



PROGRAM YEARS 2016-2018 EVALUATION REPORT

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND
ENVIRONMENTAL CONTROL

Date: 13 February 2020

Prepared for: Delaware Department of Natural Resources and Environmental Control

Prepared by: EcoMetric Consulting LLC and NMR Group Inc.

CONTENTS

- Executive Summary 10**
 - E.1 Evaluation Goals and Methodology 10
 - E.2 Evaluation Results Summary 12
 - E.3 Key Findings and Recommendations 15
 - E.3.1 EEIF Key Findings & Recommendations 15
 - E.3.2 GEP Findings & Recommendations 17
 - E.3.3 WAP Key Findings & Recommendations 18
- 1 Evaluation Methodology 20**
 - 1.1 Cross-Cutting Evaluation Approach 20
 - 1.1.1 Overall Sample Design 20
 - 1.1.2 Gross Savings Verification 23
 - 1.1.3 Net Savings Analysis 24
 - 1.1.4 Summer Peak Demand Analysis 24
 - 1.1.5 Avoided Greenhouse Gas Emissions 25
 - 1.1.6 Cost-effectiveness Analysis 26
 - 1.2 Process Evaluation 29
 - 1.3 Non-Energy Benefits (NEB) 30
- 2 Energy Efficiency Investment Fund Results 33**
 - 2.1 Impact Evaluation 34
 - 2.1.1 Program Database Review and Sampling 34
 - 2.1.2 Gross Savings Verification 36
 - 2.1.3 Verified Results 38
 - 2.1.4 Net Savings Verification 45
 - 2.1.5 Greenhouse Gas Emission Reductions 46
 - 2.1.6 Cost-effectiveness Results 46
 - 2.2 Process Evaluation 47
 - 2.2.1 Program Description 47



2.2.2	Perspectives on EEIF's Marketing.....	50
2.2.3	Perspectives on Application and Approval Process.....	51
2.2.4	Communication with Program and Program Staff.....	54
2.2.5	Comprehensiveness of Equipment & Measures Supported by EEIF.....	55
2.2.6	Customer Motivations and Barriers to Participation.....	56
2.2.7	Suggestions for Program Improvement	58
2.2.8	Program Satisfaction, Loyalty, and Overall Experience	60
3	Green Energy Program Results	64
3.1	Impact Evaluation.....	64
3.1.1	Program Database Review and Sampling	64
3.1.2	Gross Savings Verification.....	66
3.1.3	Verified Capacities and Savings (Generation).....	68
3.1.4	Net Savings Verification	71
3.1.5	Greenhouse Gas Emissions Reductions.....	71
3.1.6	Cost-effectiveness Results	72
4	Weatherization Assistance Program Results	73
4.1	Impact Evaluation.....	73
4.1.1	Program Database Review and Sampling	73
4.1.2	Gross Savings Verification.....	74
4.1.3	Verified Savings.....	79
4.1.4	Net Savings Verification	82
4.1.5	Greenhouse Gas Emission Reductions.....	83
4.1.6	Non-Energy Benefits (NEB).....	84
4.1.7	Cost-effectiveness Results	87
4.2	Process Evaluation.....	88
4.2.1	Program Description	88
4.2.2	Summary of Program Tracking Review	90
4.2.3	Marketing and Outreach.....	90

4.2.4	Program Awareness and Drivers of Participation	92
4.2.5	Implementation Challenges	93
4.2.6	DNREC Trainings.....	95
4.2.7	Quality Control Inspections.....	96
4.2.8	Program Satisfaction, Loyalty, and Overall Experience.....	96
4.2.9	Post-Weatherization Thermostat Setpoints	99
4.2.10	Planned or Possible Program Improvements.....	100
Appendix A: Program Evaluation Tearaways.....		101

TABLES

Table 1: 2016 - 2018 Reported and Gross Verified Electric and Peak Demand Savings [†]	12
Table 2: 2016 - 2018 Reported and Gross Verified Fossil Fuel Savings.....	12
Table 3: 2016 - 2018 Net Verified Savings.....	13
Table 4: 2016 - 2018 Program Cost-effectiveness Results	13
Table 5: WAP 2016 - 2017 Per-Home Savings Matrix	19
Table 6: Summary of Program Population and Sample Size.....	23
Table 7: Approved Delaware NTG Values.....	24
Table 8: 2016-2018 PJM Emissions Rates.....	25
Table 9: Process Evaluation Data Collection & Sample Design	30
Table 10: EEIF 2016 - 2018 Program Summary.....	34
Table 11: EEIF Program Data Prescriptive versus Custom Projects	34
Table 12: 2016 – 2018 EEIF Program Sample Frame	35
Table 13: 2016 – 2018 EEIF Sample Coverage.....	36
Table 14: Summary of Desk Reviews and Site Visits.....	36
Table 15: EEIF Gross Verified Savings Results	39
Table 16: 2016 – 2018 EEIF Net Verified Savings Results.....	46
Table 17: 2016 – 2018 EEIF Greenhouse Gas Emissions Reductions.....	46
Table 18: 2016 – 2018 Cost-effectiveness Results.....	47
Table 19: Means of First Hearing about the Energy Efficiency Investment Fund.....	49
Table 20: Contractor Comments on Application and Approval Process.....	52
Table 21: Contractor Feedback on Communication with Program and Program Staff	55
Table 22: Additional Equipment Recommended by Energy Efficiency Fund Participants	56
Table 23: Motivation for Participating in the Energy Efficiency Investment.....	57
Table 24: Barriers to Customer Participation	58
Table 25: Contractor Suggestions for Improving the Application and Approval Process.....	59
Table 26: Suggestions for Energy Efficiency Investment Fund Improvement.....	59
Table 27: Contractor Feedback on Overall Experience with EEIF	60

Table 28: GEP 2016 - 2018 Program Summary.....	64
Table 29: GEP Sample Frame	65
Table 30: GEP Sample Coverage.....	65
Table 31: GEP 2016 - 2018 Verified Capacities	69
Table 32: GEP 2016 - 2018 Gross Verified Savings (Generation).....	69
Table 33: 2016 – 2018 GEP Greenhouse Gas Emissions Reductions	72
Table 34: 2016 – 2018 GEP Cost-effectiveness Results.....	72
Table 35: WAP Savings Summary	73
Table 36: Summary of Savings by Fuel Type.....	74
Table 37: Reported Per-Home WAP Savings	75
Table 38: WAP 2016 - 2017 Electric Realized Savings Summary.....	80
Table 39: WAP 2016 - 2017 Fossil Fuel Realized Savings Summary.....	81
Table 40: WAP 2016 - 2017 Per-Home Savings Matrix.....	82
Table 41: WAP 2016 – 2017 Net Verified Electric Savings Summary.....	83
Table 42: WAP 2016 – 2017 Net Verified Fossil Fuel Savings Summary.....	83
Table 43: 2016 – 2018 WAP Greenhouse Gas Emissions Reductions	84
Table 44: Weatherization Assistance Program Participant Observations of Non-Energy Impacts	85
Table 45: Weatherization Assistance Program Non-Energy Benefits – Preliminary Results.....	86
Table 46: 2016 – 2017 WAP Cost-effectiveness Results.....	87
Table 47: Means of First Hearing about the Weatherization Assistance Program.....	92
Table 48: Motivation for Participating in the Weatherization Assistance Program	92
Table 49: Suggestions for Weatherization Assistance Program Improvement.....	98

FIGURES

Figure 1: Evaluation Goals	11
Figure 2: Sampling Flow Chart.....	21
Figure 3: Program Sample Compared to Portfolio Sample	22
Figure 4: Distribution of EEIF Electric Realization Rates.....	39
Figure 5: Custom Electric Realization Rate by Project Type.....	42

Figure 6: Custom Gas Realization Rate by Project Type*	44
Figure 7: Ease of Completing the Energy Efficiency Investment Fund Application	54
Figure 8: Average Contractor Satisfaction with Selected Aspects of EEIF	61
Figure 9: Energy Efficiency Investment Fund Participant Satisfaction Ratings	62
Figure 10: Net Promoter Score	63
Figure 11: Likelihood of Recommending the Energy Efficiency Investment Fund	63
Figure 12: PVWatts® Input Window	67
Figure 13: Results window for sample PVWatts® project	68
Figure 14 WAP billing analysis project flow	76
Figure 15: Reported Per-Home WAP Savings	80
Figure 16: Weatherization Assistance Program Non-Energy Benefits – Recommendations	87
Figure 17: Weatherization Assistance Program Participant Satisfaction	97
Figure 18: Likelihood of Recommending the Weatherization Assistance Program	99
Figure 19: Weatherization Assistance Program Participant Thermostat Behavior	100

ABBREVIATIONS

AESP	Association of Energy Services Professionals
AHRI	Air-Conditioning, Heating, and Refrigeration
CDD	Cooling Degree Day
DCSEU	Delaware Sustainable Energy Utility
DNREC	Delaware Department of Natural Resources and Environmental Control
DOE	U.S. Department of Energy
DRIPE	Demand-Reduction-Induced Price Effect
ECA	Energy Coordinating Agency
EEAC	Energy Efficiency Advisory Council
EEIF	Energy Efficiency Investment Fund
EM&V	Evaluation, Measurement, and Verification
GEP	Green Energy Program
GHG	Greenhouse Gas
GSS	Government Support Services
HDD	Heating Degree Day
HVAC	Heating, Ventilation, and Air-Conditioning
IPVMP	International Performance Measurement and Verification
kWh	Kilo-Watt hours
Lbs	Pounds
LIHEAP	Low-Income Home Energy Assistance Program
MMBtu	Million British Thermal Units
MW	Mega-Watts
MWh	Mega-Watt hours
NEB	Non-energy benefit
NPV	Net Present Value
NTG	Net-to-Gross
NWS	National Weather Service
PV	Photovoltaic
PY	Program Year
QCI	Quality Control Inspector
REC	Renewable Energy Credit
RFQ	Request for Qualifications
RGGI	Regional Greenhouse Gas Initiative
RR	Realization Rate
SREC	Solar Renewable Energy Credit
TMY	Typical Meteorological Year

TRC
TRM
VRF
WAP

Total Resource Cost
Technical Reference Manual
Variable Refrigerant Flow
Weatherization Assistance Program

EXECUTIVE SUMMARY

The Delaware Department of Natural Resources and Environmental Control (DNREC) retained EcoMetric Consulting, LLC and NMR Group, Inc. (EcoMetric or evaluation team) to evaluate two energy efficiency program and one renewable program offering for calendar years 2016 – 2018. DNREC's programs provide grants for equipment upgrades, engineering studies, and renewable technologies to commercial and industrial customers in Delaware. DNREC also provides weatherization services to income eligible residential customers through the weatherization assistance program. This report contains gross and net energy and demand impacts, greenhouse gas (GHG) emission impacts, cost-effectiveness results, process evaluation findings, and recommendations for improvement for three DNREC programs.

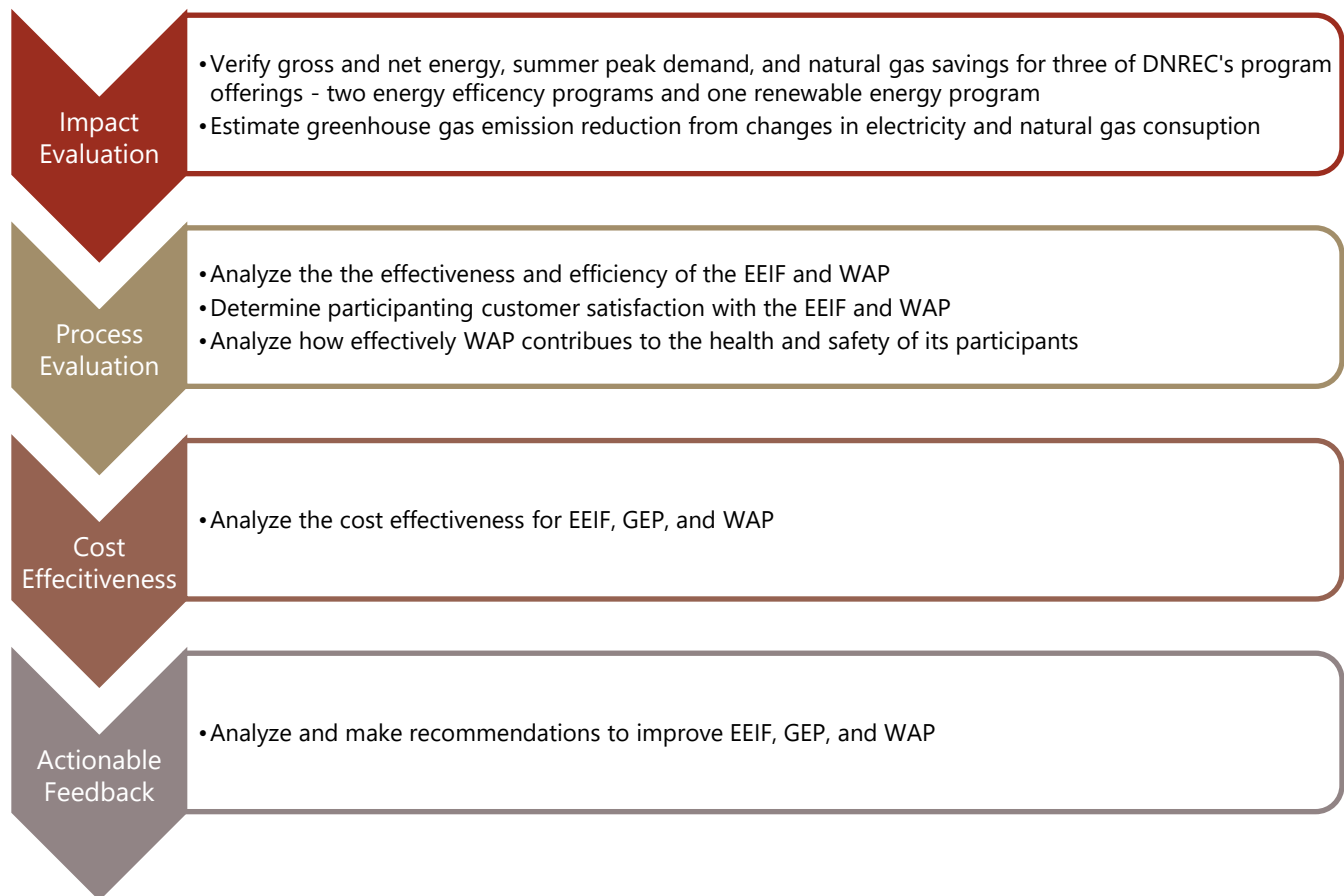
- ▶ **Energy Efficiency Investment Fund (EEIF)** – EEIF provides financial incentives to businesses, state agencies, local governments, and non-profits to make energy efficiency upgrades in existing facilities in Delaware. The incentives are designed to defray some of the cost difference for upgrading existing conventional equipment (i.e., baseline equipment) to high-efficiency solutions. Organizations apply to EEIF for either prescriptive or custom grants. The majority of the projects completed through EEIF are for prescriptive lighting.
- ▶ **Green Energy Program (GEP)** – GEP provides funding to promote the use of renewable energy to commercial, non-profit, and residential Delmarva Power and Lighting customers in Delaware. The program offers incentives for a variety of renewable technologies such as solar photovoltaic, solar hot water, wind, and geothermal systems.
- ▶ **Weatherization Assistance Program (WAP)** – WAP is overseen by the U.S. Department of Energy (DOE). WAP provides income-eligible residential customers with free energy-efficiency retrofits to reduce their energy costs and improve their health and the safety of their homes. DNREC contracts with local agencies, referred to as “subgrantees,” to administer WAP and deliver weatherization services to Delaware residents with household incomes that fall below 200% of the federal poverty line. Subgrantees are responsible for hiring, managing, and paying home energy auditors and third-party subcontractors who carry out the weatherization work recommended based on the audit results. Upon completion of the work, all homes receive a final inspection conducted by a certified Quality Control Inspector. Also, a sample of all serviced households is inspected by the State Program Monitor, who serves as the state’s weatherization technical expert.

E.1 EVALUATION GOALS AND METHODOLOGY

The EcoMetric team set forth clearly defined evaluation goals at the outset of the evaluation to help DNREC improve its energy efficiency programs. The evaluation goals support DNREC’s dedication to

providing Delaware’s residents with safe, efficient, and low-cost energy efficiency options, thereby improving the livability and economic well-being of the communities it serves. EcoMetric developed the goals in Figure 1 in collaboration with DNREC.

Figure 1: Evaluation Goals



The impact evaluation provided DNREC with verified savings that reflects the most up-to-date program and market conditions. The verified savings were used to evaluate the cost-effectiveness of DNREC’s energy efficiency and renewable energy programs. Approaches used to conduct the impact evaluation include engineering analyses, site visits, and billing analyses to calculate the verified energy, peak demand, and fossil fuel savings achieved through energy efficiency or renewable energy projects funded by each of DNREC’s programs.

The overall objective of the process evaluations is to provide DNREC program staff with recommendations about how to improve the effectiveness and efficiency of the programs, including recommendations regarding program design, program administration, cross-program promotion and outreach, implementation, delivery, and customer engagement. The EcoMetric team designed and conducted web surveys and in-depth telephone interviews with market actors such as program staff,

subgrantees, installing contractors, and participants. The goal of the surveys and in-depth interviews was to understand the market actors' perspectives and satisfaction with the program in addition to assessing the program processes.

E.2 EVALUATION RESULTS SUMMARY

EcoMetric evaluated 550 different projects, spread across 2016, 2017, and 2018 calendar years. Approximately 9 out of 10 of the EEIF (89%) and WAP (86%) participants reported they are satisfied with their overall experience with the programs when interviewed during the evaluation.

Verified savings for the 2016 – 2018 program years are summarized in Table 1 and Table 2. GEP is not governed by the Delaware EM&V regulations, so the program does not track energy savings but instead tracks capacity installed. EcoMetric calculated savings for ease of comparing across programs.

Table 1: 2016 - 2018 Reported and Gross Verified Electric and Peak Demand Savings[†]

Program	Reported Energy Savings (MWh)	Reported Peak Demand Savings (MW)	Verified Energy Savings (MWh)	Verified Peak Demand Savings (MW)	Energy Savings RR (%)
EEIF	20,455	-	20,652	2.03	101%
GEP	-	-	13,725	10.68	N/A
WAP*	367	0.02	562	0.24	153%
Total	20,822	0.02	34,939	12.95	168%

[†] Demand realization rates were calculated but are not shown since the verified demand is much higher than reported demand.

* The evaluation period for WAP was calendar years 2016 – 2017

Not Applicable (NA): the program does not track this value

Table 2: 2016 - 2018 Reported and Gross Verified Fossil Fuel Savings

Program	Reported Fossil Fuel Savings (MMBtu)	Verified Fossil Fuel Savings (MMBtu)	Fossil Fuel Savings RR (%)
EEIF	8,634	1,093	13%
WAP*	5,031	4,210	84%
Total	13,664	5,303	39%

* The evaluation period for WAP was calendar years 2016 - 2017

The EcoMetric team used the Delaware Energy Efficiency Advisory Council (EEAC)¹ approved net-to-gross ratios (NTG) to calculate the net verified savings for EEIF and WAP. The net verified savings for each program are shown in Table 3.

Table 3: 2016 - 2018 Net Verified Savings

Program	Net Verified Energy Savings (MWh)	Net Verified Peak Demand Savings (MW)	Net Verified Fossil Fuel Savings (MMBtu)
EEIF	16,250	1.59	765
WAP*	562	0.11	4,210
Total	30,537	12.38	4,975

* The evaluation period for WAP was calendar years 2016 – 2017

EcoMetric evaluated the cost-effectiveness of DNREC's programs using the Total Resource Cost (TRC) test. The TRC test compares the costs and benefits of energy efficiency programs to determine if the benefits a program provides are higher than the price of the program. The TRC test considers costs incurred by program participants and Program Administrators and benefits to the utility and ratepayers. The evaluation team used the cost and benefits defined in the Delaware EM&V regulations in the TRC test.

EcoMetric calculated the cost-effectiveness for GEP using gross verified avoided energy and demand generation values. GEP is not overseen by the EEAC, so there is not an approved net-to-gross (NTG) value for the program. EcoMetric calculated the cost-effectiveness for EEIF and WAP using net verified savings. The TRC test results for each program are shown in Table 4.

Table 4: 2016 - 2018 Program Cost-effectiveness Results

Program	NPV of Program Benefits	NPV of Program Costs	TRC Benefit-Cost Ratio
EEIF	\$26,936,669	\$10,294,802	2.62
GEP	\$50,765,366	\$51,666,001	0.98
WAP*	\$3,730,998	\$2,181,096	1.71
Total	\$81,433,033	\$64,141,899	1.27

* The evaluation period for WAP was calendar years 2016 - 2017

¹<http://www.dnrec.delaware.gov/energy/information/otherinfo/Documents/EEAC/Draft%20Proposed%20DE%20EE%20program%20NTG%20values%20with%20assumptions.pdf>



DNREC EE Portfolio Review At-A-Glance

3

**Programs
Evaluated**

550

**Projects
Evaluated**



**Spanning
2016 - 2018**

Energy Efficiency Investment Fund (EEIF)

270

**Projects
Completed**

74

**Projects
Evaluated**

16,250
MWh

1.59
MW

765
MMBtu

First Year Net Savings

101%

Electric
Realization
Rate



2.62
Total Resource
Cost Ratio



89%

Overall
Customer
Satisfaction

Green Energy Program (GEP)

9.56 MW

Solar PV

Verified

382 Tons

Geothermal

Capacity

1,303

**Projects
Completed**

31

**Projects
Evaluated**

13,725
MWh

Avoided
Electric
Generation

100%

Capacity
Realization
Rate



0.98
Total Resource
Cost Ratio

Weatherization Assistance Program (WAP)

445

**Homes
Weatherized**

380

**Homes
modeled in
billing
analysis**

562
MWh

0.11
MW

4,210
MMBtu

First Year Net Savings

153%

Electric
Realization
Rate



1.71
Total Resource
Cost Ratio



86%

Overall
Customer
Satisfaction

E.3 KEY FINDINGS AND RECOMMENDATIONS

The findings and recommendations below represent the principal results and analysis from the impact and process evaluations of DNREC's energy efficiency programs in PY2016 – PY2018. The complete list of findings and recommendations with greater detail on the data and analysis that lead to these key findings and recommendations are found in the respective program-specific sections in this report.

E.3.1 EEIF KEY FINDINGS & RECOMMENDATIONS

Finding 2: The ex ante electric savings calculations for the EEIF program were generally accurate. Nearly half of the sampled projects have an electric realization rate within $\pm 10\%$ of 100%.

Finding 3: The realization rates (RR) for the electric projects in the evaluation sample ranged from 15.5% to 373.8%.

While nearly half of the sample projects have an electric realization rate of $\pm 10\%$ of 100%, the realization rates of the other electric projects in the sample varied significantly from 100%. EcoMetric believes that every project which comes through the program have a detailed review of the savings methodology and algorithm inputs by program staff to ensure consistency and alignment with applicable Mid-Atlantic TRM algorithms. A large variation in project realization rates also impacts the precision of the verified savings and may result in a larger required sample size to achieve precision estimates.

Recommendation 2: Ensure there is an adequate number of program staff with subject matter expertise to review each of the energy efficiency projects that come through the EEIF program.

Finding 4: The ex ante savings calculations for lighting projects were not consistent with the savings methodology outlined in the Mid-Atlantic TRM. The ex ante energy and peak demand savings calculations did not utilize waste heat factors or coincident factors.

