/Year)			
	Zone 9 – Fayetteville	Zone 8 – Fort Smith	Zone 7 – Little Rock	Zone 6 – El Dorado
1979 & Earlier	.404	.360	.336	.296
1980-1989	.303	.270	.252	.222
1990-1999	.202	.180	.168	.148
2000 & Later	.152	.135	.126	.111

Example savings calculations for a home in Zone 8 are as follows:

- Retrofit – 90,000 Input BTU furnace, 95% AFUE
- Output BTU = 90,000 x .95 = 85,500
- Square Feet = 85,500 / 30 = 2,850
- Year built: 1986

$$\text{Retrofit Therms Savings} = 2,850 \text{ft.}^2 \times .270 \frac{\text{Therms}}{\text{ft.}^2} \times \left(\frac{1}{.80} - \frac{1}{.95} \right) = 130.56 \text{ Therms}$$

The same furnace in a new construction project would save:

$$\text{NC Therms Savings} = 2,850 \text{ft.}^2 \times .135 \frac{\text{Therms}}{\text{ft.}^2} \times \left(\frac{1}{.80} - \frac{1}{.95} \right) = 75.94 \text{ Therms}$$

¹⁹ Arkansas TRM V9.0 Volume 2, Page 44

9.2 Residential Water Heater Replacement (TRM V9.0 Section 2.3.1)

Energy savings values for storage tank water heaters were developed using installed Energy Factor ratings as determined by the Gas Appliance Manufacturers Association Directory of Certified Water Heating Products. Tank sizing must follow AHRI standards.

In TRM V9.0 Savings are calculated as:²⁰

$$therm_{Savings} = \frac{\rho \times C_p \times V \times (T_{SetPoint} - T_{Supply}) \times \left(\frac{1}{EF_{pre}} - \frac{1}{EF_{post}} \right)}{Conversion\ Factor}$$

ρ = Water density, 8.33 lbs./gal.

C_p = Specific heat of water, 1 BTU/lb.°F

V = Estimated annual hot water use (gal per year)

$T_{SetPoint}$ = Water heater set point, if unavailable, use 120°F

T_{Supply} = Average supply water temperature

EF_{pre} = Baseline value

EF_{post} = Energy Factor of new water heater

Conversion Factor = 100,000 BTU = 1 therm

Baseline energy factors are summarized in Table 9-2.

Table 9-2: Residential Water Heating Baseline Uniform Energy Factors

Draw Pattern	Equivalent Gallons	Baseline UEF
Very Small	20	.3056
Low	30	.5412
Medium	40	.5803
High	50	.6270

Volume estimates are provided in Table 9-3.

Table 9-3: TRM V9.0 Estimated Annual Hot Water Use

Weather Zone	40 Gal.	50 Gal.	65 Gal.	80 Gal.
9	18,401	20,911	25,093	30,111
8	18,331	20,831	24,997	29,996
7	18,267	20,758	24,910	29,892
6	17,815	20,245	24,293	29,152

Supply water temperatures are presented in Table 9-4

²⁰ Arkansas TRM V9.0, Volume 2. Pg. 122-135

Table 9-4: Residential Water Supply Inlet Temperatures

	Weather Zone	Supply Water Temp
9	Fayetteville	65.6
8	Fort Smith	66.1
7	Little Rock	67.8
6	El Dorado	70.1

Example savings calculations are as follows:

- Retrofit – 199,000 Input BTU Tankless Water Heater, 96% UEF
- High Draw Pattern
- Location: Fort Smith, Zone 8.

$$\text{Therms Savings} = \frac{1 \times 8.33 \times 20,831 \times (120 - 66.1) \times \left(\frac{1}{.627} - \frac{1}{.96} \right)}{100,000} = 51.74 \text{ Therms}$$

9.3 Smart Thermostats (TRM V9.0 Section 2.1.12)

The savings multipliers for smart thermostats are shown in Table 9-5²¹.

Table 9-5: Smart Thermostat Deemed Savings Factors

Baseline	Therms/Ft.2	kWh/Ft.2
Manual	.037	.450
Programmable	.009	.113
Default	.033	.399

9.4 Commercial Furnaces (TRM V9.0 Section 3.1.9)

Therms savings calculations for commercial furnaces apply more facility-specific information than the residential methodology. Savings were calculated as follows:²²

$$\text{Therms Savings} = \frac{\text{BTU Capacity} * \text{EFLH}_H * \left(\frac{1}{\text{Effic}_{pre}} - \frac{1}{\text{Effic}_{post}} \right)}{100,000 \text{ Therms/BTU}}$$

The TRM V9.0 EFLH values are summarized in Table 9-6.