Waste heat factors are used to account for cooling and heating impacts from efficient lighting on energy and demand based on Heating Ventilation and Air Conditioning (HVAC) type and building type. The summer peak coincidence factor ensures demand savings calculations reflect the jurisdiction's summer peak period. As was the case with many prescriptive lighting projects in EEIF, not utilizing waste heat factors results in an underestimation of energy and demand savings for air-conditioned spaces with non-electric heating—which are common in the EEIF population and throughout Delaware.

Recommendation 3: Ensure the ex ante energy and peak demand savings calculations follow the savings methodology outlined in the Mid-Atlantic TRM. The Mid-Atlantic TRM savings methodology calculates energy

(kWh) savings, peak demand (kW) savings, and a heating penalty (MMBtu) when applicable for spaces heated with natural gas.

Finding 11: Incorrect baseline conditions were used to calculate savings for three gas projects. The projects included major renovations and boiler replacements.

Custom project baselines are complicated due to their unique nature. The Delaware EM&V regulations allow for project-specific baselines for custom projects that may not align with the baselines noted for the prescriptive measures. Custom project baselines must be representative of the specific equipment or facility operation.

The EEIF program also includes large, complex projects that include major retrofits of multiple systems (electrical and HVAC). Determining which projects are major renovation versus an in-situ retrofit can be difficult, and the savings implications between the two are significant. Projects classified as new construction or major renovation must use the prevailing energy code to set the baseline. Determining if projects qualify as new construction or a major renovation requires understanding the level of work involved and specifics about the driver behind the change.

Recommendation 10: EEIF staff should continue to seek input and guidance from the EEIF technical reviewer or the independent evaluation contractor for large and intricate custom projects, particularly projects with a major renovation or market mean baselines, if an in-house subject matter expert is not available.

Recommendation 11: Reference the Delaware EM&V regulations to determine the appropriate baseline for prescriptive projects.

Finding 12: The energy, demand, and natural gas savings were not consistently calculated and claimed for fuel switching projects.

The Delaware EM&V regulations allow DNREC to claim energy and natural gas savings for projects that involve fuel switching. Fuel switching includes switching from one energy source to a different energy source and claiming savings that result from eliminating the consumption of the old fuel, but also considering the use of the new fuel in an all-fuels program. The Delaware EM&V regulations do not specify how the EEIF program should claim the savings for fuel switching projects. EEIF program staff should work with the Energy Efficiency Advisory Council (EEAC) to clarify how to claim savings for fuel switching projects through the program.

Recommendation 12: In the absence of any prior guidance, the EcoMetric team recommends the energy savings for fuel switching projects should be the fuel neutral difference between the baseline MMBtu and proposed MMBtu. Since the baseline and proposed fuel types are not the same, it is crucial to convert the fuel types to the

equivalent MMBtu to calculate the difference in energy usage. The MMBtu savings may be converted back to appropriate units (kWh, therms) if needed for program tracking.

Process Finding 1: Contractors are interested in being listed as a service provider on the EEIF website as an opportunity to connect with customers and increase program participation.

Process Recommendation 1: Explore the possibility of listing on the website the names of contractors who have completed applications through the program, with appropriate caveats.

Process Finding 3: The contractors interviewed felt that the pre-approval process could be faster, have streamlined documentation requirements, and could be made easier for customers.

During the evaluation, the EEIF program staff informed the EcoMetric team that they were in the process of developing an online application portal for program participants (including contractors) to use to fill out applications and upload project documentation. The online application portal should resolve many of the challenges identified by contractors during the EEIF process evaluation.

Process Recommendation 3: Utilize the EEIF application portal to streamline the application process for customers. The application portal is an important step that DNREC has taken to simplify the application process, including the submission of spreadsheet calculators and other project documentation.

Process Finding 6: Developing a formal mechanism for marketing and outreach may improve participation.

Process Recommendation 5: Conduct research to better understand the target markets for the program and how best to reach them, and then expand program marketing and outreach as appropriate.

Process Finding 7: Contractors are satisfied with their overall experience with the EEIF program and cite program staff as the leading factor for their satisfaction.

Process Finding 8: 89% of customers are satisfied with their overall experience with the EEIF program. Grant levels and the types of eligible equipment were the main drivers of their satisfaction with EEIF.

E.3.2 GEP FINDINGS & RECOMMENDATIONS

Finding 13: The program database consistently reports key variables for GEP projects and is easy to navigate.

The EcoMetric team found the GEP database user-friendly and was able to find critical pieces of information for sampled projects easily. These key variables were consistently reported throughout the database and facilitated an efficient review of sampled projects.

Finding 14: Annual energy generation is not tracked in the GEP database.

GEP is an extensive renewable energy program with a budget of \$2,100,000 annually for renewable energy projects in Delaware. Solar PV and geothermal heat pump measures create benefits for utilities and ratepayers by reducing the amount of electricity consumed and the peak electric demand required from the grid. These annual energy generation and peak demand reductions are critical factors in assessing the cost-effectiveness of the program. The contractors that design these systems often create estimates of energy generation (kWh) to demonstrate the economic benefits of these systems. The existing online application portal for this program already includes the capability to gather the estimated energy generation. The estimated energy generation variable should be included to the list of other variables in the Detailed Applicant Report extract to facilitate the monetization of energy and demand impacts for the cost-effectiveness calculations.

Recommendation 13: Add the estimated energy generation (kWh) variable that is captured for each GEP project in the online application portal to the Detailed Applicant Report extract.

Finding 15: The GEP overall is accurately capturing installed system capacities.

The capacity realization rates for the GEP are very close to 100%, indicating that the program is successfully capturing the capacities of systems installed under the program and accurately reporting the program's achievements.

E.3.3 WAP KEY FINDINGS & RECOMMENDATIONS

Finding 18: WAP relied on per home savings estimates calculated from a small sample of weatherized homes. EcoMetric calculated verified savings for each home and heating fuel type combination which differed from the initial per home estimates.

The EcoMetric team's billing analysis calculated average verified energy savings, demand savings, and fossil fuels savings for each home type and primary heating fuel type combination. The program currently tracks home type and primary heating fuel type for each weatherized home. Reported electric savings were generally in line with verified savings for electrically heated program homes, while reported savings for homes heated with natural gas or other fuels ranged between 31- 65% of verified savings.

Recommendation 16: Use the saving matrix in Table 5 to claim savings for each weatherized home according to the home type and primary heating fuel type.

Table 5: WAP 2016 - 2017 Per-Home Savings Matrix

Heating Type	Home Type	Per Unit Energy Savings (kWh)	Per Unit Peak Demand Reduction (kW)	Per Unit Energy Savings (MMBTU)
Electric	Single family	2,073	0.42	NA
	Manufactured home	1,023	0.05	NA
Natural Gas	Single family	1,081	0.19	9.6
	Manufactured home	851	0.20	16.2
Other fuel	Single family	1,197	0.21	10.7
	Manufactured home	968	0.22	16.7

Not Applicable (NA) for home/fuel type combination

Finding 19: The EcoMetric Team study found the total NEBs value for health to be \$236 per household per year, a net increase of \$64 over the current TRC value.

Recommendation 17: Adopt the following NEB values: \$155 for thermal comfort, \$43 for noise, and \$38 for health. These represent a conservative estimate based on primary research in Delaware at the lower bound of the 90% confidence interval for the point estimates. Conduct a follow-up NEBs study with more surveys to reduce uncertainty in the initial NEBs values, and to further investigate the reasons for higher benefits observed by Delaware's WAP participants compared to other jurisdictions.

Process Finding 12: Adding more issue-specific detail to the WAP procedure manual or developing a second manual that summarizes issue-specific institutional knowledge and making training somewhat more accessible will improve the program's process efficiency.

Process Recommendation 8: Offer webinars as an additional mode of training. Consider adding more issue-specific detail to the WAP procedure manual or developing a detailed issue-specific manual to capture institutional knowledge for subgrantees and subcontractors. Consider opening training to all subcontractor and subgrantee staff, regardless of tenure.

Process Finding 13: Subgrantees are the leading driver of WAP program awareness.

Process Finding 14: 86% of participants are satisfied with their overall experience with WAP. They are most satisfied with the application process.

1.1 CROSS-CUTTING EVALUATION APPROACH

The EcoMetric team used a variety of methods to evaluate the verified program impacts and assess customer satisfaction of DNREC's energy efficiency and renewable energy programs. The team utilized engineering desk reviews, site visits, engineering analysis, interval billing analysis, telephone surveys, documentation review, and interviews with DNREC staff, WAP subgrantees, EEIF contractors, and program participants to evaluate DNREC's energy efficiency programs. This section explains the evaluation approach in more detail, including the overall sample design and basic descriptions of methods applied.

1.1.1 OVERALL SAMPLE DESIGN

The evaluation goals used when developing this sampling plan were:

- ▶ Determine the verified first-year gross energy, demand, and natural gas savings with 90% confidence and 10% precision for the DNREC portfolio.
- ▶ Determine the verified first-year gross energy and demand savings for each program.
- ▶ Quantify the non-energy benefits (NEB) for WAP.
- ▶ Analyze and make recommendations to improve the energy efficiency and renewable energy programs.
- ▶ Estimate the avoided greenhouse gas emissions from all fuels.

The Delaware EM&V regulations² specify that a program year runs from January 1 through December 31. EcoMetric also knows that DNREC tracks program data on a fiscal year basis, which runs June 1 through May 30. The evaluation team used the EM&V regulation's definition for a program year when developing the sample design. Therefore, the program years all include projects from different fiscal years. For example, the 2016 program year for the EEIF program includes projects completed in the latter half of FY15 and the first half of FY16.

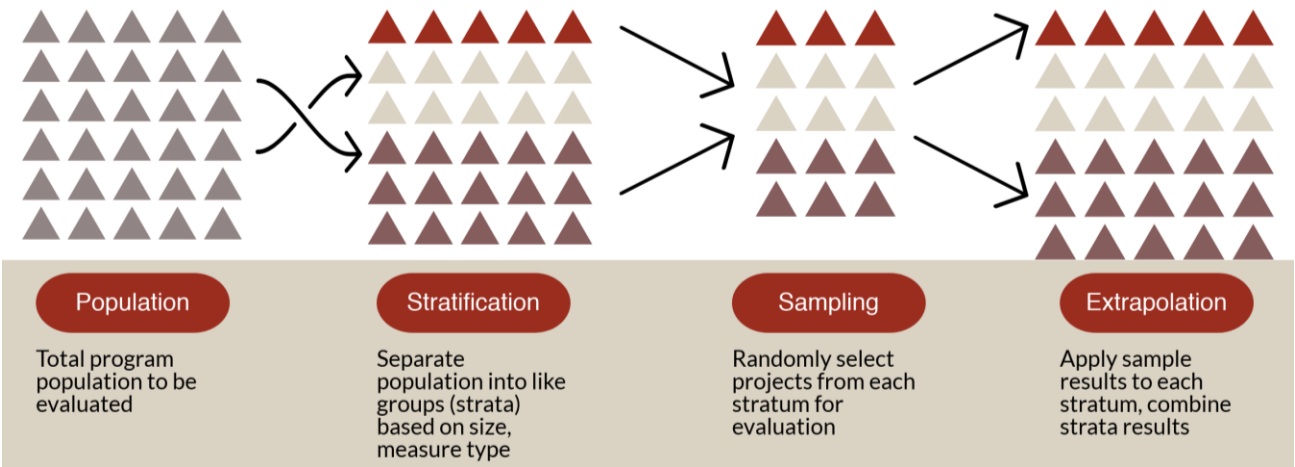
EcoMetric also combined 2016 through 2018 program year data into one single population for the GEP (GEP) and Energy Efficiency Investment Fund (EEIF) programs. The Weatherization Assistance Program (WAP) impact evaluation included 2016 and 2017 projects only to ensure sufficient ex post data is

² Regulations Governing Evaluation, Measurement, and Verification Procedures and Standards. Proposed on June 15, 2018. Section 3.0, page 3.

available from each participant. The process evaluation for WAP included projects completed through October 2018 to assess customer satisfaction and quantify NEBs with as large a sample as possible.

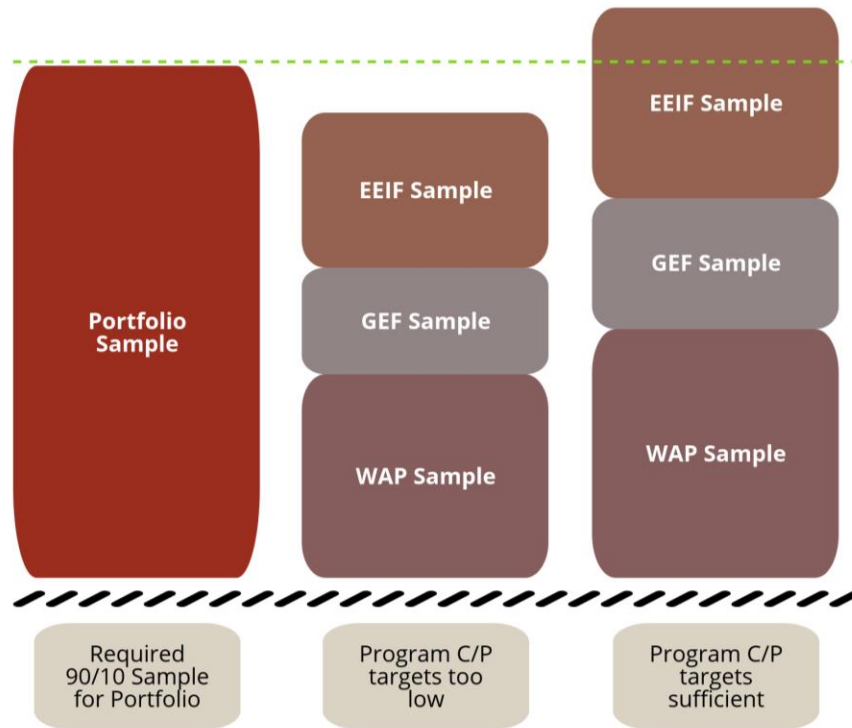
EcoMetric utilized a sampling strategy across different programs. Using a sample allowed the evaluation team to complete a statistically valid review of the program impacts while reducing the number of individual projects or surveys that were required.

Figure 2: Sampling Flow Chart



EcoMetric designed the program samples to achieve at least 90% confidence and 10% precision at the portfolio level, which is the industry standard practice for cost-effective yet rigorous evaluation sampling. This means the actual savings achieved by DNREC are 90% likely to be within plus or minus 10% of the EcoMetric verified savings. EcoMetric set target confidence and precision levels for each program, so the program level samples build to exceed the required number of sample points for the portfolio while maintaining precision below the maximum target. Further, EcoMetric conducted a census billing analysis for WAP.

Figure 3: Program Sample Compared to Portfolio Sample



The specific number of sample points for each program was calculated using industry-standard statistical methods.^{3,4} EcoMetric determined the required sample sizes for each program based on the desired confidence and precision, using the equation shown below.

$$n_0 = \left(\frac{z * C_v}{P} \right)^2$$

Where:

n_0 = required sample size if infinite population

z = z-score of confidence level for normal distribution (i.e. 1.645 for 90%)

³ Khawaja, M.S.; Rushton, J.; and Keeling, J. (2017). Chapter 11: Sample Design Cross-Cutting Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/ SR-7A4068567. <http://www.nrel.gov/docs/fy17osti/68567.pdf>

⁴ Evaluation Framework for Pennsylvania Act 129 Phase III Energy Efficiency and Conservation Programs. http://www.puc.pa.gov/Electric/pdf/Act129/SWE_PhaseIII-Evaluation_Framework082516.pdf

C_v = coefficient of variation assumed to be 0.5⁵

P = desired relative precision (i.e. 10%)

Program populations do not have infinite participants. EcoMetric adjusted the theoretically required sample size to account for finite populations using the following equation.

$$n = \frac{N * n_0}{N + n_0}$$

Where:

n = required sample corrected for finite population size

N = program population

EcoMetric tailored the sample frames, sample design, and stratification utilized to each of the three programs evaluated. Table 6 includes participant sample sizes for impact evaluation activities based on the target confidence levels/precision (margin of error) ranges. EcoMetric describes further details of the program samples within sections 2, 3, and 4 for the EEIF, GEP, and WAP programs, respectively.

Table 6: Summary of Program Population and Sample Size

Program	Projects Completed	Target Confidence / Precision	Sample Size (# of projects)
EEIF	270	Sample (90%/10%)	74
GEP	1,303	Sample (90%/10%)	31
WAP	445	Census	445
Total	2,018		550

1.1.2 GROSS SAVINGS VERIFICATION

The EcoMetric team used a variety of evaluation methods to verify the savings impacts for each of the programs. The evaluation methods include tracking system review, engineering desk reviews, site visits, and billings analyses. Program-specific methodologies for verifying gross savings, data sources, and data collection methods are described in more detail in sections 2, 3, and 4.

⁵ Evaluation industry standard is for program sampling, a Cv of 0.5 is a reasonable and conservative assumption to ensure broad sample coverage.

1.1.3 NET SAVINGS ANALYSIS

Net savings for each program were calculated using deemed NTG ratios. The NTG ratios incorporate free-ridership and spillover factors. Free-ridership accounts for any reductions to gross savings due to what the customer would have done absent the program's influence. The Delaware EEAC completed a literature review and recommended deemed NTG ratios for DNREC.⁶

EcoMetric used the approved NTG ratios, shown in Table 7, to calculate the net savings.

Table 7: Approved Delaware NTG Values

Sector - Initiative	Program	Approved NTG Ratio
Commercial & Industrial - Prescriptive	EEIF	0.80
Commercial & Industrial - Custom	EEIF	0.70
Residential - Low Income	WAP	1.00

1.1.4 SUMMER PEAK DEMAND ANALYSIS

EcoMetric verified summer coincident peak demand impacts for each project based on available data. The EcoMetric team used the following periods to calculate the summer peak demand savings:

- ▶ **EEIF:** As described in the Delaware EM&V regulations, the coincident peak is equivalent to PJM's definition of energy efficiency performance hours under the Reliability Pricing Model (RPM), defined as the hours ending 15:00 through 18:00 Eastern Prevailing Time (EPT) during all days from June 1 through August 31, inclusive, that is not a weekend or federal holiday.⁷
- ▶ **GEP:** As defined in the Delaware EM&V regulations, the coincident peak is equivalent to PJM's definition of energy efficiency performance hours under the Reliability Pricing Model (RPM), defined as the hours ending 15:00 through 18:00 Eastern Prevailing Time (EPT) during all days from June 1 through August 31, inclusive, that is not a weekend or federal holiday.
- ▶ **WAP:** WAP peak demand reduction was estimated using hours broader than defined in the Delaware EM&V regulations while still containing PJM's definition of energy efficiency performance hours under the Reliability Pricing Model (RPM). To align with available cooling loads shapes peak was defined as the hours ending 13:00 through 19:00 Eastern Prevailing Time (EPT) during all days from June 1 through August 31, inclusive, that is not a weekend or federal holiday between the 1-7 weekday hours over the peak months June to August.

⁶<http://www.dnrec.delaware.gov/energy/information/otherinfo/Documents/EEAC/Draft%20Proposed%20DE%20EE%20program%20NTG%20values%20with%20assumptions.pdf>

⁷ <http://regulations.delaware.gov/AdminCode/title7/2000/2105.shtml#TopOfPage>

1.1.5 AVOIDED GREENHOUSE GAS EMISSIONS

EcoMetric estimated the economic impact of reductions in greenhouse gas (CO₂, SO₂, and NO_x) emissions achieved by DNREC's programs and included these impacts as benefits in the cost-effectiveness analysis. EcoMetric first determined the estimated pounds of reduced emissions by applying the emissions rates from PJM's 2014-2018 CO₂, SO₂, and NO_x Emission Rates report⁸ to the net verified savings values. The 2016-2018 PJM emissions rates are shown in Table 8.

Table 8: 2016-2018 PJM Emissions Rates

GHG	Period	2016	2017	2018
CO ₂ lbs/MWh	On-Peak	1,617	1,372	1,338
	Off-Peak	1,471	1,376	1,254
SO ₂ lbs/MWh	On-Peak	1.73	0.97	0.66
	Off-Peak	1.45	0.99	0.68
NO _x lbs/MWh	On-Peak	1.48	1.26	1.03
	Off-Peak	1.14	0.99	0.67

EcoMetric then applied monetary values (\$/ton) taken from Delmarva Power and Light's 2016 Integrated Resource Plan⁹, which estimated the cost of externalities caused by greenhouse gas emissions. The resulting monetary value for each greenhouse gas was:

- ▶ CO₂: \$35.41/ton.
- ▶ SO₂: \$43,000/ton.
- ▶ NO_x: \$9,500/ton.

The economic benefit of GHG emissions reductions was calculated as follows:

$$\begin{aligned}
 & \text{Economic Benefit of GHG Emissions Reductions (\$)} \\
 &= \text{Energy Savings (MWh)} \times \text{Emissions Rate} \left(\frac{\text{lbs}}{\text{MWh}} \right) \times \left(\frac{1 \text{ ton}}{2,000 \text{ lbs}} \right) \\
 & \times \text{Externality Cost} \left(\frac{\$}{\text{ton}} \right)
 \end{aligned}$$

These monetary benefits were included in the cost-effectiveness analysis, as described in the following section.

⁸ <https://www.pjm.com/-/media/library/reports-notice/special-reports/2018/2018-emissions-report.ashx?la=en>

⁹ <https://dep.sc.delaware.gov/wp-content/uploads/sites/54/2017/03/DPL-Public-IRP-113016.pdf>

1.1.6 COST-EFFECTIVENESS ANALYSIS

EcoMetric evaluated the cost-effectiveness of DNREC's programs using the Total Resource Cost (TRC) test. The TRC test computes the ratio of program benefits to program costs, resulting in a number usually between 0.5 and 5. Programs with TRC scores of less than one show that costs exceed total benefits. A TRC score greater than one indicates the program achieved more lifetime benefits than costs. The TRC test considers costs incurred by program participants and Program Administrators and benefits to the utility and ratepayers. EcoMetric included the following costs as required in the Delaware EM&V regulations:

- ▶ Equipment and installation costs that are incremental to baseline costs
- ▶ Increases (or decreases) in operation and maintenance costs
- ▶ Cost of removal less salvage value
- ▶ Administrative costs directly attributable to the programs
- ▶ Costs for EM&V activities and utility performance incentives
- ▶ Federal tax credits as a cost reduction

The Delaware EM&V regulations also define the appropriate benefits for inclusion in the TRC test. EcoMetric included the following benefits in the TRC tests:

- ▶ Avoided electric supply costs based on energy costs in the respective zone of the PJM Regional Transmission Organization
- ▶ Avoided electric transmission, distribution, and generation capacity costs valued at marginal cost for the periods when there is a load reduction, based on relevant prices in the respective zone of the PJM Regional Transmission Organization
- ▶ Reduced SREC and RECs requirements
- ▶ Avoided gas supply and delivery costs
- ▶ The effect of lower prices for electric and gas energy and capacity in wholesale markets resulting from reductions in the quantity of energy and capacity sold in those markets, sometimes referred to as Demand-Reduction-Induced Price Effect (DRIPE)
- ▶ Avoided costs of energy savings in fuels other than electricity and natural gas, or from equivalent energy efficiency measures, such as a reduction in delivered heating fuel resulting from improvements in the building envelope or other systems
- ▶ Avoided environmental compliance costs, where such costs can be directly tied to changes in energy use

Additionally, the Weatherization Assistance Program includes non-energy benefits, as described in section 1.3 of this report.

EcoMetric obtained avoided cost, reduced Solar Renewable Energy Credit (SREC), reduced Renewable Energy Credit (REC) requirements, and DRIPE figures from the DNREC technical advisor.¹⁰

EcoMetric determined the monetary value of liquid fuel savings by first converting the MMBtu savings for in the tracking data into gallons using typical energy values for each fuel. The team then turned the gallons into dollars using average statewide prices provided by DNREC staff.