²¹ AR TRM V9.0 Vol 2.0 Pg. 83

²² Arkansas TRM V9.0, Pg. 252

Table 9-6: EFLH Values²³

Building Type	Zone 6	Zone 7	Zone 8	Zone 9
Assembly	615	854	915	1032
College/University	674	936	1002	1130
Fast Food Restaurant	287	439	472	549
Full Menu Restaurant	178	321	362	438
Grocery Store	692	941	1001	1129
Health Clinic	641	878	915	1045
Lodging	391	589	637	722
Large Office (>30k Ft ²)	816	1020	1060	1157
Small Office (<30k Ft ²)	351	534	564	644
Religious Worship	575	798	854	963
Retail	781	1043	1133	1287
School	777	1030	1094	1236

For example, if a Small Office in Fort Smith (Zone 8) installed a 70,000 BTU 96% AFUE Furnace, the resulting therms savings are calculated as:

$$\text{Therms Savings} = \frac{70,000 \text{ BTU} * 564 \text{ EFLH} * \left(\frac{1}{.80} - \frac{1}{.96}\right)}{100,000 \text{ BTU/Therm}} = 82.24 \text{ Therms}$$

9.5 Commercial Water Heaters (TRM V9.0 Section 3.3.1)

Therms savings for commercial water heaters are calculated as:²⁴

$$\text{therms Savings} = \frac{\rho * C_p * V * (T_{\text{SetPoint}} - T_{\text{Supply}}) * \left(\frac{1}{EF_{\text{pre}}} - \frac{1}{EF_{\text{post}}}\right) * \text{Days/Year}}{\text{Conversion Factor}}$$

ρ = Water Density, 8.33 lbs./Gallon

C_p = Specific Heat of Water, 1 BTU/Lb. F

V = Average daily hot water use (gallons)

T_{setpoint} = Water Heater setpoint, 140 deg. F

T_{supply} = Supply water temperature, 58 deg. F

EF_{pre} = Energy factor of existing water heater (.62 - .0019V)

EF_{post} = Energy factor of installed water heater

Days/Year = Days per year of operation

Conversion Factor = 100,000 BTU = 1 therm

²³ Arkansas TRM V9.0 Volume 2, Table 478. Pg. 526.

²⁴ Arkansas TRM V9.0, Volume 2. Pg. 357-368

Table 9-7 presents the volume and days of usage values for a facility by square footage.²⁵

Table 9-7: Hot Water Requirements by Facility Size

<i>Building Type</i>	<i>Gallons / Unit / Day</i>	<i>Unit</i>	<i>Units / 1,000 ft.2</i>	<i>Applicable Days / Year</i>	<i>Gallons / 1,000 ft.2 / Day</i>
Small Office	1	Person	2.3	250	2.3
Large Office	1	Person	2.3	250	2.3
Fast Food Rest.	.7	Meal/Day	784.6	365	549.2
Sit-down Rest.	2.4	Meal/Day	340	365	816
Retail	2	Employee	1	365	2.0
Grocery	2	Employee	1.1	365	2.2
Warehouse	2	Employee	.5	250	1.0
Elementary School	.6	Person	9.5	200	5.7
Jr. High/High School	1.8	Person	9.5	200	17.1
Health	90	Patient	3.8	365	342.0
Motel	20	Unit (Room)	5	365	100.0
Hotel	14	Unit (Room)	2.2	365	30.8
Other	1	Employee	.7	250	.7

Table 9-8 presents the volume and days of usage values by unit produced or person served.