EcoMetric determined the monetary value of reduced emissions using the approach described in section 1.1.5 above.

The TRC test compares the net present values (NPV) of costs and benefits over the lifetime of the measures implemented. The effective useful life (EUL) of each measure is used to determine lifetime savings, and a discount rate is used to discount the value of future costs and benefits to present-day dollars. EcoMetric obtained measure EULs from DNREC staff and secondary sources such as the Mid-Atlantic and Pennsylvania Act 129 Technical Reference Manuals. The Delaware EM&V regulations set forth a discount rate of 4%.

EcoMetric developed a cost-effectiveness model accounting for the appropriate costs and benefits determined through this evaluation. The model calculates a benefit-cost ratio for each program as well as the entire DNREC portfolio.

The equations EcoMetric used to calculate the TRC benefit-cost ratios are as follows:

$$TRC\ BenefitCost\ Ratio = \frac{NPV\ of\ Benefits}{NPV\ of\ Costs}$$

$$NPV\ of\ Benefits = NPV\ of\ Lifetime\ Avoided\ Costs + NPV\ of\ Lifetime\ NonEnergy\ Benefits$$

$$NPV\ of\ Lifetime\ Avoided\ Costs$$

$$= NPV\ of\ Avoided\ Cost\ of\ Energy + NPV\ of\ Avoided\ Cost\ of\ Capacity \\ + NPV\ of\ Avoided\ Cost\ of\ Fossil\ Fuel$$

$$NPV\ of\ Avoided\ Cost\ of\ Energy$$

$$= Net\ Verified\ Annual\ MWh\ Savings \times (NPV\ of\ Avoided\ Cost\ per\ MWh \\ + NPV\ of\ Avoided\ Cost\ of\ GHG\ Emissions\ per\ MWh)$$

¹⁰ *Avoided costs for use in cost-effectiveness analysis.* Prepared by Optimal Energy. February 3, 2017.

EcoMetric derived *NPV of Avoided Cost per MWh* using the avoided costs from the Optimal Energy memo and the discount rate described above. The NPV is taken over the lifetime of each measure.

NPV of Avoided Cost of GHG Emissions per MWh =
NPV(PJM lbs GHG Emissions per MWh × Delmarva Cost per lbs GHG Emissions) over the lifetime of each measure (see section 1.1.5).

NPV of Avoided Cost of Capacity

= Net Verified Annual Peak MW Reduction × NPV of Avoided Cost per MW

EcoMetric derived *NPV of Avoided Cost per MW* using the avoided costs from the Optimal Energy memo and the discount rate described above. The NPV is taken over the lifetime of each measure.

NPV of Avoided Cost of Capacity

= Net Verified Annual Peak MW Reduction × NPV of Avoided Cost per MW

EcoMetric derived *NPV of Avoided Cost per MW* using the avoided costs from the Optimal Energy memo and the discount rate described above. The NPV is taken over the lifetime of each measure.

NPV of Avoided Cost of Fossil Fuel

= Net Verified Annual MMBtu Savings × NPV of Avoided Cost per MMBtu

EcoMetric derived *NPV of Avoided Cost per MMBtu* using the avoided costs from the Optimal Energy memo and the discount rate described above. The NPV is taken over the lifetime of each measure.

NPV of Lifetime NonEnergy Benefits

= NPV of Avoided Liquid Fuel Costs + NPV of Other NonEnergy Benefits

NPV of Avoided Liquid Fuel Costs

= Net Verified Annual Liquid Fuel MMBtu Savings

× Gallons of Fuel per MMBtu of Energy × NPV of Fuel Price per Gallon

EcoMetric derived *NPV of Fuel Price per Gallon* using the fuel costs provided by DNREC staff and the discount rate described above. The NPV is taken over the lifetime of each measure.

EcoMetric derived *NPV of Other NonEnergy Benefits* using the non-energy benefits described in section 1.3 and the discount rate described above. The NPV is taken over the lifetime of each measure.

NPV of Costs = Program Administrative Costs + Incremental Measure Costs

Program Administrative Costs were provided by DNREC.

EcoMetric compiled *Incremental Measure Costs* from the tracking and measure data provided by DNREC.

1.2 PROCESS EVALUATION

The team performed process evaluations for EEIF and WAP. The objectives of the process evaluations were to identify opportunities to improve the program and to assess customer satisfaction. The process evaluations consisted of:

- ▶ Reviewing program materials and examining the program tracking data to explore patterns of program participation, develop participant survey samples, and identify key characteristics of program-supported measures.
- ▶ Conducting in-depth telephone interviews with:
 - Program staff to clarify the team's understanding of the programs and identify and prioritize topics for further research with participants, WAP subgrantees and EEIF contractors.
 - WAP subgrantees and EEIF contractors to understand their perspectives on the program and assess program processes.
- ▶ Conducting surveys with randomly selected samples of program participants to understand their participation experience, assess their satisfaction with the program, and identify opportunities for improving program design and delivery.
- ▶ Included in the surveys with WAP participants were additional questions to collect data for measuring NEBs.

The team included households and businesses that participated between 2016 and 2018 in the process evaluation sample frame. Table 9 summarizes the process evaluation data collection activities and sample sizes.

Table 9: Process Evaluation Data Collection & Sample Design

Population	Data Collection Method	Sample Frame (N)	Completed Sample Size (n)	Incentive
Energy Efficiency Investment Fund (EEIF)				
Participating End-Users	Mixed-mode internet survey with telephone follow-up	177	63	\$10 gift card
More Active Contractors	In-depth telephone interview	N/A	5	N/A
Program staff	In-depth telephone interview	1	1	N/A
Weatherization Assistance Program (WAP)				
Participating End-Users	Telephone survey (offered in English and Spanish)	445	62	\$10 Gift card
Subgrantees	In-depth telephone interview	2	2	N/A
Program staff	In-depth telephone interview	1	1	N/A

1.3 NON-ENERGY BENEFITS (NEB)

The EcoMetric team collected primary data from a sample of WAP participants to estimate non-energy benefits (NEBs) from three different perspectives:

1. Participant – customer or property manager/landlord
2. Societal
3. Utility or program administrator.

Participant NEBs are those that directly benefit the health, safety, or quality of life of the utility customer (or landlord) who participated in the program. Societal NEBs are those that accrue to society (i.e., externalities) such as public health impacts, reductions in greenhouse gas and particulate emissions, water savings, and economic improvements. These two perspectives may overlap where, for example, water savings that benefit the water supply chain can also be reaped by the customer as savings on their water bills. Utility or program administrator NEBs include benefits such as fewer terminations of service, reconnections, and customer calls.

The following typical *participant* NEBs have been monetized by other states and incorporated into cost-effectiveness testing:¹¹

- ▶ Comfort
 - Thermal comfort
 - Home productivity
 - Noise
- ▶ Health
 - Cold-related thermal stress
 - Heat-related thermal stress
 - Missed work
 - Asthma symptoms
- ▶ Safety
 - Home fires
 - Carbon monoxide poisoning
- ▶ Other
 - Property value
 - Home durability
 - Equipment reliability and maintenance

Northeast Energy Efficiency Partnerships (NEEP) prepared a comprehensive overview of how Mid-Atlantic and other states treat and use NEBs in their cost-effectiveness testing.¹² According to this overview and other documentation, Delaware applies NEBs from all three perspectives in its TRC testing: avoided compliance costs and reduced arrearages (utility), reduced emissions and water usage (societal), and health and safety (participant).¹³

¹¹ According to the 2017 NEEP study “Non-Energy Impacts Approaches and Values: an Examination of the Northeast, Mid-Atlantic, and Beyond,” some states or jurisdictions that use any or all of these NEBs their cost-effectiveness testing include Massachusetts, California, Vermont, Washington D.C., and New York.

¹² NEEP. “Non-Energy Impacts Approaches and Values: an Examination of the Northeast, Mid-Atlantic, and Beyond.” June 2017.

¹³ They also claim savings from operations and maintenance, but it does not appear that it is associated with WAP as that is usually a commercial or multifamily program NEB.

Together, EcoMetric and DNREC selected three NEBs to study through primary research with WAP participants: thermal comfort, noise, and health. The group chose these based on the following criteria:

- ▶ Thermal comfort, noise, and health are more easily measured through a single customer survey. In contrast, specific NEBs, such as changes in home fires, are difficult to accurately quantify without control groups and pre- and post-weatherization surveys. Additionally, home fires generally do not occur frequently enough to assess via surveys with small samples sizes.
- ▶ Similarly, these three NEBs are appropriate for self-reporting. Some NEBs, such as increased property value, can be challenging for respondents – particularly renters – to estimate.
- ▶ Thermal comfort, noise, and health do not extensively overlap with other NEBs. For example, as the increase in a home's property value due to weatherization is in part a function of other NEBs (e.g., thermal comfort), claiming the benefits of thermal comfort and property value could result in double counting.
- ▶ DNREC WAP measures would likely be associated with these NEBs. For example, equipment reliability and maintenance are related to the installation of new heating and cooling units, which DNREC's WAP does not directly support, so EcoMetric deprioritized studying that NEB.
- ▶ Because DNREC's WAP is delivered to single-family customers, the property manager and landlord NEBs, such as tenant complaints, were less relevant to explore.

Section 4.1.6 presents the results of the team's NEBs research.

2 ENERGY EFFICIENCY INVESTMENT FUND RESULTS

The Energy Efficiency Investment Fund program (EEIF) provides financial incentives to businesses, state agencies, local governments, and non-profits to make energy efficiency upgrades in existing facilities in Delaware. The incentives are designed to defray some of the cost difference between high-efficiency equipment and equipment that is no more efficient than what is commonly installed in commercial buildings (i.e., “baseline” equipment).

Organizations apply to EEIF for either “prescriptive” or “custom” incentives. The majority of projects supported by EEIF are prescriptive lighting.

Prescriptive: The prescriptive path offers set incentives for standard efficiency measures. These include energy-efficient lighting, lighting control improvements, high efficiency heating, water heating systems, and vending applications. Organizations that participate apply for a grant for the total of incentives applicable to their project. Grants cannot exceed 30% of the total project cost for eligible prescriptive or custom measures. For each measure implemented through the prescriptive path, the program assigns savings based on TRM-derived savings algorithms or deemed savings values.

Custom: The custom path supports cost-effective energy efficiency measures that DNREC does not offer on a prescriptive basis. Custom incentives vary by project and depend on incremental cost, calculated energy and demand savings of a retrofit project, and cost-effectiveness and total project cost. Custom projects are generally more complex than prescriptive projects and include aggressive measures that permanently raise the efficiency levels of standard equipment.¹⁴

Delaware contractors typically bring end-user customers into the program and help them through the process of becoming EEIF grantees. DNREC staff are responsible for reviewing and approving applications, tracking the details of each project for the program, and disbursing grant monies upon project completion.

¹⁴ For a full list of the kinds of projects that may be eligible for custom incentives through EEIF, see <https://dnrec.alpha.delaware.gov/climate-coastal-energy/efficiency/energy-efficiency-investment-fund/>.

2.1 IMPACT EVALUATION

2.1.1 PROGRAM DATABASE REVIEW AND SAMPLING

The Energy Efficiency Investment Fund (EEIF) program had 270 different projects completed during 2016 through 2018 calendar years. EcoMetric defined each line item in the tracking data as a unique project. Additionally, projects were only included in the analysis if they were assigned “completed” status.

The EEIF program has seen participation increase steadily, and savings increase significantly during the 2016 – 2018 timeframe. A summary of each program year is shown in Table 10.

Table 10: EEIF 2016 - 2018 Program Summary

Calendar Year	Projects Completed	Energy Savings (MWh)	Gas Savings (MMBtu)
2016	136	6,801	94
2017	59	4,222	1,832
2018	75	9,431	6,708
Total	270	20,455	8,634

Finding 1: Peak demand savings (kW) are not tracked in the EEIF program database. Most energy efficiency projects completed through the program realize peak demand savings.

Recommendation 1: Track and claim peak demand savings for each project in the program tracking database.

Prescriptive projects provide much of the electrical savings for each program year. Custom projects provide all the natural gas savings for each program year.

Table 11: EEIF Program Data Prescriptive versus Custom Projects

Calendar Year	Project Type	Projects Completed	Energy Savings (MWh)	Gas Savings (MMBtu)
2016	Prescriptive	88	5,128	0
	Custom	48	1,674	94
2017	Prescriptive	52	3,871	0
	Custom	7	351	1,832
2018	Prescriptive	67	8,768	0
	Custom	8	663	6,708
Total		270	20,455	8,634

The sample frame for the EEIF program stratifies each program year into prescriptive and custom strata. EcoMetric pulled projects with natural gas savings into a separate stratum to ensure reliable estimates of

the natural gas savings. The sample design further divided each of the three project types (prescriptive, custom, and gas) into certainty and probability sub-strata. Certainty projects are those who contribute a significant amount of energy savings to the prevailing strata. EcoMetric allocated projects with electricity savings higher than 500 MWh and natural gas projects with more than 1,000 MMBtu to the certainty strata.

EcoMetric assigned all remaining projects to the probability strata. Due to the large number and significant savings of prescriptive projects, EcoMetric further divided the probability strata into large and small strata. Large prescriptive projects are those with more than 200 MWh but less than 500 MWh. The small prescriptive probability stratum includes all projects with less than 200 MWh of energy savings. The EEIF program sample frame is shown in Table 12.

Table 12: 2016 – 2018 EEIF Program Sample Frame

Project Type	Strata	Description	Projects	Energy Savings (MWh)	Gas Savings (MMBtu)
Prescriptive	Certainty	Greater than 500 MWh	5	3,648	0
	Large Probability	200 - 500 MWh	22	7,023	0
	Small Probability	Under 200 MWh	180	7,095	0
Custom - Electric	Certainty	Greater than 500 MWh	1	602	0
	Probability	Under 500 MWh	52	1,360	0
Custom - Gas	Certainty	Greater than 1,000 MMBtu	3	0	6,967
	Probability	Under 1,000 MMBtu	7	727	1,667
Total			270	20,455	8,634

A total of 74 sample points was drawn for the EEIF program to target 90% confidence and 10% precision. The sample points were allocated first to the certainty strata, and then to the probability strata. Utilizing certainty strata ensures that EcoMetric evaluated the most significant projects, and ultimately allows EcoMetric to reduce the number or probability sites that are needed. The number of sample points allocated to each stratum and the percentage of projects and savings covered by the sampled projects is shown in Table 13.

Table 13: 2016 – 2018 EEIF Sample Coverage

Project Type	Strata	Sample Points	Sampled MWh	Percent MWh	Sampled MMBtu	Percent MMBtu
Prescriptive	Certainty	5	3,648	18%	0	0%
	Large Probability	13	4,084	20%	0	0%
	Small Probability	32	1,884	9%	0	0%
Custom - Electric	Certainty	1	601.89	3%	0	0%
	Probability	17	636	3%	11	0%
Custom - Gas	Certainty	3	0	0%	6,967	81%
	Probability	3	617	3%	1,156	13%
Total		74	11,471	56%	8,134	94%

2.1.2 GROSS SAVINGS VERIFICATION

2.1.2.1 Engineering Desk Reviews

The primary data source for the EEIF projects was applications, product specification sheets, scanned calculations, and other data and documentation provided by the program staff in support of the reported savings estimates. EcoMetric carefully reviewed the supplied documentation for each project. The review of project documentation provided an understanding of the efficiency upgrades implemented, and just as importantly, how savings from these upgrades were estimated.

EcoMetric also conducted site visits for a sample of custom and prescriptive projects. The site visits allow for additional data collection to supplement engineering desk reviews. During the site visits, the participant was interviewed to confirm any factors that may impact the energy savings for the installed equipment. Table 14 summarizes the number of desk reviews and site visits that the EcoMetric team completed for the 2016-2018 evaluation period.

Table 14: Summary of Desk Reviews and Site Visits

Measure Type	Number of Desk Reviews	Number of Site Visits
Prescriptive	44	6
Custom - Electric	18	0
Custom - Gas	2	4
Total	64	10

2.1.2.2 Engineering Desk Reviews

To verify gross savings estimates, the EcoMetric team completed engineering desk reviews for a sample of projects in the evaluation sample. The evaluation sample included both custom and prescriptive projects. Engineering desk reviews for prescriptive projects ensured the savings followed the

methodology in the Mid-Atlantic TRM. The engineering review for custom projects focused on the specific details unique to the measure type and operating parameters at the site of installation.

Both custom and prescriptive projects received a documented review as part of the engineering desk review. The document review included examining all the information in the project files to ensure that projects were consistent with program assumptions. EcoMetric also compared the project documentation to information captured in the tracking system to determine data accuracy. Where a project was inconsistent with the approved assumptions or methods, EcoMetric recalculated the savings based on our experience and engineering judgment, as well as any information available in the project files. EcoMetric also collected additional information during site visits.

The engineering desk review also included a detailed review of the savings calculations for the custom and prescriptive projects. As noted above, the savings methodologies for custom and prescriptive projects were different. Detailed descriptions of the custom and prescriptive savings reviews are below.

- ▶ For custom projects that were in the EEIF evaluation sample, the engineering desk reviews included the following:
 - Review of engineering analyses for technical soundness, proper baselines, and appropriate approaches for the specific application
 - Review of methods determining demand savings to ensure they are consistent with Delaware EM&V regulations for calculating peak savings
 - Review of input data for appropriate variables such as equipment capacities, equipment quantities, hours of operation, and weather data to determine if they are consistent with facility operation
 - Confirmation of installation using invoices and post-installation reports or documentation
 - Review of input data for appropriate baseline specifications to ensure the equipment type, capacities, and efficiencies are consistent with the criteria set forth the Delaware EM&V regulations
- ▶ For prescriptive projects that were in the EEIF evaluation sample, the engineering desk reviews included the following:
 - Review of invoices and specification sheets to confirm installation date as well as equipment capacities, equipment quantity, and equipment type
 - Review of measures available in the Mid-Atlantic TRM to determine the most appropriate algorithms which apply to the installed measure

- Recreation of savings calculations using the Mid-Atlantic TRM algorithms and inputs as documented by submitted specifications, invoices, and any post-installation documentation

2.1.2.3 Site Visits

Site visits were used to supplement the document reviews for targeted projects that warranted a higher level of measurement. The targeted use of site visits allowed the evaluation team to verify inputs with high uncertainty and provides greater confidence in the savings attributed to each measure (and thereby program).

The EcoMetric team developed a site-specific measurement and verification plan that identified factors of uncertainty that have a significant impact on the calculated energy savings and set forth a proposed analysis methodology including data to be collected, questions to be asked for the customer interview, and equipment to be inspected.

The site visits enabled the EcoMetric team to physically inspect the installed equipment and ask the customer detailed questions about the equipment operation before and after the completion of the project. The site visits also allowed the engineers to confirm equipment capacities, equipment quantities, and annual hours of operation. When available, customers provided updated operating data and utility bills that EcoMetric used in the verified savings analyses.

2.1.2.4 Billing Analysis

A billing analysis (IPMVP Option C¹⁵) was used for measures that were high impact, weather-sensitive, or had significant interactive effects. A regression analysis was performed on consumption data and statistically adjusted for key variables that changed over time and were correlated with consumption. The EcoMetric team incorporated weather-normalized consumption as the dependent variable and included heating- and cooling-degree days directly in the model.

2.1.3 VERIFIED RESULTS

EEIF projects fall into three general categories: prescriptive, custom – electric, and custom – gas projects. Table 15 shows gross verified energy savings for the EEIF projects evaluated. Overall, the measures achieved an electric realization rate of 101%, resulting in 20,652 MWh of first-year electric savings. The gas realization rate was 12.7%, resulting in 1,093 MMBtu of first-year gas savings. The relative precision¹⁶ of the electric savings realization rate was 7.5% at the 90% confidence level. The relative precision of the

¹⁵ <https://www.nrel.gov/docs/fy02osti/31505.pdf>

¹⁶ Relative precision represents the uncertainty of the calculated realization rate for the program's population relative to the value of the program's realization rate for the sample at the 90% confidence level.

gas savings realization rate was 14% at the 90% confidence level due to higher variance in the sample. Gross demand savings totaled 2.03 MW.

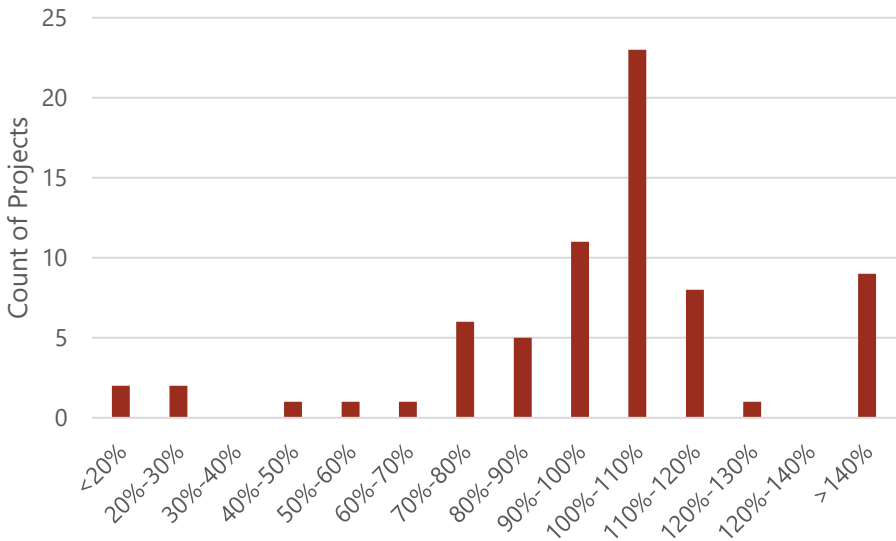
Table 15: EEIF Gross Verified Savings Results

Project Type	# of Projects Completed	Electric Realization Rate	Gross Verified Electric Savings (MWh)	Relative Electric Precision at 90% Confidence	Gross Verified Demand Savings (MW)	Gross Verified Gas Savings (MMBtu)	Relative Precision Gas at 90% Confidence
Prescriptive	207	103%	17,938	7.5%	1.66	0	NA
Custom - Electric	53	72%	1,980	7.5%	0.22	0	NA
Custom - Gas	10	90%	734	NA	0.16	1,093	14.0%
Total	270	101%	20,652		2.03	1,093	

Not Applicable (NA): the value is not applicable

Figure 4 shows the distribution of electric realization rates for the EEIF sample. Over 45% of the sampled projects have an electric realization rate between 90% and 110%, highlighting the overall accuracy of ex ante electric savings calculations for the program.

Figure 4: Distribution of EEIF Electric Realization Rates



Finding 2: The ex ante electric savings calculations for the EEIF program were generally accurate. Nearly half of the sampled projects have an electric realization rate within ±10% of 100%.

Finding 3: The realization rates (RR) for the electric projects in the evaluation sample ranged from 15.5% to 373.8%.

While nearly half of the sample projects have an electric realization rate of $\pm 10\%$ of 100%, the realization rates of the other electric projects in the sample varied significantly from 100%. EcoMetric believes that every project which comes through the program have a detailed review of the savings methodology and algorithm inputs by program staff to ensure consistency and alignment with applicable Mid-Atlantic TRM algorithms. A large variation in project realization rates also impacts the precision of the verified savings and may result in a larger required sample size to achieve precision estimates.

Recommendation 2: Ensure there is an adequate number of program staff with subject matter expertise to review each of the energy efficiency projects that come through the EEIF program.

2.1.3.1 Gross Savings Results for Prescriptive Projects

The 207 prescriptive projects completed through the EEIF program achieved 17,938 MWh of gross verified electric savings, accounting for 87% of the program's total electric savings. Ex ante electric savings were generally accurate, resulting in an overall electric realization rate of 103.1%¹⁷. Realization rates for these prescriptive projects varied from 100% for several overarching reasons detailed in the following findings and recommendations.

Finding 4: The ex ante savings calculations for lighting projects were not consistent with the savings methodology outlined in the Mid-Atlantic TRM. The ex ante energy and peak demand savings calculations did not utilize waste heat factors or coincident factors.

Waste heat factors are used to account for cooling and heating impacts from efficient lighting on energy and demand based on Heating Ventilation and Air Conditioning (HVAC) type and building type. The summer peak coincidence factor ensures demand savings calculations reflect the jurisdiction's summer peak period. As was the case with many prescriptive lighting projects in EEIF, not utilizing waste heat factors results in an underestimation of energy and demand savings for air-conditioned spaces with non-electric heating—which are common in the EEIF population and throughout Delaware.

Recommendation 3: Ensure the ex ante energy and peak demand savings calculations follow the savings methodology outlined in the Mid-Atlantic TRM. The Mid-Atlantic TRM savings methodology calculates energy

¹⁷ Based on the evaluation team's experience, the realization rates for prescriptive programs throughout the industry typically range from 90% to 100%.

(kWh) savings, peak demand (kW) savings, and a heating penalty (MMBtu) when applicable for spaces heated with natural gas.

Finding 5: The building type and heating type were not always correctly reported by the participant in the EEIF Prescriptive Grant applications. Several applications left the building and heating type blank or selected more than one option.

Not having accurate building type and heating type data has multiple implications in the calculation of energy and demand savings leveraging the Mid-Atlantic TRM for lighting projects. For example, the hours of use, waste heat factors (energy and demand) and coincidence factors all vary by building type. While an engineer can usually estimate the building type by the company's name or location, commercial participants often have complex sites with multiple building types and sizes. For example, a car dealership can have an industrial type warehouse or shop along with retail space and offices. In terms of heating types, annual waste heat energy factors in the Mid-Atlantic TRM V7.0 for an office in Delaware range from 1.10 for non-electric heating to 0.75 for electric resistance heating.¹⁸

Recommendation 4: Update the EEIF Prescriptive Grant Application to include building type options that match the Mid-Atlantic TRM V7.0. Add a note that the building type chosen should reflect the space where the efficient measure is installed. Remove the note "check all that apply" from the building heat section of the application and replace it with a note to select only the "primary" heating type for the space where the efficient measure is being installed. Heating type options should match the TRM 7.0: Natural Gas, Electric Resistance, Heat Pump and Other—please specify.

Most of the information provided in the applications and ex ante reviews were satisfactory for accurate ex post electric, demand, and natural gas savings calculations. However, the evaluation team did find some common issues with this data in the prescriptive project sample.

Finding 6: A portion of custom lighting projects completed in 2016 did not include documentation to verify the existing fixture power. EEIF staff appear to have addressed the finding as the project documentation for custom projects completed in 2017 and 2018 include the appropriate information to verify equipment specifications.

Recommendation 5: Continue to ensure participants submit documentation such as fixture model numbers, photos, or specification sheets for custom lighting projects so the input power of the existing light fixtures can be verified.

¹⁸ Mid-Atlantic Technical Reference Manual Version 7.0 (May 2017). Appendix D, pg. 465.

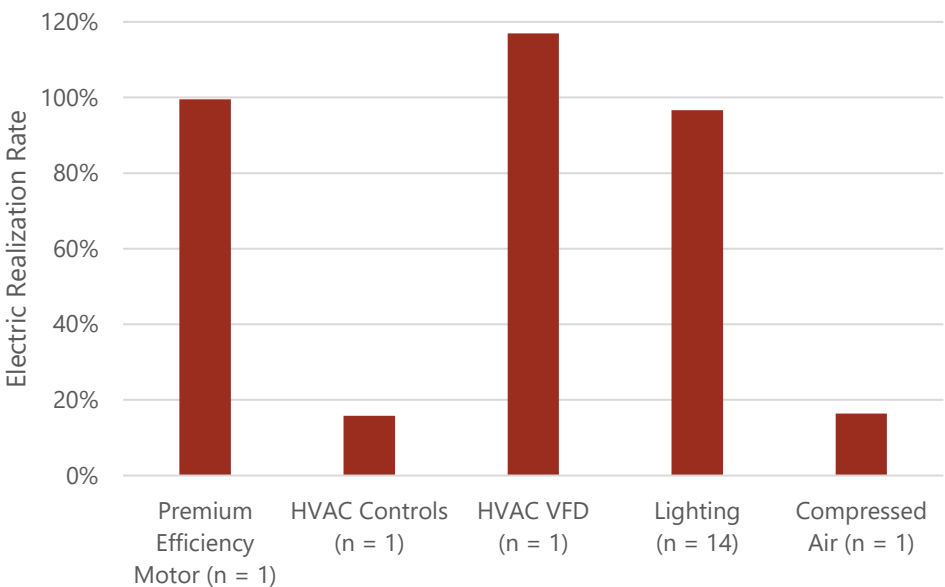
Finding 7: Ex Ante savings analyses used nominal lamp wattage for HID fixtures instead of the input fixture power, which includes both the nominal lamp watts and power to operate the ballast.

Recommendation 6: Ensure all projects replacing HID fixtures with LED fixtures use the total input fixture power.

2.1.3.2 Gross Savings Results for Custom Electric Projects

The EcoMetric team evaluated lighting and non-lighting custom projects in the supplied program data. The evaluated custom electric projects included a variety of equipment types such as compressed air, HVAC controls, HVAC VFD, lighting, and premium efficiency motors. Figure 5 shows the weighted realization rates for each custom project type in the evaluation sample. The weighted realization rate for the 14 custom lighting projects and the premium efficiency motor project were between 95% and 100%.

Figure 5: Custom Electric Realization Rate by Project Type



All the custom electric projects received an engineering desk review. Since custom non-lighting projects are not bound by the saving algorithms in the Mid-Atlantic TRM, EcoMetric carefully reviewed the savings methodology and technical soundness of algorithm assumptions. The savings methodology for the custom projects varied by technology type. The engineering reviews also focused on verifying the correct baseline from which customers or vendors calculated the savings.

EcoMetric also reviewed the input variables to the saving algorithms to ensure the variables were appropriate and reasonable based on the facility and equipment specific information such as invoices.

The 53 custom electric projects completed through the EEIF program achieved 1,980 MWh of gross verified electric savings, accounting for 10% of the programs total verified electric savings. The verified electric energy savings yielded a 72% realization rate. Based on the evaluation team's experience, realization rates ranging from 70% – 80% can be expected for custom projects due to their complex and variable nature.

Finding 8: The ex ante savings calculations for the custom lighting projects were generally accurate, but the realization rates varied from 100% for the same reasons as the prescriptive lighting projects detailed in section 2.1.3.1.

Recommendation 7: Apply Recommendations 2 through 5 to custom lighting projects as well.

Finding 9: The ex ante savings for a large custom motor and pump project were correctly calculated leveraging pump data measured in the pre- and post-project period.

One of the largest custom motor and pump project achieved over 600,000 kWh of verified electric savings with a realization rate of 99.6%. Custom non-lighting projects are often quite complex and can require measured operating data from the pre- and post-project periods to calculate savings accurately.

Recommendation 8: Continue enforcing the requirement that program participants submit measured operating data from the pre- and post-implementation periods to support energy savings calculations for large custom non-lighting projects.

Finding 10: The ex ante savings calculations for non-lighting projects were not consistent with the savings methodology outlined in the Mid-Atlantic TRM.

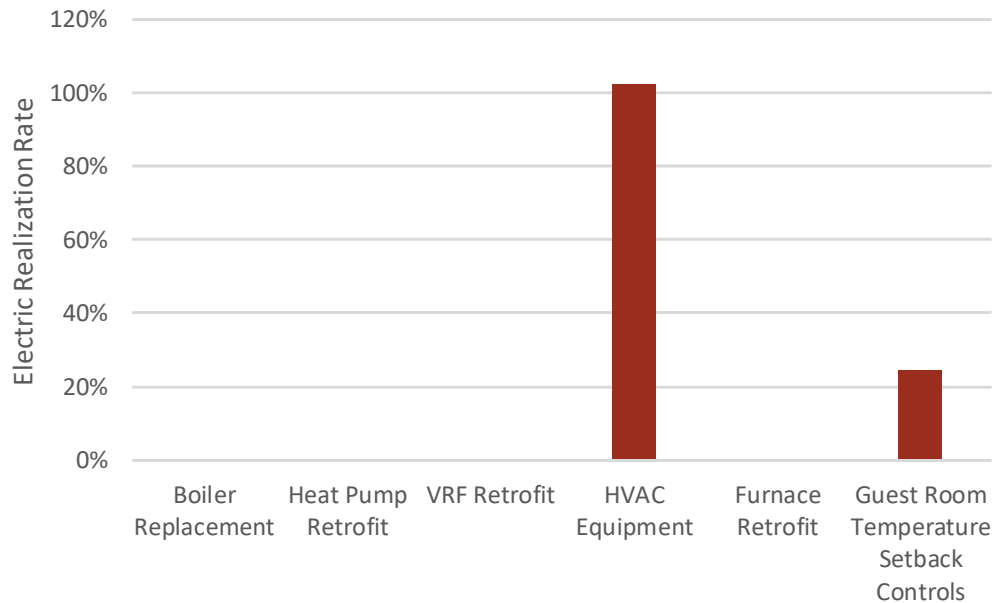
The Mid-Atlantic TRM sets forth savings algorithms and deemed inputs parameters for non-lighting measures that are offered through EEIF such as HVAC VFDs. It is important that the ex ante savings calculations follow the methodology outlined in the TRM for all applicable measures.

Recommendation 9: Program staff should default to the savings methodology outlined in the Mid-Atlantic TRM for non-lighting prescriptive projects.

2.1.3.3 Gross Savings Results for Custom Gas Projects

The evaluated custom gas projects included a variety of equipment types such as boiler replacements, heat pump retrofits, variable refrigerant flow (VRF) retrofits, furnace retrofits, and guest room temperature controls. Figure 6 shows the realization rates for each custom project type in the evaluation sample.

Figure 6: Custom Gas Realization Rate by Project Type*



*Boiler Replacement, Heat Pump Retrofit, VRF Retrofit, and Furnace Retrofit measures had a 0% RR for gas savings.

Similar to the electric custom projects, custom gas projects are not bound by the saving algorithms in the Mid-Atlantic TRM. EcoMetric carefully reviewed the savings methodology and technical soundness of algorithm inputs and assumptions. Four of the six custom gas projects received a site visit while the two remaining custom gas projects received an engineering desk review.

Site visits enabled EcoMetric to physically verify the installation of equipment for each of the four custom projects. The EcoMetric team interviewed the participant to gain a better understanding of the project and how the equipment operated before and after the completion of the project. The site visits also focus on the factors that contribute to baseline selections such as the condition of in-situ equipment, any considerations for alternative efficiency operations, and the type of project (new construction, major renovation, in-situ replacement on failure or end of life, or early replacement). EcoMetric also collected any equipment operating data or billing data from the customer if it was available. Information collected during the visit was used to calculate the verified energy savings.

The six custom gas projects completed through the EEIF program achieved 1,093 MMBtu of the gross verified gas savings. The six custom gas projects also achieved 734 MWh of gross verified electric savings, accounting for 4% of the program's total electric savings. The realization rates for the custom gas projects varied from 100% for the following reasons.

Finding 11: Incorrect baseline conditions were used to calculate savings for three gas projects. The projects included major renovations and boiler replacements.

Custom project baselines are complicated due to their unique nature. The Delaware EM&V regulations allow for project-specific baselines for custom projects that may not align with the baselines noted for the prescriptive measures. Custom project baselines must be representative of the specific equipment or facility operation.

The EEIF program also includes large, complex projects that include major retrofits of multiple systems (electrical and HVAC). Determining which projects are major renovation versus an in-situ retrofit can be difficult, and the savings implications between the two are significant. Projects classified as new construction or major renovation must use the prevailing energy code to set the baseline. Determining if projects qualify as a major renovation requires understanding the level of work involved and specifics about the driver behind the change.

Recommendation 10: EEIF staff should continue to seek input and guidance from the EEIF technical reviewer or the independent evaluation contractor for large and intricate custom projects, particularly projects with a major renovation or market mean baselines, if an in-house subject matter expert is not available.

Recommendation 11: Reference the Delaware EM&V regulations to determine the appropriate baseline for prescriptive projects.

Finding 12: The energy, demand, and natural gas savings were not consistently calculated and claimed for fuel switching projects.

The Delaware EM&V regulations allow DNREC to claim energy and natural gas savings for projects that involve fuel switching. Fuel switching includes switching from one energy source to a different energy source and claiming savings that result from eliminating the consumption of the old fuel, but also considering the use of the new fuel in an all-fuels program. The Delaware EM&V regulations do not specify how the EEIF program should claim the savings for fuel switching projects.

Recommendation 12: In the absence of any prior guidance, the EcoMetric team recommends the energy savings for fuel switching projects should be the fuel neutral difference between the baseline MMBtu and proposed MMBtu. Since the baseline and proposed fuel types are not the same, it is crucial to convert the fuel types to the equivalent MMBtu to calculate the difference in energy usage. The MMBtu savings may be converted back to appropriate units (kWh, therms) if needed for program tracking.

2.1.4 NET SAVINGS VERIFICATION

The NTG ratios for prescriptive and custom commercial & industrial (C&I) projects were deemed through work completed by the Delaware Energy Efficiency Advisory Council. The NTG ratios incorporate free-

ridership and spillover factors. Free-ridership accounts for any reductions to gross savings due to what the customer would have done absent the program's influence. The NTG ratio for prescriptive projects was deemed to be 0.8 while the NTG ratio for custom projects was deemed to be 0.7. Table 16 shows the net savings for the EEIF program. EcoMetric calculated the net verified savings using the equation below.

$$\text{Net Verified Savings} = \text{Gross Verified Savings} \times \text{NTG Ratio}$$

Table 16: 2016 – 2018 EEIF Net Verified Savings Results

Measure Type	Approved C&I NTG	Gross Verified Energy Savings (MWh)	Gross Verified Peak Demand Reduction (MW)	Gross Verified Gas Savings (MMBtu)	Net Verified Energy Savings (MWh)	Net Verified Peak Demand Reduction (MW)	Net Verified Gas Savings (MMBtu)
Prescriptive	0.8	17,938	1.66	0	14,350	1.33	0
Custom - Electric	0.7	1,980	0.22	0	1,386	0.15	0
Custom - Gas	0.7	734	0.16	1,093	514	0.11	765
Total		20,652	2.04	1,093	16,250	1.59	765

2.1.5 GREENHOUSE GAS EMISSION REDUCTIONS

EcoMetric estimates the net present value (NPV) of the lifetime monetary benefits of greenhouse gas (GHG) emissions reduction achieved by the EEIF program to be \$10,700,853 for projects completed in calendar years 2016, 2017, and 2018. Table 17 shows the lifetime electric savings, lifetime GHG reduction, and lifetime NPV of GHG reduction economic benefits for the program. See section 1.1.5 for details on how EcoMetric calculated the economic benefits of GHG emissions reductions.

Table 17: 2016 – 2018 EEIF Greenhouse Gas Emissions Reductions

Measure Type	2016 - 2018 Net Verified Electric Savings (MWh)	Lifetime Electric Savings (MWh)	2016 - 2018 Net Verified Gas Savings (MMBtu)	Lifetime Gas Savings (MMBtu)	Lifetime GHG Reduction (lbs)	Lifetime NPV of GHG Reduction Economic Benefits (\$)
Prescriptive	14,350.4	215,037	0.00	0	314,281,644	\$9,449,824
Custom - Electric	1,386.0	20,769	0.00	0	30,354,161	\$912,689
Custom - Gas	513.8	7,699	764.93	12,513	11,252,502	\$338,340
Total	16,250	243,505	764.93	12,513	355,888,308	\$10,700,853

2.1.6 COST-EFFECTIVENESS RESULTS

EcoMetric's cost-effectiveness analysis shows that the Energy Efficiency Investment Fund program has a benefit-cost ratio of 2.62 using the Total Resource Cost (TRC) test. This indicates that the program is cost-

effective. Table 18 provides details on the total benefits and costs which EcoMetric included in the TRC test for the Energy Efficiency Investment Fund program.

Table 18: 2016 – 2018 Cost-effectiveness Results

Benefit / Cost	NPV of Benefit/Cost
Lifetime Avoided Cost of Energy	\$24,502,589
Lifetime Avoided Cost of Capacity	\$2,390,739
Lifetime Avoided Cost of Fossil Fuel	\$43,341
Lifetime Non-Energy Benefits	\$0
Total Benefits	\$26,936,669
Program Administrative Costs	\$632,444
Measure Costs	\$9,662,358
Total Costs	\$10,294,802
TRC Benefit-Cost Ratio	2.62

Refer to section 1.1.6 for details on how EcoMetric performed the cost-effectiveness analysis.

2.2 PROCESS EVALUATION

The process evaluation entailed reviewing program materials and examining the program tracking data, conducting in-depth interviews with the program manager and five contractors who were among the more active in applying for EEIF grants on behalf of customers, and fielding a mixed phone (web and telephone) survey with 63 organizations that received EEIF grants during the study period.

2.2.1 PROGRAM DESCRIPTION

This detailed program description is based on information from the Delaware Energy Efficiency Advisory Council (EEAC) Annual Report for 2017¹⁹ and interviews completed by the EcoMetric team. It is meant to provide context for the process evaluation observations and findings.

2.2.1.1 Who Participates?

According to the program manager, applicants—that is, the entities who submit grant applications to EEIF—typically include facility managers, executives at facilities, or contractors working on behalf of customers. Some contractors provide turnkey services to customers, including scoping a project, applying for the grant, installing the measures, and using the grant to reduce the price of the project. Others also provide design services and may supply the equipment as well. The reduced project price serves as a

¹⁹ Delaware Energy Efficiency Advisory Council Annual Report 2017.

<http://www.dnrec.delaware.gov/energy/information/otherinfo/Documents/EEAC/2017-eeac-annual-report.pdf>

marketing tool for the contractor. The project manager noted that some contractors have repeatedly applied to the program on behalf of many customers and estimated that between 60% and 80% of applicants are contractors. EEIF works with whoever applies to obtain the needed documentation.

Customers are businesses, state agencies, local governments, and non-profits located in Delaware. While the EEIF website refers to “participating contractors,” in this evaluation, “participants” or “customers” refer to the end-use customers who obtained a grant from EEIF, not to contractors.

2.2.1.2 Supported Measures and Equipment

Organizations apply to EEIF for either “prescriptive” or “custom” incentives. The prescriptive path offers set incentives for common efficiency measures. These include energy-efficient lighting, lighting control improvements, high-efficiency natural gas heating, and water heating systems, and vending applications. The custom path supports cost-effective energy efficiency measures that DNREC does not offer on a prescriptive basis. Custom incentives vary by project.²⁰

According to the program manager, EEIF is in the process of updating lighting incentives to ensure that they reflect current market conditions. This was precipitated by a review of other state incentive programs from a third-party reviewer. A review of the program data found that most incentives were for prescriptive lighting.

2.2.1.3 Marketing

While DNREC’s program plan for 2016-2018 anticipated that the program would increase marketing in 2017 and 2018 to fully subscribe the program,²¹ EEIF currently has no formal mechanism for marketing or outreach. Four of the five contractors interviewed for the program indicated that word-of-mouth is the primary way that they generate EEIF projects. All five contractors indicated that they are the primary way participants learn about EEIF. The EEIF program manager noted that some customers also learn about the program online, or on occasion through community events at which EEIF staffs a table.

Table 19 summarizes how surveyed customers first heard about the EEIF program. Almost one-half (46%) of participating customers first heard about EEIF from a contractor, electrician, or distributor. About one-quarter (24%) of participants first heard about EEIF from a colleague, business associate, or friend. These findings support the observations of the contractors and program manager.

²⁰ For a full list of the kinds of projects that may be eligible for custom incentives through EEIF, see <https://dnrec.alpha.delaware.gov/climate-coastal-energy/efficiency/energy-efficiency-investment-fund/>.

²¹ Three-Year Program Plan Energy Efficiency Investment Fund (EEIF), Energy Efficiency Industrial (E2I), and Weatherization Assistance Program (WAP). 2016. DNREC. December 7.

Table 19: Means of First Hearing about the Energy Efficiency Investment Fund

Heard About EEIF Through	Percent (n=63)
Contractor, electrician, or distributor	46%
Colleague, business associate, or friend	24%
Web search	10%
Contacted utility	3%
Newspaper or radio	3%
Participated before	3%
Other	6%
Don't know	5%

When asked about plans for marketing, the program manager noted that EEIF is developing a marketing brochure to use in conjunction with EEIF's annual report at meetings, workshops, and other events. The program manager would like to develop a more targeted approach to marketing and outreach, including social media, in-person presentations, and possibly radio advertising.

2.2.1.4 Application and Approval Process

As of the time of this study, applicants must submit hard copies of their applications and supporting documentation. The application process involves two rounds of review of the application and documentation; one for pre-approval and one for final approval.

Pre-approval. DNREC administrative staff is responsible for alerting applicants to impediments to pre-approval such as missing information. DNREC staff conduct two technical reviews of each application submitted. Once program staff determines that all paperwork has been submitted and project requirements are met, staff submit it to DNREC leadership for pre-approval, and the applicant is notified of the grant award.

Final approval. Once the applicant's project is completed, the applicant submits the final invoices and proof of payment. DNREC staff reviews this documentation twice as well. After the second review determines the project as completed is indeed eligible for the grant, the application is passed to DNREC leadership for final approval. Once leadership has approved the application, DNREC staff awards the grant monies and update the project details in the EEIF tracking database.

2.2.1.5 Application and Approval Process

EEIF is in the process of developing an online application portal that would accept applications and documentation electronically. An online portal would give EEIF a database in-house and provide

contractors and customers with up-to-date information about the status of their applications. The portal is expected to debut by Spring 2020.

EEIF program staff implement quality assurance protocols during the application review process. This includes vetting the proposed scope against the final product installation to ensure that the equipment installed meets EEIF's technical specifications. For custom projects, it also involves ensuring that energy savings algorithms are based on industry best practices and that any input assumptions are reasonable and well-sourced.

In addition, the process includes asking if the customer disposed of previous bulbs properly and if fixtures or other equipment were installed following local, regional, and federal codes. While EEIF staff members try to perform site inspections of a sample of grantee projects upon completion, from April through December 2018 DNREC staff did not have enough time to undertake these inspections. Inspections involve two staffers visiting the facility before and after installation, taking photographs, meeting the applicants, and making sure that the equipment was not purchased before the application was pre-approved.

2.2.2 PERSPECTIVES ON EEIF'S MARKETING

2.2.2.1 Contractors

During the in-depth-interviews, three contractors provided the following feedback on EEIF's marketing:

- ▶ *"DNREC could do a better job reaching out to lighting contractors explaining the benefits of the lighting rebate program and how to get customers interested."*
- ▶ *"DNREC may want to do some more community outreach...especially if they incorporate trade allies. DNREC could offer a list of people who have done successful projects in the area for customers to choose from. That would be welcomed."*
- ▶ One contractor was not aware that they could use any written marketing associated with EEIF, such as the annual report. This contractor would like to be able to *"promote them [EEIF] with a tag, saying we're a DNREC/EEIF supporter.... A lot of the other utilities have our name on their website that says here's some of the service providers, but I'm not aware of DNREC having that. If they do, I'd love to know that."*

Four of five contractors interviewed expressed interest in being listed as a service provider on the EEIF website. EEIF may be able to help connect prospective participants with contractors without requiring contractors to respond to a Request for Qualifications (RFQ). DNREC could list the names of contractors who have completed applications through the program on the website, which is available from the program tracking database, with a caveat that EEIF makes no claims about the quality of the contractors' work and the list does not imply endorsement.