Table 9-8: Hot Water Requirements by Unit or Person

<i>Building Type</i>	<i>Size Factor</i>	<i>Average Daily Demand</i>
Dormitories	Men	13.1 Gal. per Man
	Women	12.3 Gal. per Woman
Hospitals	Per Bed	90.0 Gal. per Patient
Hotels	Single Room with Bath	50.0 Gal. per Unit
	Double Room with Bath	80.0 Gal. per Unit
Motels	# Units:	
	Up to 20	20.0 Gal. per Unit
	21 to 100	14.0 Gal. per Unit
	101 and Up	10.0 Gal. per Unit
Restaurants	Full Meal Type	2.4 Gal. per Meal
	Dive-in Snack Type	0.7 Gal. per Meal
Schools	Elementary	0.6 Gal. Per Student
	Secondary and High School	1.8 Gal. Per Student

9.6 Commercial Faucet Aerators (TRM V9.0 Section 3.3.2)

Savings are calculated as follows:²⁶

$$Annual\ Therms = [(F_B * U_B) - (F_P * U_P)] * Days * (T_H - T_C) * C_H * C_G / Eff_G$$

The inputs for this equation are defined in Table 9-9.

²⁵ Ibid

²⁶ Arkansas TRM V9.0, Volume 2. Pg. 369-372

Table 9-9: DI Aerator Savings Calculation Parameters

Parameter	Description	Value
F _B	Baseline Flow Rate (GPM)	2.2
F _P	Post Flow Rate (GPM)	≤ 1.5
Days	Annual operating days for the facility ²⁷	
	Prison	365
	Hospital, Nursing Home	365
	Dormitory	274
	Multifamily	365
	Lodging	365
	Commercial	250
	School	200
T _c	Average supply (cold) water temperature (deg. F)	Zone 9: 65.6
		Zone 8: 66.1
		Zone 7: 67.8
		Zone 6: 70.1
T _H	Average mixed hot water temperature (deg. F)	105
U _B	Baseline water Usage Duration	
	Prison	30 min/day/unit
	Hospital, Nursing Home	3 min/day/unit
	Dormitory	30 min/day/unit
	Multifamily	3 min/day/unit
	Lodging	3 min/day/unit
	Commercial	30 min/day/unit
	School	30 min/day/unit
U _P	Post Water Usage Duration (assumed)	= U _B
C _H	Unit Conversion: 8.33 BTU/Gallons/deg. F	8.33
C _G	Unit Conversion: 1 Therm/100,000 BTU	1/100,000
Eff _G	Efficiency of Gas Water Heater	.8

These values translate into per-faucet savings values by facility type, detailed in Table 9-10 and Table 9-11 for 1.0 and 0.5 GPM aerators, respectively.²⁸

Table 9-10: 1.0 GPM Commercial Aerator Savings

Facility Type	Fayetteville (Zone 9)	Fort Smith (Zone 8)	Little Rock (Zone 7)	El Dorado (Zone 6)
Prison	53.91	53.22	50.90	47.75
Hospital / Nursing Home	5.35	5.32	5.09	4.78
Dormitory	40.47	39.95	38.21	35.85
Multifamily	5.35	5.32	5.09	4.78
Lodging	5.35	5.32	5.09	4.78
Commercial	36.92	36.45	34.86	32.71
School	29.54	29.16	27.89	26.16

²⁷ For facilities that operate year-round: conservatively assume operating days of 360/year; for schools open weekdays except summer: 360 x (5/7) x (9/12) = 193; for dormitories with few occupants in the summer: 360 x (9/12) = 270; and for normal commercial buildings: 360 x (5/7) = 257

²⁸ Table values interpolated based on data in Arkansas TRM V9.0, Volume 2. Pg. 369-372

Table 9-11: 0.5 GPM Commercial Aerator Savings

Facility Type	Fayetteville (Zone 9)	Fort Smith (Zone 8)	Little Rock (Zone 7)	El Dorado (Zone 6)
Prison	76.37	75.40	72.10	67.65
Hospital / Nursing Home	7.64	7.54	7.21	6.76
Dormitory	57.33	56.60	54.13	50.78
Multifamily	7.64	7.54	7.21	6.76
Lodging	7.64	7.54	7.21	6.76
Commercial	52.31	51.64	49.39	46.33
School	41.85	41.31	39.51	37.07

9.7 Pre-Rinse Spray Valves (TRM V9.0 Section 3.8.11)

Low-flow pre-rinse spray valves PRSVs were also direct-installed at a wide range of facility types with food service applications. The savings per unit for these were calculated as follows:²⁹

$$\text{Annual Therms} = [(F_B * U_B) - (F_P * U_P)] * \text{Days} * (T_H - T_C) * C_H * C_G / \text{Eff}_G$$

$$\text{Peak Therms} = P * [(F_B * U_B) - (F_P * U_P)] * (T_H - T_C) * C_H * C_G / \text{Eff}_G$$

Table 9-12 presents the definition of these parameters.³⁰

²⁹ Arkansas TRM V9.0, Volume 2. Pg. 514-517

³⁰ Ibid

Table 9-12: Pre-Rinse Spray Valves Savings Calculation Parameters

Parameter	Description	Value
F _B	Baseline Flow Rate (GPM)	2.25
F _P	Post Flow Rate (GPM)	1.28
Days	Annual operating days for the facility ³¹	
	Fast Food Restaurant	365
	Casual Dining Restaurant	365
	Institutional	365
	Higher Education	274
	School / K-12	200
T _C	Average supply (cold) water temperature (deg. F)	Zone 9: 65.6
		Zone 8: 66.1
		Zone 7: 67.8
		Zone 6: 70.1
T _H	Average mixed hot water temperature (deg. F)	120
U _B	Baseline water Usage Duration	
	Fast Food Restaurant	45 min/day/unit
	Casual Dining Restaurant	105 min/day/unit
	Institutional	210 min/day/unit
	Higher Education	210 min/day/unit
	School / K-12	105 min/day/unit
U _P	Post Water Usage Duration (assumed)	= U _B
C _H	Unit Conversion: 8.33 BTU/Gallons/deg. F	8.33
C _G	Unit Conversion: 1 Therm/100,000 BTU	1/100,00
Eff _G	Efficiency of Gas Water Heater	.8

9.8 Commercial Low Flow Showerheads (TRM V9.0 Section 3.3.5)

Savings are calculated as follows:³²

$$Annual\ therms = \frac{8.33 * C_p * \Delta V * (T_{HW} - T_{Supply}) * \left(\frac{1}{E_t}\right)}{100,000\ BTU/therm} * \frac{days}{year}$$

In this formula, ΔV is calculated as follows:

$$\Delta V = U * N * (Q_b - Q_p) * F_{HW}$$

U = average shower duration (7.8 minutes)

N = Number of showers per showerhead per day

Q_b = Baseline flow rate (2.5 GPM);

Q_p = Installed flow rate (in GPM); and

³¹ For facilities that operate year-round: conservatively assume operating days of 360/year; for schools open weekdays except summer: 360 x (5/7) x (9/12) = 193; for dormitories with few occupants in the summer: 360 x (9/12) = 270; and for normal commercial buildings: 360 x (5/7) = 257

³² Arkansas TRM V9.0, Volume 2. Pg. 381-388

F_{HW} = Hot Water Fraction (share of water which is from the water heater)
 The inputs for this equation are defined in Table 9-13

Table 9-13: DI Showerhead Savings Calculation Parameters

Parameter	Description	Value
F_B	Baseline Flow Rate (GPM)	2.2
F_P	Post Flow Rate (GPM)	≤ 1.5
Days	Annual operating days for the facility	
	Hospital, Nursing Home	365
	Lodging	365
	Commercial	250
	24 Hour Fitness Center	365
T_C	Average supply (cold) water temperature (deg. F)	Zone 9: 65.6
		Zone 8: 66.1
		Zone 7: 67.8
		Zone 6: 70.1
T_H	Average mixed hot water temperature (deg. F)	120
U_P	Post Water Usage Duration (assumed)	= U_B
C_G	Unit Conversion: 1 Therm/100,000 BTU	1/100,00
E_T	Efficiency of Gas Water Heater	.8

Table 9-14: Daily Hot Water Reduction

Installed Flow Rate	Weather Zone	Hospital / Nursing	Lodging	Commercial Employee Shower	24 Fitness Center	Schools
2.0 GPM	9	2.5	3.5	1.9	56.3	2.0
	8	2.5	3.5	1.9	56.1	2.0
	7	2.5	3.5	1.8	55.4	2.0
	6	2.4	3.4	1.8	54.4	2.0
1.75 GPM	9	3.8	5.3	2.8	84.4	3.1
	8	3.8	5.3	2.8	84.1	3.1
	7	3.7	5.2	2.8	83.1	3.0
	6	3.6	5.1	2.7	81.5	3.0
1.5 GPM	9	5.0	7.1	3.8	112.6	4.1
	8	5.0	7.0	3.7	112.2	4.1
	7	4.9	6.9	3.7	110.8	4.0
	6	4.9	6.8	3.6	108.7	.9

9.9 Commercial Door Air Infiltration (TRM V9.0 Section 3.2.11)

Savings are calculated as follows³³:

Annual therms =

³³ Arkansas TRM V9.0, Volume 2. Pg. 350-356

$$\frac{(CFM_{pre,day} * Hours_{day} + CFM_{pre,night} * Hours_{night}) \left(CFM_{reduction} * 1.08 * \Delta T * \frac{1.0kW}{ton} \right)}{80\% AFUE * \frac{100,000Btu}{therm}}$$

$$Peak\ therms = Annual \frac{therms}{ELFH_H}$$

The inputs for this equation are defined in Table 9-15.