Process Finding 1: Contractors are interested in being listed as a service provider on the EEIF website as an opportunity to connect with customers and increase program participation.

Process Recommendation 1: Explore the possibility of listing on the website the names of contractors who have completed applications through the program, with appropriate caveats.

2.2.2.2 Website Review

The EcoMetric team examined the EEIF website, reading through each page and checking for functioning links. The team agrees with an observation made by the program manager that the website would be more appealing with a more modern feel.

The team found out-of-date information on the [EEIF home page](#). The home page says that “DNREC will publish a list of participating contractors familiar with the Energy Efficiency Investment Fund approval process and capable of installing eligible measures. Interested contractors may apply on the participating contractors page.” According to the program manager, in 2017 EEIF was informed by the Government Support Services (GSS) that requiring contractors to apply to be qualified for and listed on the EEIF website as an EEIF-participating contractor would mean the contractors would also be required to go through an RFQ process. As a result, EEIF no longer has plans to list contractors on the website.

Four of five contractors expressed interested in being on such a list, however, noting “It would almost be a marketing tool for my company and my contractor” and “It would be a good source of lead generation,” although one noted that whether they would apply would depend on the criteria. That same contractor added that “A lot of the other utilities have our name on their website that says here’s some of the service providers, but I’m not aware of DNREC having that. If they do, I’d love to know that.” It seems likely that this would help customers find contractors and might make them more inclined to participate.

Process Finding 2: The EEIF website home page contains out-of-date information about plans to list “participating contractors” on the web site.

Process Recommendation 2: As there are no current plans to list participating contractors, remove references to this list on the EEIF home page.

2.2.3 PRESPECTIVES ON APPLICATION AND APPROVAL PROCESS

Before interviewing contractors and surveying customers, the EcoMetric team asked the program manager to identify aspects of EEIF that need improvement. The program manager named three possible improvements related to the application and approval process: (1) reducing the administrative burden of having physical application files located at three different desks; (2) shortening the length of

time it takes to award a grant; and (3) shortening the length of time it takes to deliver a grant check after a project receives final approval (six to eight weeks).

She noted that the latter two items discourage applicants. Contractors also see a need for improvement in the length of time it takes to award a grant and deliver a grant check. Contractors are the driving force behind participation in the EEIF program, completing or helping to complete 60% of program applications.

2.2.3.1 Contractors

Contractors offered the most feedback on the program application and approval process during the team's in-depth interviews. Table 20 summarizes this feedback.

Table 20: Contractor Comments on Application and Approval Process

Comments	Count (by contractor)
Needs Improvement	
Long application process or pre-approval time	4
Application is confusing to customers or difficult to navigate	3
Insufficient staff for application review	2
Lack of information/communication about status of application	2
Redundant questions on application	2
Difficulty obtaining 12-months of energy bills for application	2
Application process requires too much manual calculation	1
Assignment of project identification numbers is slow and unclear	1
Contractor must initiate contact with DNREC when information is missing from application	1
More documentation is required than for other programs	1
Proof of payment can be burdensome for clients with large orders	1
Kudos	
Application process is easy	1
Application's comprehensiveness means there is no missing data	1

Some comments from the contractors on the application process included:

- ▶ *"It's hard with Delaware because I don't want the customer to miss out and I know the answer's gonna be no because the 12 months of bills that are needed. A lot of time if a customer can't access an accounting department for those 12 months, they'll just bag the rebate altogether, especially if the pre-approval time is 6 weeks."*
- ▶ *"The waits get lengthy and . . . they don't promote or say where something is in the queue. . . . Some of these projects by the time they are put in to be approved to the time that we finally have all the invoices in, it could be 6-7 months. And if I have hundreds of these, it's unbelievably stressful to keep them all straight."*

- ▶ *“There are a lot of redundant questions – asking what is your calculated rebate for this particular type of light, what are the energy savings, what’s the project cost in scope, when it could actually be easier if they created a spreadsheet for me to pop in the responses it would help streamline the process a bit. They’ll ask for spec sheets two or three times.”*
- ▶ *“[The amount of information required on the application is] a lot, but it is helpful because then there is no process delay. I think the EEIF program runs smoothly because they already have everything on hand, whether they need it or not. I rarely get an email asking if I can provide/confirm this or that because it’s all included in the application from the beginning.”*
- ▶ *“Ease of use as far as the application process.”*

The program manager is aware of many of these issues. During her interview, she noted that EEIF had developed some ways to help applicants navigate the application process, such as an “application checklist for each pathway so that customers who inquire before applying know exactly what we expect documentation-wise. We also try to work with applicants the best we can. For example, if they are taking over a facility and don’t have access to 12 months of utility bills, then we work with them on providing us that data.” She noted that EEIF has already pared down the data the program collects to make it more efficient for both applicants and program staff.

Process Finding 3: The contractors interviewed felt that the pre-approval process could be faster, have streamlined documentation requirements, and could be made easier for customers.

During the evaluation, the EEIF program staff informed the EcoMetric team that they were in the process of developing an online application portal for program participants (including contractors) to use to fill out applications and upload project documentation. The online application portal should resolve many of the challenges identified by contractors during the EEIF process evaluation.

Process Recommendation 3: Utilize the EEIF application portal to streamline the application process for customers. The application portal is an important step that DNREC has taken to simplify the application process, including the submission of spreadsheet calculators and other project documentation.

Process Finding 4: Contractors also noted that the application process could be easier to navigate and that increased communications about the status of applications would be helpful.

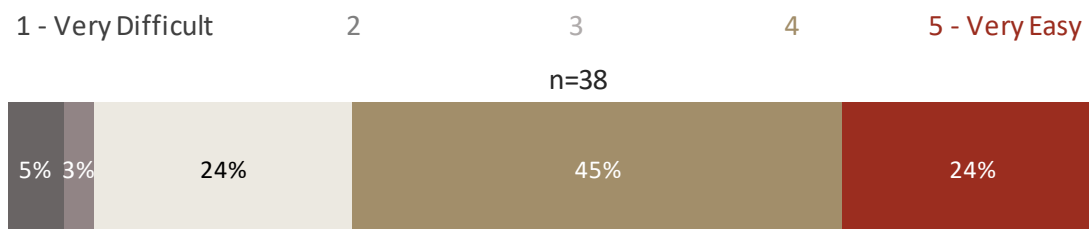
Process Recommendation 4: Consider incorporating suggestions from contractors for the on-line application, including adding checklists to ensure that all documentation is in place before submitting the application, automating the calculations, and automatically sending an email when the application is submitted confirming that the application has been received and supplying the applicant with the project identification number.

2.2.3.2 Customers

About one-third (35%) of 63 participating customers surveyed said their contractor completed the EEIF application. Thirty-seven percent of customers completed the EEIF application on their own and 25% completed the application with assistance from their contractor.

Customers who completed the application were asked to rate ease of completion using a scale from 1 to 5, where one is very difficult to complete and five is very easy to complete. About two-thirds (69%) of customers who completed the application said 4 or 5. The average rating is 3.8. Only three out of 38 respondents (7%) said 1 or 2.

Figure 7: Ease of Completing the Energy Efficiency Investment Fund Application



Process Finding 5: About two-thirds of the customers who completed their own EEIF application found the process to be easy., while 7% found it difficult.

2.2.4 COMMUNICATION WITH PROGRAM AND PROGRAM STAFF

When the team asked contractors to describe the interaction and communication between their companies and DNREC staff, most contractors provided feedback about program communication generally, not just with staff. Table 21 summarizes this feedback. While the fifth contractor referred to communication with program staff as “outstanding,” this contractor also said that he would like to see more communication from the program about the status of program funding. This comment may have been precipitated by the fact that the program was suspended from February through October of 2016 due to lack of funds.

Table 21: Contractor Feedback on Communication with Program and Program Staff

Comments	Count (by contractor)
Needs Improvement	
Lack of communication about the status of applications	2
General lack of communication	2
Lack of communication about the status of program funding	1
Kudos	
Communication with staff is outstanding	1
Felicity is extremely responsive	1
Felicity is extremely helpful	1

2.2.5 COMPREHENSIVENESS OF EQUIPMENT & MEASURES SUPPORTED BY EEIF

Three of the five contractors offered feedback on the range of equipment and measures supported by EEIF. All three felt that the program's support was sufficiently comprehensive.

- ▶ *"The program, as far as I know, offers incentives for any energy improvement measure that you create, so I think they are technically covering a majority of anything that is a possible solution for reducing the load on the grid."*
- ▶ *"Their program is pretty comprehensive."*
- ▶ *"They're covering pretty much every part of the business that I do, which is basic retrofits for existing lighting indoor and outdoor."*

However, one contractor observed that EEIF could clarify the types of lighting fixtures supported by the program: "It isn't very explicit in the different fixture types that I get involved in. Sometimes I have to guess or call or email the program to make sure."

Table 22 summarizes the equipment that EEIF participants recommended the program add. One contractor suggested that if EEIF were to support additional prescriptive measures other than lighting, such as HVAC or commercial kitchen equipment, this might help garner additional savings.

Table 22: Additional Equipment Recommended by Energy Efficiency Fund Participants

Recommended Additional Equipment	Percent (n=30)
HVAC equipment	40%
Solar panels	17%
Additional lighting	13%
Water heaters	10%
Insulation	7%
Other	37%

*Percentages sum to greater than 100% because this was a multiple-response question.

Individual customers recommended several other types of equipment, including metering equipment, controls systems, doors, roofs, refrigeration, monitoring base commissioning, low flow water fixtures, air compressors, cooking equipment, and distributed generation.

2.2.6 CUSTOMER MOTIVATIONS AND BARRIERS TO PARTICIPATION

The team asked contractors and the program manager for their perspectives on the reasons that customers participate in EEIF, and situations or factors that might prevent some eligible customers from participating. The team also asked participating customers the reasons they had chosen to install equipment supported by EEIF.

The program manager identified offsetting the cost of their project as the primary reason a customer would decide to participate in EEIF. Not surprisingly, two contractors cited financial support as a motivating factor. Another noted that when a customer needs to repair, the program process helps with decision-making.

- ▶ *“They all want to save energy and money, so if it means a quicker payback they are inclined to do this.”*
- ▶ *“You have a business owner that is already in the process of needing to do a repair, and the question is are they going to repair it with a like-product or are they going to take that investment and go with a more efficient product. That’s what the program helps with is getting them to make the better decision.”*

One contractor—the same one who said that the program application and approval process was easy—cited the ease of the application and participation process here, too. Another mentioned customers being motivated by reducing their carbon footprint and demonstrating good citizenship.

- ▶ *“Ease of application and the ease of the process. Very streamlined, good people to work with. I think it’s really simplified. bottom line is they want to know how much is this going to cost me, what’s the timeline to get this project done, how much up front, and how much of the rebate am I going to get.”*
- ▶ *“They want to be good citizens. They want to show to their populations that they are reducing their energy loans and carbon footprint.”*

Table 23 summarizes the motivating factors customers provided for installing equipment through EEIF.

Table 23: Motivation for Participating in the Energy Efficiency Investment

Reasons for Installing Equipment	Percent (n=63)
Save money on energy costs	98%
Reduce operating or maintenance costs	90%
Install more reliable equipment	60%
Improve work environment	59%
Advance long-term strategic energy management plan	54%
Save money on equipment purchase/installation	51%
Increase safety/security	40%
Promote positive public relations	35%
Improve production or productivity	30%
Reduce environmental footprint	3%

The program manager identified several reasons that eligible customers might not participate in EEIF:

- ▶ the amount of paperwork a customer or contractor must fill out to obtain a grant
- ▶ the two-step approval process
- ▶ lack of awareness of the program, particularly among small businesses
- ▶ for large energy users, not knowing the size of the award up-front, and thus how much capital they need for a project

Table 24 shows the barriers to customer participation that the contractors mentioned. The most frequently mentioned barrier had to do with a lack of understanding of the program by customers who attempt to participate on their own. As contractors noted,

- ▶ *"There are a lot of hurdles with paperwork. Customers say that they can't find it [the paperwork] on the website, so I walk them through it. They don't know what EEIF means, they're basically looking for utility rebates. They don't know what prescriptive is."*
- ▶ *"DNREC has 2 types of rebates: prescriptive (most people find this straightforward) and custom (people find this confusing). It would be helpful if they [DNREC] provided more information or clarity on the custom rebate program."*

Table 24: Barriers to Customer Participation

Improvement Suggestions	Count (by contractor)
The website does not make it clear what customers must do to participate in EEIF on their own; customers don't understand EEIF terminology on website, or complicated program for which it is hard to find materials on website	3
The customer-paid portion of project after incentive can be too high for smaller customers	2
Pre-approval takes too long for customers or contractors	2
Project is too small given the amount of work to obtain incentive	1
Hurdles of the application process	1
Don't have the staff to handle paperwork	1
Some customers simply won't participate	1

Process Finding 6: Developing a formal mechanism for marketing and outreach may improve participation.

Process Recommendation 5: Conduct research to better understand the target markets for the program and how best to reach them, and then expand program marketing and outreach as appropriate.

2.2.7 SUGGESTIONS FOR PROGRAM IMPROVEMENT

The team asked contractors, customers, and the program manager how the program could be improved. As contractor feedback on the program focused overwhelmingly on the application and approval process, so did their suggestions, which are summarized in Table 25.

Table 25: Contractor Suggestions for Improving the Application and Approval Process

Improvement Suggestions	Count (by contractor)
Put some of the questions on the application form into spreadsheet format	2
Move application process on-line	2
Add staff	2
Speed up approval process	1
In on-line application portal, have checklists to ensure that all documentation is in place before submission	1
Automatic email confirmation that application has been received, with a project identification number	1
Online application process that automates calculations	1
Store basic contractor information, such as electrical license and certificate of insurance, on-line so that contractors don't need to submit it with every application	1
Have online portal alert contractors by email when there is a note or message about an application on file	1

Table 26 summarizes what customers would like to see change about the EEIF. Over one-half (59%) of customers said 'nothing.' The remaining customers offered suggestions for improvement that were almost entirely related to the application and approval process.

Table 26: Suggestions for Energy Efficiency Investment Fund Improvement

Suggestions for Improvement	Percent (n=63)
Nothing	59%
Application process	11%
Communication	6%
Time to receive money	6%
Approval time	5%
Grant amount	5%
Duration from start to finish	5%
Contractor training	3%
Other	8%

*Percentages sum to greater than 100% because this was a multiple-response question.

The program manager offered suggestions for improvements to the application or approval process that were similar or related to many of those offered by contractors and customers:

- ▶ Use resources more efficiently. For example, pare down program guidelines and operational procedures and eliminate collecting any unnecessary information.
- ▶ Develop a more approachable application process.

- ▶ Develop a schedule for checking the status of pending and pre-approved applications and ensuring that expired applications are denied.

The program manager identified three ideas for improvements not associated with the application and approval process. These were:

- ▶ Obtain assistance with EEIF's approach to analyzing energy savings
- ▶ Offer more incentive pathways, and pair EEIF incentives with other incentives DRNEC offers
- ▶ Develop targeted marketing and outreach approach to solicit new applications
- ▶ Give the website a more modern feeling

2.2.8 PROGRAM SATISFACTION, LOYALTY, AND OVERALL EXPERIENCE

2.2.8.1 Contractors

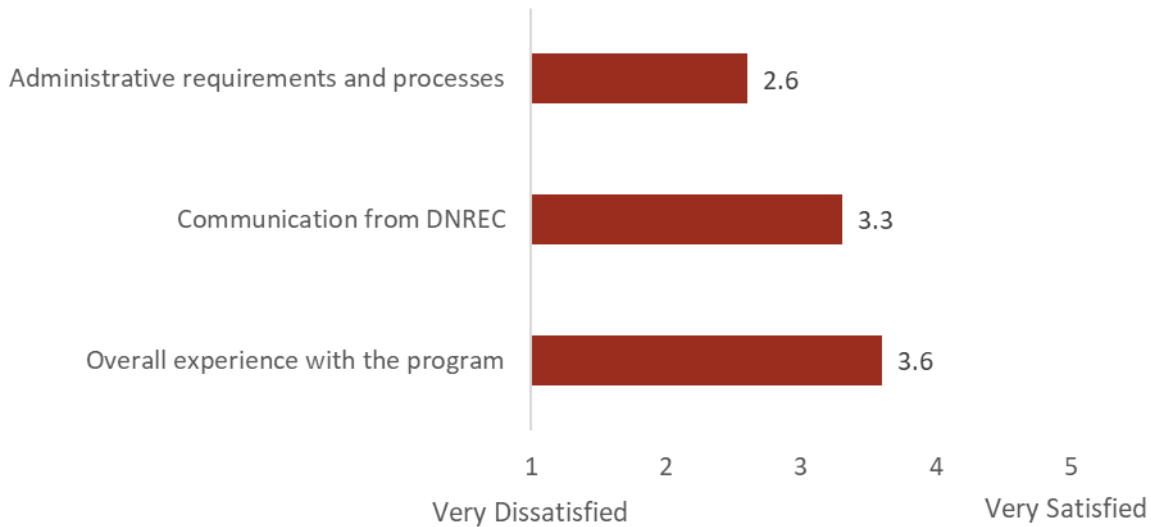
The EcoMetric team asked contractors for feedback on their overall experience with EEIF. Their responses are summarized in Table 27. Generally, contractors expressed appreciation for the helpful program staff.

Table 27: Contractor Feedback on Overall Experience with EEIF

Overall Experience	Count (by contractor)
Kudos	
Helpful program staff	3
Quick responses to inquiries	1
Worth it despite being cumbersome because of business, it brings in	1
Needs Improvement	
Cumbersome or difficult to navigate process	2
Slow response time	1

The team asked contractors to rate their satisfaction with a variety of aspects of the program, on a scale of 1 (very dissatisfied) to 5 (very satisfied). As Figure 8 shows, on average these five contractors were most satisfied with their overall experience of the program (3.6 of 5, or "somewhat satisfied,") and least satisfied with program administrative requirements and processes (2.6 of 5, or "somewhat dissatisfied").

Figure 8: Average Contractor Satisfaction with Selected Aspects of EEIF



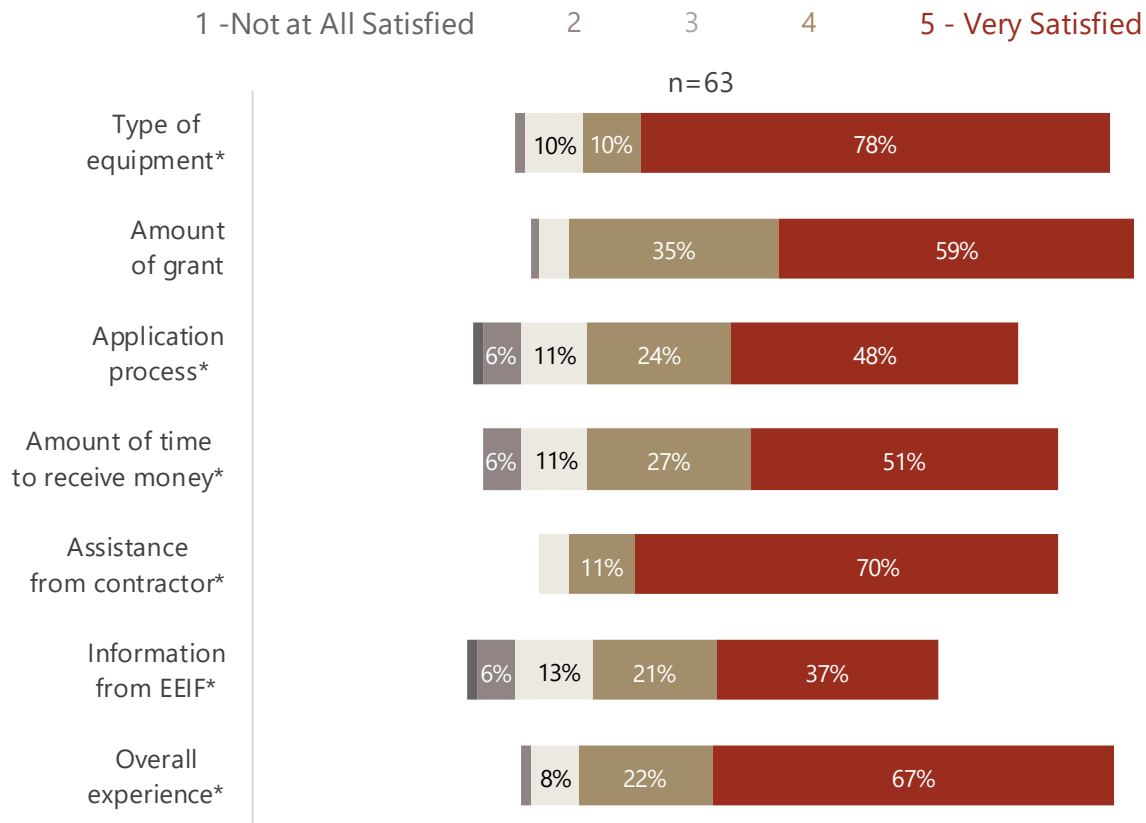
Process Finding 7: Contractors are satisfied with their overall experience with the EEIF program and cite program staff as the leading factor for their satisfaction.

2.2.8.2 Customers

The survey asked customers to name the single best thing about EEIF. The most common response was the grant money, mentioned by 48% of respondents. Thirteen percent of customers said the ease of the process (13%) or the savings in energy costs (13%) was the best thing about the program. Ten percent of customers said the working relationship with program staff or contractors was the best thing, 5% said the energy efficiency improvements, and 3% said staff or contractor expertise.

Figure 9 depicts the participating customers' satisfaction with the program. Almost nine out of ten respondents (89%) were somewhat or very satisfied with their overall experience. Customers were least likely to be satisfied with the application process and information from the EEIF about other energy-saving opportunities. Nevertheless, over one-half of customers were satisfied or very satisfied with these aspects of the program.

Figure 9: Energy Efficiency Investment Fund Participant Satisfaction Ratings



*Percentages sum to less than 100% because a few respondents said, 'don't know' or 'not applicable.'

Process Finding 8: 89% of customers are satisfied with their overall experience with the EEIF program. Grant levels and the types of eligible equipment were the main drivers of their satisfaction with EEIF.

Customers were also asked to rate the likelihood of recommending the EEIF program to others. The response scale ranged from 0 to 10, with 0 being “extremely unlikely” and 10 “extremely likely.” This rating is used to calculate the Net Promoter Score (NPS), a well-established measure of customer loyalty. With the NPS, respondents are grouped as promoters (score 9-10), passives (7-8), and detractors (0-6). The NPS is calculated by subtracting the percentage of detractors from the percentage of promoters and presented as a whole number, as shown in Figure 10. The net promotor score was 78, a very high value. Overall, 84% of customers that participated in the program are “promoters” (Figure 11)—that is, there is a

high likelihood that these customers will actively promote the program to other potential participants by word-of-mouth.

Figure 10: Net Promoter Score

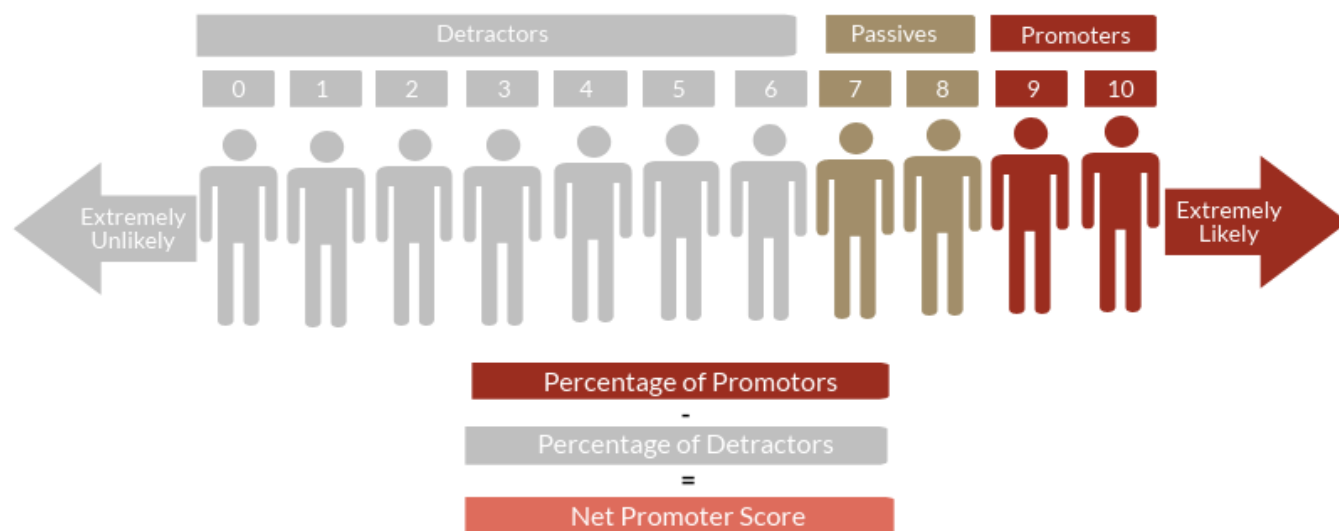
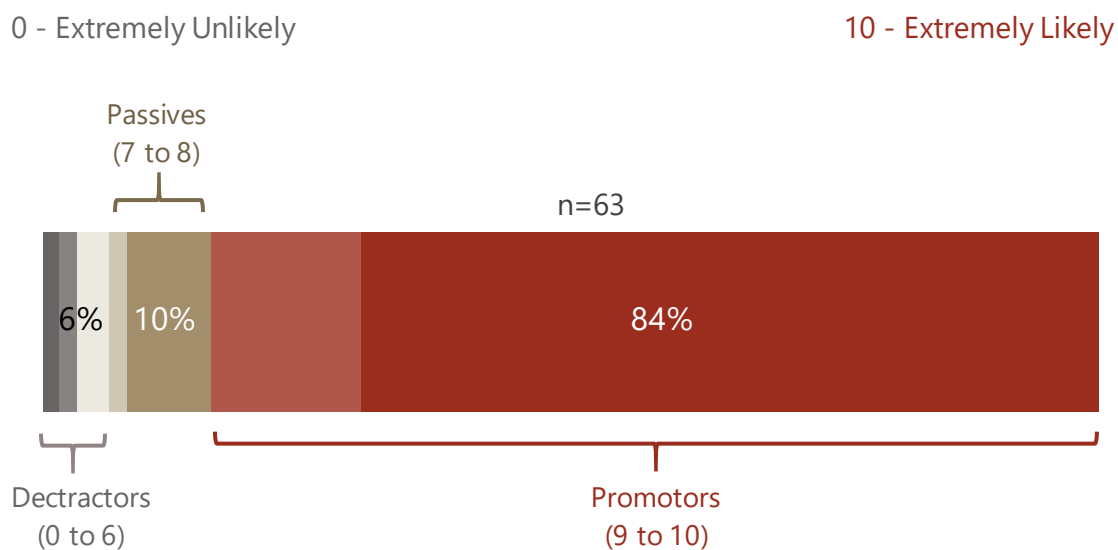


Figure 11: Likelihood of Recommending the Energy Efficiency Investment Fund



The Green Energy Program (GEP) provides funding to promote the use of renewable energy to commercial, non-profit, and residential customers throughout Delmarva Power and Light's service territory in Delaware. The program offers incentives for a variety of renewable technologies such as solar photovoltaic (PV), solar hot water, wind, and geothermal systems.

The customers apply for grant funding on the Green Grant Delaware²² internet portal for the respective technology type. The grant amount is calculated based on the capacity of the installed equipment.

3.1 IMPACT EVALUATION

3.1.1 PROGRAM DATABASE REVIEW AND SAMPLING

GEP had 1,303 different projects completed during 2016 through 2018 calendar years. EcoMetric defined each project as a unique application²³ and included only projects with payment status equal to "paid."

Solar PV projects are the most significant measure for the GEP. On an equivalent energy basis²⁴, PV accounts for more than 90% of the installed capacity through the program. Table 28 shows a summary for each program year for GEP.

Table 28: GEP 2016 - 2018 Program Summary

Program Year	Measure	Projects Completed	Capacity (MW)	Capacity (Tons)	Capacity (Sq. Ft.)
2016	PV	195	2	0	0
	Geothermal	30	0	171	0
	Solar Water	0	0	0	0
2017	PV	580	5	0	0
	Geothermal	25	0	137	0
	Solar Water	0	0	0	0
2018	PV	458	3	0	0
	Geothermal	14	0	75	0
	Solar Water	1	0	0	59
Total		1,303	10	383	59

²² <http://greengrantdelaware.com/>

²³ Application_ID is the variable in the program data which defines unique applications

²⁴ Simply converting tons to watts for geothermal projects by multiplying tons by 12,000 and dividing by 3412.

The sample frame for GEP breaks out the different measures into separate strata. EcoMetric further separated each measure type into sub-strata with the appropriate facility type. The sample frame does not include the one solar hot water heating project. A summary of the sample frame is shown in Table 29.

Table 29: GEP Sample Frame

Measure	Facility Type	Stratum	Count	Percent (count)	Capacity	Unit	Percent Capacity
Solar PV	Non-Profit	Probability	16	1%	0.4	MW	5%
	Non-Residential	Probability	9	1%	0.3	MW	3%
	Residential	Large Probability	228	18%	3.0	MW	31%
		Small Probability	980	75%	5.9	MW	61%
Geothermal	Residential	Probability	69	5%	382.3	Tons	0%
Total			1,303	100%			100%

Strata designated as probability had the target sample randomly selected from the projects within the strata. The large and small designation for residential PV projects separates projects which were greater than 10,000 W (0.01 MW) into the large probability strata and those less than 10,000 W (0.01 MW) into the small probability strata.

EcoMetric selected a sample of 31 projects, targeting 90% confidence and 15% precision for the program. EcoMetric allocated the sample points to each of the measure and facility type combinations in proportion to their respective installed capacities. The number of sample points allocated to each stratum and the percentage of projects and capacity covered by the sampled projects is shown in Table 30.

Table 30: GEP Sample Coverage

Measure	Facility Type	Stratum	Sampled Count	Percent Sampled (count)	Sampled Capacity	Unit	Percent Sampled Capacity
Solar PV	Non-Profit	Probability	3	19%	0.1	MW	28%
	Non-Residential	Probability	3	33%	0.1	MW	35%
	Residential	Large Probability	10	2%	0.2	MW	2%
		Small Probability	12				
Geothermal	Residential	Probability	3	4%	56.0	Tons	4%
Total			31	2%			4%

Finding 13: The program database consistently reports key variables for GEP projects and is easy to navigate.

The EcoMetric team found the GEP database user-friendly and was able to find critical pieces of information for sampled projects easily. These key variables were consistently reported throughout the database and facilitated an efficient review of sampled projects.

Finding 14: Annual energy generation is not tracked in the GEP database.

GEP is an extensive renewable energy program with a budget of \$2,100,000 annually for renewable energy projects in Delmarva Power and Light's service territory. Solar PV and geothermal heat pump measures create benefits for utilities and ratepayers by reducing the amount of electricity consumed and the peak electric demand required from the grid. These annual energy generation and peak demand reductions are critical factors in assessing the cost-effectiveness of the program. The contractors that design these systems often create estimates of energy generation (kWh) to demonstrate the economic benefits of these systems. The existing online application portal for this program already includes the capability to gather the estimated energy generation. The estimated energy generation variable should be included to the list of other variables in the Detailed Applicant Report extract to facilitate the monetization of energy and demand impacts for the cost-effectiveness calculations.

Recommendation 13: Add the estimated energy generation (kWh) variable that is captured for each GEP project in the online application portal to the Detailed Applicant Report extract.

3.1.2 GROSS SAVINGS VERIFICATION

3.1.2.1 Data Collection

The primary data sources for the GEP were the grant applications, interconnection applications, plot diagrams, equipment specification sheets, and invoices. The EcoMetric team securely accessed all of the program data from the program's online web portal.

3.1.2.2 Engineering Desk Reviews

The EcoMetric team completed engineering desk review for all the projects in the evaluation sample. The reviews used all information included in project files to assess savings and ensure that projects are consistent with program assumptions. EcoMetric compared project files to information captured in the tracking system to determine data accuracy and verify the capacity for each of the sample projects.

The EcoMetric team also used PVWatts^{®25} and the information in the project files to calculate the generation for each solar PV project. EcoMetric used the prescriptive methodology for a geothermal heat pump in the Mid-Atlantic TRM to calculate the savings for each geothermal project.

The PVWatts[®] calculator takes user inputs such as solar PV capacity, module type (standard, premium, and thin-film), tilt, azimuth and estimated system losses. Users can add details about the inverter and ground covering ratio (shading factor) in the Advanced Parameters tab. The calculator assumes a typical ground coverage ratio of 0.4. Inverter efficiency and size ratio can be calculated in the tool by the user using data available from specification sheets. The calculator also provides the user with an option to draw the solar PV panels on a Google maps interface which approximately generates a DC system size in kW for the user to enter into the calculator.

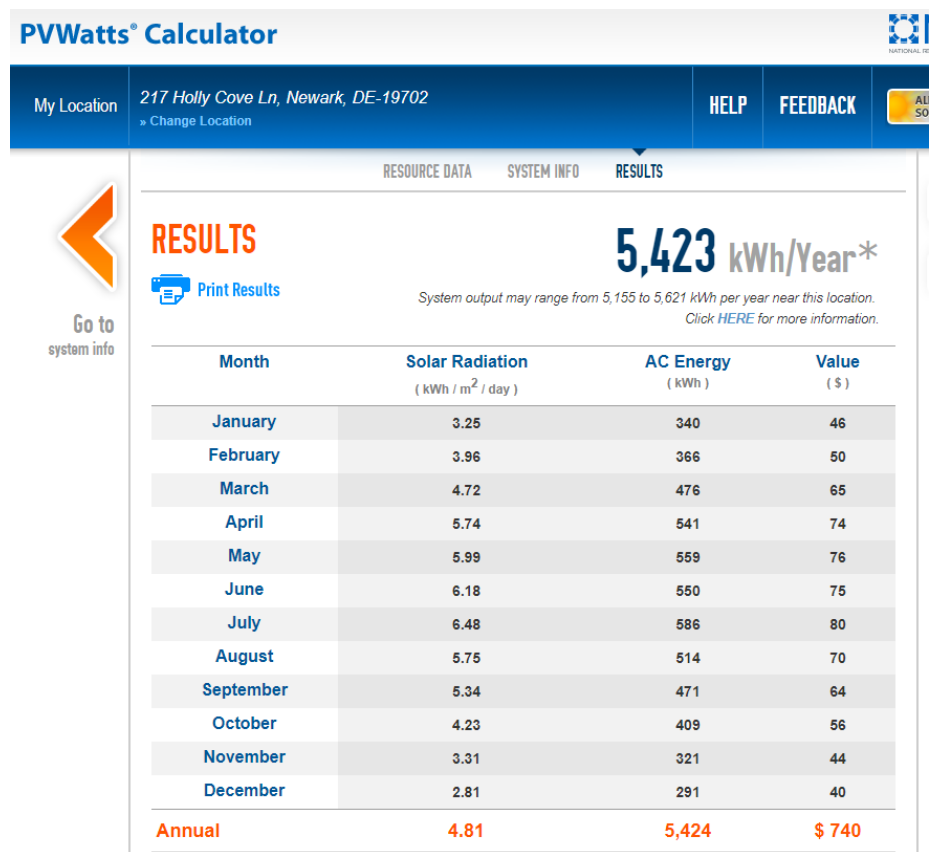
Figure 12: PVWatts[®] Input Window

The screenshot displays the PVWatts Calculator web application. At the top, the title "PVWatts[®] Calculator" is shown alongside the NREL logo. Below this is a navigation bar with "My Location" (217 Holly Cove Ln, Newark, DE-19702), "HELP", "FEEDBACK", and a "ALL SOLAR" button. The main interface has three tabs: "RESOURCE DATA", "SYSTEM INFO" (selected), and "RESULTS". On the left, a "Go to resource data" button is visible. The "SYSTEM INFO" section is titled "SYSTEM INFO" and includes a "RESTORE DEFAULTS" button. It contains several input fields: "DC System Size (kW)" (3.38), "Module Type" (Standard), "Array Type" (Fixed (open rack)), "System Losses (%)" (14.08), "Tilt (deg)" (34), and "Azimuth (deg)" (165). Each field has an information icon. Below these is an "Advanced Parameters" section with "DC to AC Size Ratio" (1.2), "Inverter Efficiency (%)" (98), and "Ground Coverage Ratio" (0.4), also with information icons. On the right, there is a "Draw Your System" section with a description and a map interface for visualizing the system layout.

²⁵ <https://PVWatts@.nrel.gov/> Estimates the energy production and cost of energy of grid-connected photovoltaic (PV) energy systems.

The tool calculates results using the input parameters entered and expressed in terms of annual electricity generated by the panels. PVWATTS® provides the user with an option to download monthly or hourly performance data of the panels in the form of an excel workbook.

Figure 13: Results window for sample PVWatts® project



3.1.3 VERIFIED CAPACITIES AND SAVINGS (GENERATION)

The GEP is not governed by the Delaware EM&V regulations, so the program does not track energy or demand savings. Instead, the GEP focuses on installed capacity as the key performance metric. Therefore, the EcoMetric team verified the system capacities for a sample of projects in the program. Overall, the program achieved a weighted capacity realization rate of 99.82%% for solar PV projects. The weighted capacity realization rate for geothermal projects was 99.94%. The relative precision²⁶ of the solar PV capacity realization rate was 0.003% at the 90% confidence level. The relative precision of the geothermal capacity realization rate 1.51% at the 90% confidence level. The verified capacities and precision values are shown in Table 31.

²⁶ Relative precision represents the uncertainty of the calculated realization rate for the program’s population relative to the value of the program’s realization rate for the sample at the 90% confidence level.

Table 31: GEP 2016 - 2018 Verified Capacities

Measure	Facility Type	Stratum	Verified Capacity	Unit	Relative Precision at 90% Confidence
Solar PV	Non-Profit	Probability	0.45	MW	0.29%
	Non-Residential	Probability	0.25	MW	0.29%
	Residential	Large Probability	2.92	MW	0.29%
		Small Probability	5.94	MW	0.29%
Geothermal	Residential	Probability	382.26	Tons	0.15%

In addition to verifying the system capacities, EcoMetric also verified the energy production from solar PV, energy savings from geothermal, and peak demand reduction for projects in the GEP. EcoMetric calculated energy and demand savings for solar PV projects using the PVWatts® calculator and information provided by customers in GEP Grant Applications, Interconnection Application, and Agreements, and submitted engineering drawings and pictures of installed systems, as described in sections 3.1.2.2 and 3.1.3.1. Similarly, EcoMetric calculated energy and demand savings for geothermal projects using the “Ground Source Heat Pumps” methodology contained in the Mid-Atlantic Technical Reference Manual (TRM) and information from the installed units’ AHRI certificates, as described in sections 3.1.2.2 and 3.1.3.2. Table 32 shows the verified savings (generation) for the solar PV and geothermal projects completed through GEP.

Table 32: GEP 2016 - 2018 Gross Verified Savings (Generation)

Measure	Facility Type	Stratum	Gross Verified Energy Savings (MWh)	Gross Verified Peak Demand Savings (MW) ²⁷
Solar PV	Non-Profit	Probability	623	0.4
	Non-Residential	Probability	370	0.3
	Residential	Large Probability	4,031	2.7
		Small Probability	8,503	7.1
Geothermal	Residential	Probability	197	0.1
Total			13,725	10.7

²⁷ The peak demand generated by a solar PV array may be slightly higher than the nameplate capacity, which is why peak demand savings may be larger than installed capacity.

Finding 15: The GEP overall is accurately capturing installed system capacities.

The capacity realization rates for the GEP are very close to 100%, indicating that the program is successfully capturing the capacities of systems installed under the program and accurately reporting the program's achievements.

3.1.3.1 Gross Savings Verification for Solar PV projects

For solar photovoltaic projects, EcoMetric used specification sheets of PV panels and inverters to estimate operating wattages and total wattages for all orientations (azimuth and tilt). Using PVWatts®²⁸ (an NREL software), EcoMetric estimated annual solar PV generation based on the inverter size, the total wattage of PV panels, orientation, and PV panel type (standard, premium, and thin-film). This process was repeated for all orientations of the PV panels to calculate annual savings for the entire project.

To calculate peak demand reduced by solar PV systems, EcoMetric analyzed hourly performance from all PV panel orientations from the hours of 3 PM – 6 PM during the months of June – August. An average of power generated during these hours was estimated to be the demand savings for each project.

Finding 16: Contractors do not list the system shading factors in the project documentation.

Shading factor is a key input used to determine the anticipated performance of a solar PV system. The contractors did not fill in the shading angles on the applications the EcoMetric team reviewed, so it was not clear if these factors were considered by the contractors when designing the systems. While it was not clear if the contractors considered the shading angles, DNREC's GEP staff conduct a Solar Shade Analysis (SSA) for every solar PV project that is submitted to the program. This analysis includes the orientation and shading parameters for the installed solar PV system.

***Recommendation 14:** For solar PV projects, ensure that contractors are consistently recording the shading factor for each project on the application form.*

3.1.3.2 Gross Savings Verification for Geothermal projects

For geothermal projects, EcoMetric verified the installed capacity by obtaining the AHRI certificates for the model numbers of installed geothermal heat pumps. EcoMetric used the "Ground Source Heat Pumps" methodology contained in the Mid-Atlantic TRM to determine the gross verified energy savings and peak demand reductions. The verified savings calculations used cooling capacity, cooling efficiency, heating

²⁸ <https://PVWatts@.nrel.gov/> Estimates the energy production and cost of energy of grid-connected photovoltaic (PV) energy systems.

capacity, and heating efficiency for the installed units taken from the AHRI certificates. EcoMetric used the baseline efficiencies and full load hours from the TRM.

Finding 17: EcoMetric found discrepancies between the nominal capacities of installed systems and the capacities documented in the models' AHRI certificates.

EcoMetric considers estimates of energy savings and demand reductions calculated using capacities listed in AHRI certificates to be more accurate than those calculated using nominal capacities, as AHRI is an independent third-party testing organization.

Recommendation 15: Use AHRI certificates rather than nominal values to verify the capacity of installed geothermal heat pump systems.

3.1.4 NET SAVINGS VERIFICATION

GEP is not governed by the Delaware EM&V regulations and does not have a deemed statewide net-to-gross ratio. Additionally, GEP does not track reported generation from the renewable projects completed through the program. Therefore, EcoMetric did calculate net verified energy and peak demand savings (generation) for GEP.

3.1.5 GREENHOUSE GAS EMISSIONS REDUCTIONS

EcoMetric estimates the net present value (NPV) of the lifetime monetary benefits of greenhouse gas (GHG) emissions reductions achieved by the GEP to be \$12,427,231 for projects completed in calendar years 2016, 2017, and 2018. The verified energy savings from the sample were extrapolated to the 2016 – 2018 program population following the sampling methodology described in section 3.1.1. The EcoMetric team used the total energy saving from the program population, in addition, to measure EULs to calculate the lifetime electric savings, lifetime GHG reduction, and lifetime NPV dollar savings. Table 33 shows the lifetime electric savings, lifetime GHG reduction, and lifetime NPV of GHG reduction economic benefits for the program. See section 1.1.5 for details on how EcoMetric calculated the economic benefits of GHG emissions reductions.

Table 33: 2016 – 2018 GEP Greenhouse Gas Emissions Reductions

Measure Type	Facility Type	2016 - 2018 Net Verified Electric Savings (MWh)	Lifetime Electric Savings (MWh)	Lifetime GHG Reduction (lbs)	Lifetime NPV of GHG Reduction Economic Benefits (\$)
Solar PV	Non-Profit	623	15,571	21,847,416	\$564,864
	Non-Residential	370	9,262	12,994,890	\$335,982
	Residential	12,535	313,366	439,666,434	\$11,367,561
Geothermal	Residential	197	3,934	5,749,138	\$158,823
Total		13,725	342,134	480,257,878	\$12,427,231

3.1.6 COST-EFFECTIVENESS RESULTS

EcoMetric's cost-effectiveness analysis shows that the GEP has a benefit-cost ratio of 0.98 using the Total Resource Cost (TRC) test. The benefit-cost ratio is based on gross verified savings since net verified savings were not calculated for this program. Solar PV costs are on a decline, and lower measure costs will improve the benefit-cost ratio of the program in future years. Table 34 provides details on the total benefits and costs which EcoMetric included in the TRC test for the GEP.

Table 34: 2016 – 2018 GEP Cost-effectiveness Results

Benefit / Cost	NPV of Benefit/Cost
Lifetime Avoided Cost of Energy	\$27,338,067
Lifetime Avoided Cost of Capacity	\$23,427,298
Total Benefits²⁹	\$50,765,366
Program Administrative Costs	\$843,391
Measure Costs	\$50,822,610
Total Costs	\$51,666,001
TRC Benefit-Cost Ratio	0.98

Refer to section 1.1.6 for details on how EcoMetric performed the cost-effectiveness analysis.

²⁹ There is no lifetime avoided cost of fossil fuel or lifetime non-energy benefits for this program, so they were not included in this chart.

4 WEATHERIZATION ASSISTANCE PROGRAM RESULTS

The U.S. Department of Energy (DOE) oversees DNREC's Weatherization Assistance Program (WAP). WAP provides income-eligible residential customers with free energy-efficiency retrofits to reduce their energy costs and improve their health and the safety of their homes. DNREC contracts with local non-profit agencies, referred to as "subgrantees," to administer WAP and deliver weatherization services to Delaware residents with household incomes that fall below 200% of the federal poverty line. Subgrantees are responsible for hiring, managing, and paying home energy auditors and third-party subcontractors who carry out the weatherization work recommended based on the audit results. Upon completion of the work, all homes receive a final inspection conducted by a Building Performance Institute (BPI)-certified Quality Control Inspector. Also, a sample of all serviced homes is inspected by the State Program Monitor, who serves as the state's weatherization technical expert.

4.1 IMPACT EVALUATION

4.1.1 PROGRAM DATABASE REVIEW AND SAMPLING

The Weatherization Assistance Program (WAP) includes 445 projects completed in 2016 and 2017. The program claimed 5,031 MMBtu in gas savings, 367 MWh in electric savings, and 0.04 MW in peak demand savings. Table 35 summarizes the gas and electric savings for each program year.

Table 35: WAP Savings Summary

Program Year	Projects Completed	Gas Savings (MMBtu)	Energy Savings (MWh)	Demand Savings (MW)
2016	202	2,262	169	0.02
2017	243	2,769	198	0.02
Total	445	5,031	367	0.04

The evaluation team conducted a census review of the projects completed in 2016 and 2017 for the impact evaluation. A census review includes analyzing savings for all 445 projects completed in 2016 and 2017. The evaluation analysis methodology includes reviewing monthly utility bills for each of the projects. The program data shows that customers use various fuel types to condition their homes. Table 36 summarizes the savings from each fuel type.