Table 9-15: DI Door Infiltration Savings Calculation Parameters

Parameter	Description	Value
CFM _{pre}	Calculated pre-retrofit air infiltration rate (ft ³ /min)	
CFM _{reduction}	Average infiltration reduction	79%
ΔT	Change in temperature across gap barrier	
Hours _{day}	12-hour cycles per day, per month	4,380 hours
Hours _{night}	12-hour cycles per day, per month	4,380 hours
EFLH _H	Equivalent full-load hours	See table below

Table 9-16: EFLH_H By Weather Zone

Building Type	Zone 6	Zone 7	Zone 8	Zone 9
Assembly	575	798	855	824
College/University	630	874	936	902
Fast Food Restaurant	288	440	474	455
Full Menu Restaurant	181	328	370	336
Grocery Store	688	935	995	965
Health Clinic	646	885	922	895
Lodging	389	587	635	605
Large Office (>30k ft. ²)	811	1,014	1,054	1,036
Small Office (≤30k ft. ²)	353	538	568	538
Religious Worship	537	745	798	769
Retail	780	1,041	1,131	1,099
School	774	1,026	1,089	1,064

These values translate into per linear foot savings values by weather zone, detailed in the table below.

Table 9-17: Deemed Annual Therm Savings per Linear Foot

Weather Zone	Gap Width (inches)			
	1/8	1/4	1/2	3/4
Zone 9	5.34	10.80	21.43	32.16
Zone 8	4.64	9.38	18.62	27.96
Zone 7	3.91	7.92	15.71	23.58
Zone 6	2.89	5.86	11.62	17.44

10 Appendix D: Detailed NTG Tables

11 Appendix E: Cost-Benefit Inputs

Table 11-1: BHE Avoided Cost Values

Year	\$/Therm	\$/kWh	\$/kW	\$/Gallon Water
2022	\$0.4173	\$0.0347	\$95.40	\$0.0077
2023	\$0.4258	\$0.0360	\$97.33	\$0.0081
2024	\$0.4345	\$0.0374	\$99.30	\$0.0085
2025	\$0.4434	\$0.0392	\$101.30	\$0.0089
2026	\$0.4524	\$0.0402	\$103.35	\$0.0093
2027	\$0.4617	\$0.0414	\$105.44	\$0.0097
2028	\$0.4711	\$0.0422	\$107.57	\$0.0102
2029	\$0.4807	\$0.0539	\$109.74	\$0.0107
2030	\$0.4905	\$0.0551	\$111.96	\$0.0112
2031	\$0.5005	\$0.0579	\$114.22	\$0.0117
2032	\$0.5107	\$0.0602	\$116.53	\$0.0123
2033	\$0.5211	\$0.0617	\$118.89	\$0.0129
2034	\$0.5318	\$0.0630	\$121.29	\$0.0135
2035	\$0.5426	\$0.0651	\$123.74	\$0.0142
2036	\$0.5537	\$0.0677	\$126.24	\$0.0148
2037	\$0.5650	\$0.0693	\$128.79	\$0.0156
2038	\$0.5765	\$0.0711	\$131.39	\$0.0163
2039	\$0.5883	\$0.0739	\$134.05	\$0.0171
2040	\$0.6003	\$0.0746	\$136.78	\$0.0179
2041	\$0.6173	\$0.0767	\$140.66	\$0.0188

Table 11-2: BHE Discount Rates

Test	Discount Rate
TRC	5.62%
UCT	5.62%
RIM	5.62%
PCT	9.00%

Table 11-3: Line & Distribution Losses

Line & Distribution Loss Type	Rate
Gas Distribution Losses	2.69%
Line Losses – Energy	6.49%
Line Losses – Demand	10.82%