Table 36: Summary of Savings by Fuel Type

Fuel Type	Projects Completed	Gas Savings (MMBtu)	Energy Savings (MWh)	Demand Savings (MW)
Electric	127	0	246	0.04
Gas	102	1,614	39	0.00
Gas/Electric	1	16	0	0.00
Kerosene	2	32	1	0.00
Oil	81	1,281	31	0.00
Oil/Electric	1	16	0	0.00
Propane	131	2,072	50	0.00
Total	445	5,031	367	0.04

4.1.2 GROSS SAVINGS VERIFICATION

4.1.2.1 Data Collection

The EcoMetric team used data from several sources to calculate the gross verified savings for the weatherization program. The program provided a database of customer information, utility information, and inspection dates for homes that had weatherization treatment between January 1, 2016 and December 31, 2017. DNREC program staff also provided a database that listed home characteristics and weatherization treatment measures. The information provided by the program was critical when developing the billing analysis model.

The EcoMetric team also requested electrical and natural gas billing data from four utility companies for the participating customers. The billing data was used along with local and typical meteorological year 3 (TMY3)³⁰ weather data in the billing analysis model to calculate the verified gross savings for this program.

4.1.2.2 Reported Savings

The weatherization program developed per-home energy and fossil fuel savings based on a combination of a billing analysis and deemed savings calculations. The deemed savings were calculated using an excel based calculation tool. The tool calculated the savings for each measure that WAP offers. The tool utilized savings algorithms and assumptions from the Delaware TRM. The savings tool also used project-specific

³⁰ "The TMY3s are data sets of hourly values of solar radiation and meteorological elements for a 1-year period. Their intended use is for computer simulations of solar energy conversion systems and building systems to facilitate performance comparisons of different system types, configurations, and locations in the United States and its territories." https://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/

measure information from a sample of 97 homes that received weatherization treatment. The deemed savings analysis resulted in 15.8 MMBtu in savings per weatherized home.

A billing analysis of the pre- and post-case utilizing billing data was also conducted to calculate savings for a sample of six homes that received weatherization treatment. The billing analysis resulted in 15.1 MMBtu of savings, very near the 15.8 MMBtu calculated using the measure analysis.

Due to the similar savings estimates produced by the billing analysis and excel-based deemed savings tool, the program decided to use the per-home savings from the deemed savings tool. The reported per-home savings are shown in Table 37. Fossil fuel savings are shown in first column (15.82 MMBtu) for homes with fossil fuel heat. The electric savings for homes with gas heat are shown in the second column (381 kWh) while the energy and peak demand savings for electrically heated homes are shown in the third (1,935 kWh) and fourth (0.28 kW) columns, respectively.

Table 37: Reported Per-Home WAP Savings

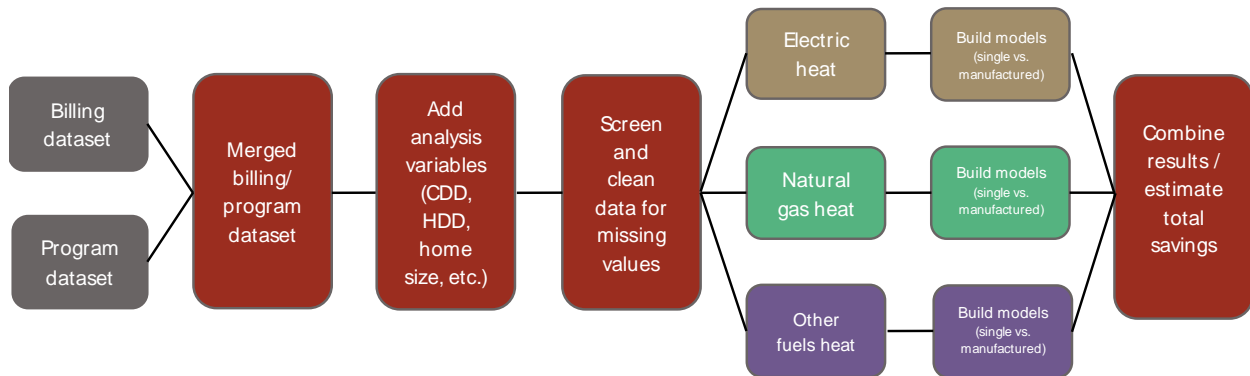
Home Type	Site Fossil Fuel Savings per Home (MMBtu)	Site Electric Savings: Home with Gas Heat (kWh)	Site Electric Savings: Homes with Electric Heat (kWh)	Summer Peak Reduction (kW)
Average Savings	15.82	381	1,935	0.28

4.1.2.3 Billing Analysis

EcoMetric utilized a monthly utility billing data analysis (IPMVP Option C³¹) to estimate average WAP program whole-home electricity and gas savings by analyzing 2016-2017 program year projects. Project data for 2018 was excluded from the analysis because full annual post-project billing data will not be available until the end of 2019. Billing analysis entailed pooled panel regression modeling of energy consumption data along with key statistical control of variables correlated with energy consumption. The basic billing analysis project flow involved bringing together program and billing data sources, adding analysis variables and cleaning the data, building separate savings models by heating fuel and home type, and estimating final savings. Figure 13 summarizes the overall billing analysis project flow.

³¹ The International Performance Measurement and Verification Protocol (IPMVP) defines standard terms and suggest best practice for quantifying the results of energy efficiency investments. A summary can be found at; https://www.energy.gov/sites/prod/files/2016/01/f28/mv_guide_4_0.pdf

Figure 14 WAP billing analysis project flow



EcoMetric estimated energy efficiency impacts by modeling participants' actual energy consumption before and after program intervention. While the overall quality and completeness of the data received for the evaluation was high, EcoMetric removed projects from the analysis which were;

- ▶ Missing square footage of the home.
- ▶ Missing project installation date.
- ▶ Less than 12 months of monthly bills either pre or post measure installation.

The final analysis data set after cleaning and preparation contained 12-36 months of billing energy consumption data for both pre and post-installation of weatherization and direct install measures. The model included a total of 380 homes or 85% of the 445 non-demonstration program participants for the 2016-2017 program years. Energy savings for homes with missing or incomplete data were estimated using the final savings models.

Weather data corresponding to the actual billed energy dates from the Wilmington, Delaware National Weather Service (NWS) weather station along with building square footage from program tracking data was merged with energy consumption data and used as model predictors. EcoMetric transformed the weather data into Heating degree (HDD) and cooling degree (CDD) day values calculated at a base of 65 °F. The HDD and CDD values indicate whether a typical home would either need to be heated or cooled if the outdoor temperature was less than or greater than 65 °F. The following equations show the derivations of HDD and CDD values;

$$\text{HDD} = \text{Temp}_{\text{Base}} - \text{Temp}_{\text{avg}}$$

where $\text{Temp}_{\text{Base}} = 65\text{ }^{\circ}\text{F}$ and Temp_{avg} = the average of the high and low temperature for the day. If the average temperature is greater than 65 °F the value of HDD is 0. The formula for CDD values is similar where:

$$CDD = \text{Temp}_{\text{avg}} - \text{Temp}_{\text{Base}}$$

The values of Temp_{avg} and $\text{Temp}_{\text{Base}}$ are defined the same except in cases where the average temperature for the day is less than 65 °F then the value of CDD is zero. For the WAP analysis HDD and CDD values were estimated daily and summed to match the billing period days.

EcoMetric added billed energy data for April 2015 as a predictor in the models to control for non-weather-related base energy usage. Square footage of homes is typically correlated to the sizing of heating, ventilation, and air conditioning (HVAC) systems and serves as a proxy for the nameplate data of the customer's HVAC systems. Square footage correlates with the number of lighting fixtures and appliances within the home.

Different combinations of HDD, CDD, and square footage variables along with several different model forms were run to best explain change in energy usage from program participation. EcoMetric estimated separate savings models by home type (manufactured or single-family) and primary heating type (electric, natural gas or other). All final model fits were significant with p-values < .01 and adjusted R-square values ranged between 25 and 62% depending on primary heating fuel and home type. All regression coefficients except for the manufactured home HDD variables included in the final models are significant at the 90% confidence level or higher.

Equation (1) lists the final regression model for single-family and manufactured homes where participants primarily heated with natural gas.

$$CCF_{i,j} = \beta_0 + \beta_1 HDD_j SQFT_j + \beta_2 I_{i,j} HDD_i SQFT_j + \varepsilon_{i,j} \quad (1)$$

where;

$CCF_{i,j}$ = Billed Centum Cubic Feet (volume) of natural gas for month i and customer j

HDD_i = Heating degree days (65 degrees F base) for month i

$SQFT_j$ = Home size in square feet for participant j

$I_{i,j}$ = Post-program participation status for month i and participant j

$\beta_0, \beta_1, \beta_2, \varepsilon$ = Coefficients determined by the regression model and error term (ε)

The final WAP savings calculations for each participant follow equation (2) where β_2 is the regression model coefficient identified in equation (1) that identifies the average change in energy use after program participation given the other controlling parameters in equation (1):

$$\Delta CCF_j = \beta_2 HDDNorm_j SQFT_j \quad (2)$$

where;

- ΔCCF_j = Annual change in annual natural gas consumption for participant j following program participation (program savings)
- $HDDNorm_j$ = Normal 30-year average annual heating degree days for participant j
- $SQFT_j$ = Home size in square feet for participant j
- β_2 = The value of the coefficient β_2 determined by equation (1)

Equation (3) lists the final regression model for single-family and manufactured homes who primarily heat with electricity or other non-natural gas fuels:

$$KWH_{i,j} = \beta_0 + \beta_1 BASE + \beta_2 HDD_j SQFT_j + \beta_3 CDD_j SQFT_j + \beta_4 I_{i,j} HDD_i SQFT_j + \beta_5 I_{i,j} CDD_i SQFT_j + \varepsilon_{i,j} \quad (3)$$

where:

- $KWH_{i,j}$ = Billed kilowatt-hours for month i and customer j
- HDD_i = Heating degree days (65 degrees F base) for month i
- CDD_i = Cooling degree days (65 degrees F base) for month i
- $SQFT_j$ = Home size in square feet for participant j
- $BASE_j$ = Baseload energy use for participant j
- $I_{i,j}$ = Post-program participation status for month i and participant j
- $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \varepsilon$ = Coefficients determined by regression model and error term (ε)

Similar to equation (2), EcoMetric calculated the final WAP savings calculations for each participant who heats with electricity or another non-natural gas fuel using equation (4) where now β_4 and β_5 are the two regression model coefficients identified in equation (3). These betas identify the average change in energy use after program participation given the other controlling parameters identified in equation (3):

$$\Delta KWH_j = \beta_4 HDDNorm_j SQFT_j + \beta_5 CDDNorm_j SQFT_j \quad (4)$$

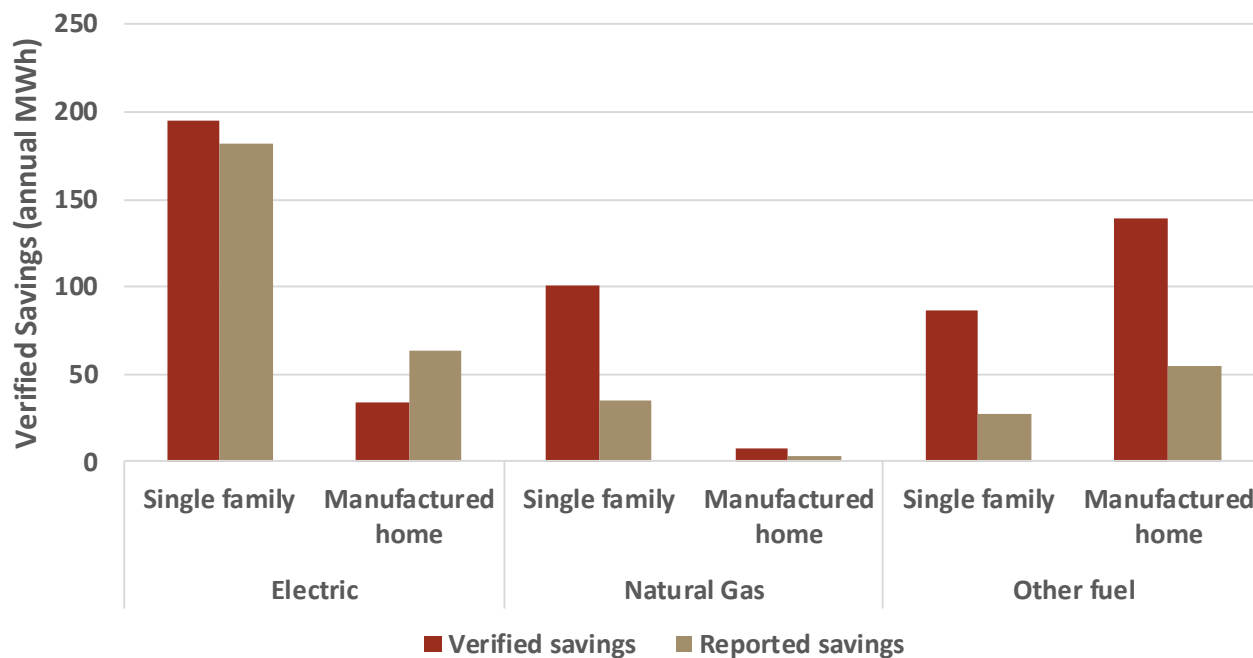
where, ΔKWH_j is the annual change in annual billed electricity for participant j and the additional parameters $CDDNorm$ is defined similarly to $HDDNorm$ only for cooling degree days. EcoMetric calculated the final realized program savings by applying equations (2) and (4) to all 2016-2017 program year projects. Final savings for projects with insufficient project tracking data for modeling were estimated using average program values of square footage.

EcoMetric determined WAP peak demand reductions using both results from the regression analysis along with other assumptions. The models estimated cooling specific annual savings per home as part of the billing analysis by identifying the portion of whole house savings attributable to normalized peak summer weather. Using regional central cooling load shapes, EcoMetric assumed that 23% of total annual cooling savings claimed from WAP projects occur between the 1-7 weekday hours over the peak months June to August. An average kW value could then be estimated by taking the resulting annual cooling savings and divided by the typical number of weekday peak hours in summer (390).

4.1.3 VERIFIED SAVINGS

The 445 weatherized homes completed through the 2016-2017 WAP program achieved 562 MWh of gross verified first-year electric savings. Ex ante savings were generally accurate for electrically heated homes, but under-reported for homes heated with natural gas or other fuels, resulting in an electric realization rate of 153%. The increased savings are most likely due to the whole home regression billing analysis capturing the full savings from non-HVAC direct install measures including lighting, ventilation, electric water heating measures, and potential decreased furnace fan use. A comparison of the reported per-home savings and verified per-home savings is shown in Figure 15.

Figure 15: Reported Per-Home WAP Savings



The billing analysis was not able to identify weather-related versus non-weather-related gas or electric measure savings because of incomplete program tracking databases and the inability to link the full program database to customer billing data. Table 38 summarizes the verified electric savings.

Table 38: WAP 2016 - 2017 Electric Realized Savings Summary

Heating Type	Home Type	Program Projects	Reported Energy Savings (MWh)	Verified Energy Savings (MWh)	Verified Energy Savings Precision	Energy Savings RR	Reported Peak Demand Reduction (MW)	Total Verified Peak Demand Reduction (MW)	Peak Demand Reduction RR
Electric	Single family	94	182	195	10%	107%	0.03	0.04	149%
	Manufactured home	33	64	34	10%	53%	0.01	0	18%
Natural Gas	Single family	93	35	101	6%	284%	—	0.02	NA
	Manufactured home	9	3	8	6%	223%	—	0	NA
Other fuel	Single family	72	27	86	6%	314%	—	0.01	NA
	Manufactured home	144	55	139	6%	254%	—	0.03	NA
Total		445	367	562	7%	153%	0.04	0.11	301%

Not Applicable (NA): the value is not applicable for this home/fuel type combination

Peak kW reduction per project was estimated at 0.24 kW (0.00024 MW) while varying between 0.05 kW (0.00005 MW) for electrically heated manufactured homes and 0.42 kW (0.00042 MW) for electrically heated single-family homes. The overall program average of 0.24 kW (0.00024 MW) per project is close to the previously deemed value of 0.28 kW (0.00028 MW) per home, but the updated evaluation estimates expand the ability of program managers to estimate peak reduction for all projects regardless of heating fuel or home type.

Billing analysis of gas savings for natural gas heated homes resulted in verified savings of 10,138 CCF (982 MMBtu) in annual natural gas savings. Verified savings were less than reported savings resulting in realization rates of 61% and 103% for single-family and manufactured homes, respectively. Realization rates for other fossil fuel heated homes were similar with rates ranging between 67% and 105%. Table 39 summarizes the verified gas savings.

Table 39: WAP 2016 - 2017 Fossil Fuel Realized Savings Summary

Heating Type	Home Type	Program Projects	Reported MMBtu Savings	Verified MMBtu Savings	MMBtu RR	MMBtu Savings Precision
Electric	Single family	94	NA	NA	NA	NA
	Manufactured home	33	NA	NA	NA	NA
Natural Gas	Single family	93	1471	895	61%	17%
	Manufactured home	9	142	146	103%	17%
Other fuel	Single family	72	1,139	768	67%	17%
	Manufactured home	144	2,278	2,400	105%	17%
Total		445	5,031	4,210	84%	17%

Not Applicable (NA): the value is not applicable for this home/fuel type combination

Finding 18: WAP relied on per home savings estimates calculated from a small sample of weatherized homes. EcoMetric calculated verified savings for each home and heating fuel type combination which differed from the initial per home estimates.

The EcoMetric team's billing analysis calculated average verified energy savings, demand savings, and fossil fuels savings for each home type and primary heating fuel type combination. The program currently tracks home type and primary heating fuel type for each weatherized home. Reported electric savings were generally in line with verified savings for electrically heated program homes, while reported savings for homes heated with natural gas or other fuels ranged between 31- 65% of verified savings.

Recommendation 16: Use the saving matrix in Table 40 to claim savings for each weatherized home according to the home type and primary heating fuel type.

Table 40: WAP 2016 - 2017 Per-Home Savings Matrix

Heating Type	Home Type	Per Unit Energy Savings (kWh)	Per Unit Peak Demand Reduction (kW)	Per Unit Energy Savings (MMBTU)
Electric	Single family	2,073	0.42	NA
	Manufactured home	1,023	0.05	NA
Natural Gas	Single family	1,081	0.19	9.6
	Manufactured home	851	0.20	16.2
Other fuel	Single family	1,197	0.21	10.7
	Manufactured home	968	0.22	16.7

Not Applicable (NA): the value is not applicable for this home/fuel type combination

4.1.4 NET SAVINGS VERIFICATION

The Delaware Energy Efficiency Advisory Council (EEAC) deemed the NTG ratios for low income-qualified programs.³² The NTG ratio for all low-income qualified programs is 1.0. Table 41 and Table 42 show the net verified electric savings and net verified fossil fuel savings for WAP, respectively. EcoMetric calculated the net verified savings using the equation below.

$$\text{Net Verified Savings} = \text{Gross Verified Savings} \times \text{NTG Ratio}$$

³²<http://www.dnrec.delaware.gov/energy/information/otherinfo/Documents/EEAC/Draft%20Proposed%20DE%20EE%20program%20NTG%20values%20with%20assumptions.pdf>

Table 41: WAP 2016 – 2017 Net Verified Electric Savings Summary

Heating Type	Home Type	Approved Low Income NTG	Gross Verified Energy Savings (MWh)	Gross Verified Peak Demand Reduction (MW)	Net Verified Energy Savings (MWh)	Net Verified Peak Demand Reduction (MW)
Electric	Single family	1.0	195	0.04	195	0.04
	Manufactured home	1.0	34	0.00	34	0.00
Natural Gas	Single family	1.0	101	0.02	101	0.02
	Manufactured home	1.0	8	0.00	8	0.00
Other fuel	Single family	1.0	86	0.01	86	0.01
	Manufactured home	1.0	139	0.03	139	0.03
Total			562	0.11	562	0.11

Table 42: WAP 2016 – 2017 Net Verified Fossil Fuel Savings Summary

Heating Type	Home Type	Approved Low Income NTG	Gross Verified MMBtu Savings	Net Verified MMBtu Savings
Electric	Single-family	1.0	NA	NA
	Manufactured home	1.0	NA	NA
Natural Gas	Single family	1.0	895	895
	Manufactured home	1.0	146	146
Other fuel	Single-family	1.0	768	768
	Manufactured home	1.0	2,400	2,400
Total			4,210	4,210

Not Applicable (NA): the value is not applicable for this home/fuel type combination

4.1.5 GREENHOUSE GAS EMISSION REDUCTIONS

EcoMetric estimates the net present value (NPV) of the lifetime monetary benefits of greenhouse gas (GHG) emissions reductions achieved by WAP to be \$401,928 for projects completed in calendar years 2016 and 2017. Table 43 shows the lifetime electric savings, lifetime GHG reduction, and lifetime NPV of GHG reduction economic benefits for the program. See section 1.1.5 for details on how EcoMetric calculated the economic benefits of GHG emissions reductions.

Table 43: 2016 – 2018 WAP Greenhouse Gas Emissions Reductions

Heating Type	Home Type	2016 - 2018 Net Verified Electric Savings (MWh)	Lifetime Electric Savings (MWh)	2016 - 2018 Net Verified Gas Savings (MMBtu)	Lifetime Gas Savings (MMBtu)	Lifetime GHG Reduction (lbs)	Lifetime NPV of GHG Reduction Economic Benefits (\$)
Electric	Single family	195	3,266	NA	NA	6,829,900	\$199,253
	Manufactured home	34	566	NA	NA	2,397,731	\$69,951
Natural Gas	Single family	101	1,685	895	15,005	1,344,802	\$39,233
	Manufactured home	8	128	146	2,447	128,758	\$3,756
Other fuel	Single family	86	1,445	NA	NA	1,015,755	\$29,633
	Manufactured home	139	2,337	NA	NA	2,060,122	\$60,101
Total		562	9,427	1,041	17,452	13,777,067	\$401,928

Not Applicable (NA): the value is not applicable for this home/fuel type combination

4.1.6 NON-ENERGY BENEFITS (NEB)

The EcoMetric team's interviewers asked participants if they experienced positive, negative, or no changes to the following since their participation in WAP:³³

- ▶ The draftiness of your home or your comfort in your home.
- ▶ Noise you hear from outside your home or from appliances, heating, or cooling equipment inside your home.
- ▶ Household members' health conditions, such as frequency or intensity of colds, flu, or other conditions like asthma or arthritis.

As shown in Table 44, three-quarters of respondents observed improvements in thermal comfort following participation. Smaller shares observed improvements in noise (40%) and health (37%).

³³ This battery of questions and subsequent monetization approach replicated that used in a 2011 study. Source: NMR. "Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts Evaluation." Prepared for Massachusetts Program Administrators. August 15, 2011. <http://ma-eeac.org/wordpress/wp-content/uploads/Special-and-Cross-Sector-Studies-Area-Residential-and-Low-Income-Non-Energy-Impacts-Evaluation-Final-Report.pdf>

Table 44: Weatherization Assistance Program Participant Observations of Non-Energy Impacts

Type of Impact	Thermal Comfort	Noise	Health
Positive	75%	40%	37%
Negative	-	-	7%
No Impact	25%	60%	56%

Note: Percentages exclude don't know and refusal responses, so sample sizes vary.

If DNREC respondents experienced positive or negative impacts, interviewers asked them, relative to their expected energy bill savings,³⁴ how much the positive change “adds to the value” of living in their home each year or how much the negative changes “takes away” from it, in terms of dollars. Their average estimates are the *initial* NEB values. The first set of rows of Table 45 (*Responses, Including Outliers*), shows their responses.

As implied previously in section 1.3, NEBs are susceptible to double-counting, so the EcoMetric team used a scaling approach to adjust for this as needed. To that end, if respondents reported more than one NEB, then interviewers asked them to think of all the changes *combined* and estimate their *total* value relative to bill savings. Their responses enabled analysts to avoid double counting by changing individual NEBs values proportionally to sum to the *total* estimate (i.e., normalize). As the second set of rows in Table 45 shows, NEB values decreased somewhat after scaling and removing a few outliers.

The billing analysis completed for the gross savings verification indicated that the preliminary bill savings per respondent used in the NEBs surveys based on deemed savings values were slightly high (roughly \$40), so after collecting survey data, the EcoMetric team adjusted the NEBs results based on the billing analysis. This modification resulted in the adjusted NEBs point estimates shown in the third set of rows: \$208 for thermal comfort, \$74 for noise, and \$75 for health.

³⁴ The EcoMetric team estimated preliminary bill savings values prior to survey fielding by using deemed savings values associated with household-specific measures that were recorded as installed in the program tracking data.

Table 45: Weatherization Assistance Program Non-Energy Benefits – Preliminary Results

Value		Thermal comfort (n=57)	Noise (n=58)	Health (n=54)
Responses, Including Outliers	Dollar (per household)	\$306	\$166	\$165
	% of bill savings	57%	31%	31%
Scaled, Outliers Removed	Dollar (per household)	\$236	\$77	\$84
	% of bill savings	44%	15%	16%
Adjusted Estimates, Post Billing Analysis	Dollar (per household)	\$220	\$74	\$75
	% of bill savings	41%	15%	15%

Note: Sample sizes exclude respondents unable to estimate values. Scaled values exclude outliers more than three standard deviations from the mean.

Even after scaling, removing outliers, and applying billing analysis results, these preliminary NEBs estimates appeared high compared to results observed in other jurisdictions. The higher values are likely due to differences in the condition of homes before treatment and because the WAP participants had limited exposure to energy conservation compared to low income weatherization programs in other jurisdictions. As the process evaluation notes, the WAP participants also had high overall program satisfaction scores. This likely resulted in greater perceived NEBs.

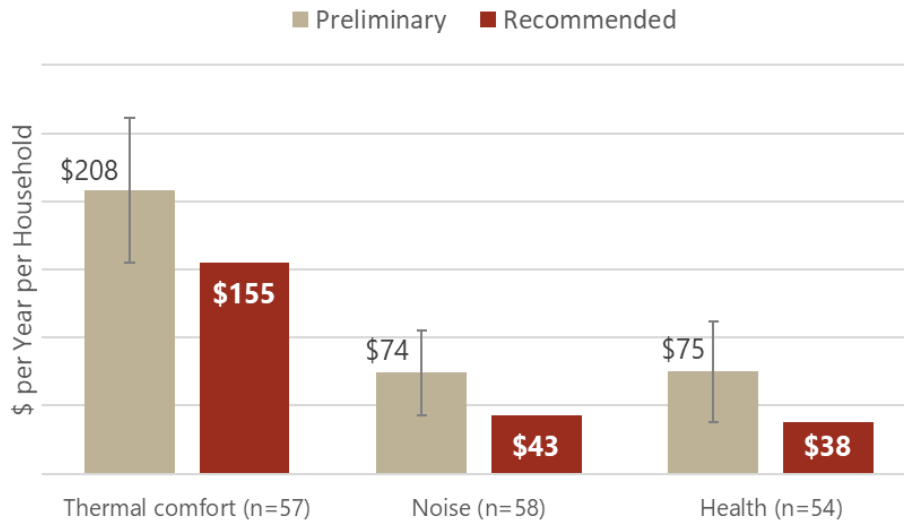
Figure 16 shows each NEB estimate with the 90% confidence interval for the point estimate. The 90% confidence interval defines the range of values which it is 90% certain includes the actual average value of a particular statistic for the whole population. Each NEB point estimate falls at the mid-point of the range. The EcoMetric team recommends that for each NEB, DNREC adopt the value at the lower bound of the 90% confidence interval. This is a more conservative approach than adopting the point estimates. These recommended values are **\$155 for thermal comfort, \$43 for noise, and \$38 for health**, as shown in Figure 16. Summing the three lower-bound values results in a total NEBs value of \$236 per household per year.³⁵

Finding 19: The EcoMetric Team study found the total NEBs value for health to be \$236 per household per year, a net increase of \$64 over the current TRC value.

***Recommendation 17:** Adopt the following NEB values: \$155 for thermal comfort, \$43 for noise, and \$38 for health. These represent a conservative estimate at the lower bound of the 90% confidence interval for the point estimates. Conduct a follow-up NEBs study with more surveys to reduce uncertainty in the initial NEBs values, and to further investigate the reasons for higher benefits observed by the WAP participants compared to low income programs in other jurisdictions.*

³⁵ Delaware currently claims \$172 savings from health. This value was drawn directly from a Massachusetts 2016 study.

Figure 16: Weatherization Assistance Program Non-Energy Benefits – Recommendations



Note: The recommended values are the lower bound estimates, calculated at a 90% confidence interval.

4.1.7 COST-EFFECTIVENESS RESULTS

EcoMetric's cost-effectiveness analysis shows that the Weatherization Assistance Program has a benefit-cost ratio of 1.71 using the Total Resource Cost (TRC) test, indicating the program is cost-effective. Table 46 provides details on the total benefits and costs which EcoMetric included in the TRC test for the Weatherization Assistance Program.

Table 46: 2016 – 2017 WAP Cost-effectiveness Results

Benefit / Cost	NPV of Benefit/Cost
Lifetime Avoided Cost of Energy	\$877,396
Lifetime Avoided Cost of Capacity	\$176,818
Lifetime Avoided Cost of Fossil Fuel	\$71,123
Lifetime Non-Energy Benefits	\$2,605,661
Total Benefits	\$3,730,998
Program Administrative Costs	\$2,181,096
Measure Costs	\$0
Total Costs	\$2,181,096
TRC Benefit-Cost Ratio	1.71

Refer to section 1.1.6 for details on how EcoMetric performed the cost-effectiveness analysis.

4.2 PROCESS EVALUATION

The process evaluation entailed reviewing program materials and examining the program tracking data, conducting in-depth interviews with the program manager and local agencies, and fielding a telephone survey with 632 households that participated in the program during the study period.

4.2.1 PROGRAM DESCRIPTION

This detailed program description is based on information from the WAP Annual Report for 2017³⁶ and the Three-Year Program Plan³⁷ and interviews. It is meant to provide context for the process evaluation observations and findings.³⁸

The U.S. Department of Energy (DOE) oversees the Weatherization Assistance Program (WAP). WAP provides income-eligible residential customers with free energy-efficiency retrofits to reduce their energy costs and improve their health and the safety of their homes. DNREC's \$7.4 million three-year WAP budget for PY2016 – PY2018 is funded by the U.S. Department of Energy, U.S. Department of Health & Human Services through the federal Low-Income Home Energy Assistance Program (LIHEAP), Regional Greenhouse Gas Initiative (RGGI), and Pepco Utility Fund. The DOE WAP requires DNREC (as the WAP "grantee") to contract with local non-profit agencies, referred to as "subgrantees," to administer WAP and deliver weatherization services to eligible residents. The DNREC WAP program currently works with two local subgrantees to carry out home energy audits, identify energy savings opportunities, and install selected weatherization and health-and safety-related measures. Most completed projects include insulation, air sealing, and ventilation retrofits. Participating customers live in single-family or manufactured homes which they may rent or own.

In PY2016 and PY2017, DNREC WAP worked with just one subgrantee, the non-profit Catholic Charities which served all three counties in Delaware (New Castle, Kent, and Sussex). At the beginning of Program Year 2018, the WAP program added a second subgrantee, Energy Coordinating Agency (ECA), to serve New Castle County while Catholic Charities continued to be the subgrantee for Kent and Sussex counties.

³⁶ Department of Natural Resources and Environmental Control, Division of Climate, Coastal, & Energy. 2018. "Annual Report – Program Year 2017, Weatherization Assistance Program." April 15. Accessed from <http://www.dnrec.delaware.gov/energy/Documents/Weatherization/2018-wap-annual-report.pdf>

³⁷ Department of Natural Resources and Environmental Control, Division of Climate, Coastal, & Energy. 2016. "Three-Year Program Plan Energy Efficiency Investment Fund (EEIF), Energy Efficiency Industrial (E2I), and Weatherization Assistance Program (WAP)." December 7. Accessed from <http://www.dnrec.delaware.gov/energy/information/otherinfo/Documents/EEAC/DNREC%202016-2018%20Program%20Plan%20Update%20FINAL.pdf>

³⁸ The program description is based on information from the WAP Annual Report for 2017 and the Three-Year Program Plan, supplemented by interviews. Department of Natural Resources and Environmental Control, Division of Climate, Coastal, & Energy. 2018. "Annual Report – Program Year 2017, Weatherization Assistance Program." April 15. Accessed from <http://www.dnrec.delaware.gov/energy/Documents/Weatherization/2018-wap-annual-report.pdf>

Catholic Charities also administers the LIHEAP program, which provides financial assistance to low-income Delawareans who need help meeting their home energy costs, throughout Delaware including New Castle County.

Subgrantees are responsible for hiring, managing, and paying home energy auditors and third-party subcontractors. Auditors, who may be on subgrantee staff or employed by a subcontractor, conduct required home energy audits and final inspections after measure installation. Subcontractors perform weatherization services that are recommended based on the audit results.

Delaware residents are eligible for the WAP program if their household income falls below 200% of the federal poverty line and they have not previously received weatherization services through the program. Subgrantees determine the eligibility of prospective participants, or clients, based on information clients provide, such as household income and energy use. After subgrantees select a client for participation in the program, a home energy audit is scheduled to assess opportunities for energy savings and health and safety improvements. If the auditor finds any safety concerns that preclude the home from participating in WAP, such as moisture, mold, or poor roof conditions, the subgrantee defers weatherization until the issue is resolved.

WAP collaborates with other programs to maximize client participation and minimize deferrals. Most prominently, WAP partners with the Pre-Weatherization Assistance Program (Pre-WAP), which was established in 2015 and is funded by Delaware Sustainable Energy Utility (DESEU), to address household weatherization projects deferred due to structural concerns identified during the audits. Because Pre-WAP has a different funding source, it can often assist when WAP cannot, such as in the case of general home repairs and dehumidifier installation. WAP also leverages Catholic Charities' role administering LIHEAP in Delaware to facilitate bringing eligible households or "clients" into the program.

A successful audit—i.e. one that does not result in a deferral—produces a work order that itemizes each recommended measure. The subgrantee is responsible for reviewing the work order and selecting a subcontractor to complete the weatherization services. Upon completion of the work, the DOE requires that all homes receive a final inspection conducted by a BPI-certified Quality Control Inspector (QCI). A sample of all serviced homes is inspected by the State Program Monitor, who serves as the state's weatherization technical expert. In Program Year 2018, DNREC hired a new State Program Monitor.

DNREC expects WAP will achieve annual energy savings of nearly 600 MWh and maintain a Total Resource Cost (TRC) benefit-cost ratio of 0.6 over program years 2016 to 2018. The TRC ratio is expected to be higher with the inclusion of NEBs calculated by the evaluation team.

4.2.2 SUMMARY OF PROGRAM TRACKING REVIEW

The EcoMetric team analyzed the sample frame for the WAP participant survey, which included 640 projects with inspection dates indicating they were completed between June 2016 and early March 2019. The review primarily focused on data from the program tracking database for WAP program years 2016 (April 1, 2016 through March 31, 2017) and 2017 (April 1, 2017 through March 31, 2018)³⁹ to identify **general trends in the administration of the program**. During the tracking data review, the team encountered some data limitations.

- ▶ The data on which this analysis was based comprised three different Hancock data extraction files that the team merged. Data for some households appeared in more than one file.⁴⁰
- ▶ The data files excluded data from projects completed in the first three months of PY2016 before electronic tracking began.
- ▶ Almost one-quarter (24%) of the households did not have a final inspection date. The team understands that these homes were either deferred or in progress.
- ▶ The WAP program year is April 1 to March 31, but some of the information reviewed was available only by the calendar year.

During the data review, the team also found some areas where data quality could be improved:

- ▶ Pre-WAP participation flags were not recorded consistently.
- ▶ Installed measures were not standardized or categorized by weatherization measure type and frequently include multiple measures within one cell.
- ▶ Some of the database fields had blank cells (e.g., "TotalSqFt" was blank for many records).

EcoMetric's analysis of Hancock data showed that during the PY2016-PY2018 period (i.e. both Year 1 and Year 2), when the 38 projects without electronic data are factored in, WAP exceeded participation projections for this period laid out in the DNREC Three-Year Plan for 2016-2018 by 33 projects, or 5%.

4.2.3 MARKETING AND OUTREACH

4.2.3.1 Current Strategies

The primary responsibility for program marketing and outreach lies with DNREC WAP staff. WAP performs community outreach by visiting libraries, senior centers, the food pantry, laundromats, and the Delaware

³⁹ Department of Natural Resources and Environmental Control, Division of Climate, Coastal, & Energy. 2018. "Annual Report – Program Year 2017, Weatherization Assistance Program." April 15. Accessed from <http://www.dnrec.delaware.gov/energy/Documents/Weatherization/2018-wap-annual-report.pdf>

⁴⁰ A household may appear in more than one file for reasons such as a subsequent visit for a warranty claim.

Department of Labor. They have also developed some radio advertisements, a bilingual pamphlet, and have a small social media presence.

Subgrantees also perform some marketing. As noted above, Catholic Charities is well established in the market as the implementer of LIHEAP in Delaware, and it benefits from name recognition associated with this. Catholic Charities primarily markets WAP by offering it to clients who are already in their office applying to LIHEAP, as eligibility requirements are the same for both programs. Catholic Charities supplements marketing at LIHEAP intake with community outreach to schools, community centers, and health fairs.

Process Finding 9: Developing a formal mechanism for marketing and outreach for both WAP staff and subgrantees should make marketing efforts more effective and might increase participation.

Process Recommendation 6: Develop and implement a marketing strategy for WAP and explore ways to support subgrantees in their marketing efforts.

ECA markets the program by distributing marketing materials, networking in target markets, engaging with community centers, and reaching out to city officials, community organizations, and mobile home parks. As this subgrantee explained, “The people we serve are primarily elderly or don’t have a lot of means, so rather than try to have them get to our office for intake, I’m trying to bring it to their location to a place where they feel comfortable and safe.”

4.2.3.2 Challenges

The program manager noted that some common program marketing strategies might not be effective for WAP because participants may not want to be associated with a low-income program. As she explained, “If we ask permission for the auditor to hand out brochures to neighbors, some people say no because they don’t want their neighbors to know.”

A review of the WAP website on August 9, 2019 found three broken links: WAP eligibility requirements, information for professionals, and program plans and reports. These links had all been fixed and were functioning correctly as of November 5, 2019.

The program manager would like to see more effort put into advertising. She suggested that adding a community relations staff member to DNREC WAP staff could help develop WAP’s social media strategy and ensure that WAP marketing is appropriate and effective. One subgrantee recommended that WAP develop a stronger social media presence.

4.2.4 PROGRAM AWARENESS AND DRIVERS OF PARTICIPATION

The EcoMetric team asked respondents about how they first heard of WAP. A summary of participants' responses is shown in Table 47. Over one-half of respondents (58%) first heard about WAP through Catholic Charities or the Energy Coordinating Agency (ECA).

Table 47: Means of First Hearing about the Weatherization Assistance Program

Heard About WAP Through	Percent (n=62)
Catholic Charities or ECA	58%
Family or friends	19%
Social services	11%
Utility advertisement or bill insert	3%
Energy assistance referral	2%
Other	6%

Process Finding 10: Subgrantees are the leading driver of WAP program awareness.

The reasons respondents installed equipment through the WAP are summarized in Table 48. The main reasons were to save money and make their homes more comfortable (44% and 40% of respondents, respectively).

Table 48: Motivation for Participating in the Weatherization Assistance Program

Reasons for Installing Equipment	Percent* (n=62)
Save money	44%
Make home more comfortable	40%
Learn about energy-saving opportunities	23%
Home needed it	18%
It was recommended	10%
Receive free energy-saving upgrades	5%

*Percentages sum to greater than 100% because this was a multiple-response question.

4.2.4.1 Barriers to Participation

The team asked subgrantees and the program manager for their perspectives on the reasons that might prevent an eligible client from participating in WAP. All three identified health and safety issues found during the audit as the primary barrier to participation. These issues are often moisture, mold, or poor roof conditions that preclude them from participating until remediation is complete. WAP cannot weatherize homes with such health and safety issues, so these are deferred from participation until the issues are resolved. Internal to each subgrantee is a process to defer homes to Pre-WAP where the

identified health and safety issues are usually resolved. The homes then return to WAP for the full complement of services.

One subgrantee and the program manager mentioned that providing the documentation required to participate can be a challenge for applicants. As the program manager explained, WAP application requirements mirror those of LIHEAP, for which all occupants of the home must provide a birth certificate and Social Security card, and adults must provide income information. This can prevent applicants from moving forward in the process if they are not United States citizens or if they have lost their identification documents. If some adult household members do not provide income or identification information, the level of income needed to be eligible for participation drops to that of a smaller household.

4.2.5 IMPLEMENTATION CHALLENGES

Both subgrantees indicated that they find it difficult to find and retain experienced subcontractors. As a result, some subcontractors lack adequate experience and expect the subgrantee to provide them with additional training beyond what DNREC offers. The subgrantees explained that it was difficult to bring such subcontractors up to the level of quality they required. One did not have the time or ability to undertake the task.

The program tracking data review suggested that subgrantees did not meet their PY2018 production goals, and the program manager affirmed that subgrantees have had difficulty meeting these goals. She explained that meeting goals requires developing and maintaining steady flows of clients, auditors, and subcontractors. It is necessary to have enough clients who want services, enough auditors available to conduct audits to meet the rate of requests, and enough subcontractors to whom grantees can assign the work so that units are weatherized within a short enough time. She noted that auditors and QC inspectors are particularly difficult to find and retain. They require experience, BPI certifications, and industry continuing education credits. To manage this flow, subgrantee managers must have a combination of technical knowledge, business administration skills, and client intake skills that are not commonly found together.

One subgrantee noted that many contractors are not willing to do work in Wilmington. Additionally, Wilmington requires a permit for weatherization. These factors increase costs and time to complete projects in that city.

Both subgrantees identified mold as a challenge to implementation. According to one subgrantee, Pre-WAP and other programs that can prepare homes to participate in WAP do not often address mold issues because it is not possible to ensure that what the program corrects will mitigate the problem. Even if a mold problem appears to have been mitigated, tightening a home can cause it to reappear. One subgrantee noted that there are many moisture issues in homes in Delaware, and the other subgrantee stated that mold in housing will likely become more common with climate change.

4.2.5.1 Communication with DNREC

Both subgrantees provided positive descriptions of their interactions and communications with DNREC. One subgrantee is very satisfied with the quality of communication from DNREC, saying, “They are very easy to work with, very reasonable. If you have a common-sense question or argument, they are very open. They’ve been amazing to work with.” The other subgrantee was similarly pleased, noting that, “Whenever we had a question about anything – procedural, a specific job – we could always go to DNREC and get a reasonable response in a reasonable amount of time.”

The team asked subgrantees to rate their satisfaction with communication from DNREC on a scale of 1 (very dissatisfied) to 5 (very satisfied). One subgrantee rated it at 4 (somewhat satisfied) and the other at 5 (very satisfied).

4.2.5.2 Hancock Software System

DNREC provides subgrantees and auditors with access to the Hancock Software System (Hancock) to enable them to collaborate, collect data during audits, and share information. DNREC oversees all aspects of Hancock, including the contractual relationship, ensuring that the software reflects changing program thresholds such as federal poverty income guidelines, and software training.

Once an application is completed, the software will determine the client’s eligibility. Upon approval, the subgrantee schedules the audit and assigns an auditor to the job. During the audit, the auditor records all pertinent information in Hancock, making the audit process essentially paperless.

While Hancock offers audit scheduling, one subgrantee explained that they also use a Google Calendar to track all field work with their auditors and subcontractors, allowing the auditors to arrive for the final inspection while the subcontractors are still on-site.

The subgrantees differed in their perception of Hancock software. One subgrantee stated

- ▶ *“I actually enjoy using Hancock, I like the one-stop approach”*

while noting that “there are some things that can be better” and referring to the frequency of “glitches” having been reduced. The other subgrantee said that it “works OK” and offered the following suggestions for improving it:

- ▶ **Track additional data and client information.** *“It’s impossible to track anything in Hancock. You absolutely need outside spreadsheets for any sort of data collection beside the bare minimum from Hancock.”*
- ▶ **Add a client waitlist feature to enhance audit scheduling.** *“Unfortunately, the Hancock system doesn’t really give a great waiting list. So, once I review the applications, I put them kind of in order of how I got them and when I schedule them, I just call down the list.”*

- ▶ **Improve the schedule view.** *“Hancock can assign jobs but it’s not easy for the auditors to see where [is] the address, name, or visit time of their next client to visit that day.”*
- ▶ **Add automatic email notifications when a task is complete.** *“It would be nice if Hancock sent an alert when something is complete, after I upload an invoice for example.”*

The EcoMetric team’s review of data from the Hancock system revealed some additional areas for improvement:

- ▶ Pre-WAP participation flags were not tracked consistently.
- ▶ Installed measures were not standardized or categorized by weatherization measure type and frequently included multiple measures within one cell.
- ▶ Some of the database fields had blank cells (e.g., “TotalSqFt” was blank for many records).

Some of these data gaps may be due in part to the aversion some auditors have to bypassing paper and inputting data directly into Hancock. One subgrantee noted that their auditors like to write down information on paper forms and input the data into Hancock later—and that the forms did not include everything for which Hancock asks.

Process Finding 11: An improvement in the consistency of data input by users of Hancock and minor improvements to the Hancock system might incrementally improve WAP’s process efficiency.

Process Recommendation 7: Improve program data collection and tracking requirements and expectations. This could include upgrades to the Hancock System to allow for additional data collection. Explore the other suggestions for improvements offered in this section of the report.

4.2.6 DNREC TRAININGS

DNREC staff plan and conduct all training sessions for WAP subgrantees, auditors, and subcontractors. One subgrantee described the DNREC training as “very good” and the other subgrantee characterized them as “effective.” One subgrantee specifically appreciated that DNREC “brought in other industry professionals and provided Hancock training directly from Hancock personnel.” The two subgrantees noted that communication around upcoming trainings is well done. They commented that DNREC sends out reminders several months in advance to explain the topics in each session.

The team asked subgrantees to rate their satisfaction with the training on a scale of 1 (very dissatisfied) to 5 (very satisfied). One subgrantee rated it at 4 (somewhat satisfied) and another at 5 (very satisfied).

One subgrantee offered the following suggestions to help make DNREC training more effective:

- ▶ **Offer some training as webinars.** *“Some trainings, like refreshers, can be done by webinar.”*

- ▶ Add more detail to the existing procedure manual or develop a second one that summarizes issue-specific institutional knowledge. *“There’s a lot of institutional knowledge that’s not written down anywhere. There’s no procedures manuals [sic]. There’s a generic manual but we don’t use it for a lot of issues that are specific.”*
- ▶ Allow new hires to attend training. *“I understand DNREC’s point of you want who you’re training to be the ones staying and not new people. It would be nice if it was a little less restrictive.”*

Process Finding 12: Adding more issue-specific detail to the WAP procedure manual or developing a second manual that summarizes issue-specific institutional knowledge and making training somewhat more accessible might improve the program’s process efficiency.

Process Recommendation 8: Offer webinars as an additional mode of training. Consider adding more issue-specific detail to the WAP procedure manual or developing a detailed issue-specific manual to capture institutional knowledge for subgrantees and subcontractors. Consider opening training to all subcontractor and subgrantee staff, regardless of tenure.

4.2.7 QUALITY CONTROL INSPECTIONS

The team asked subgrantees to rate their satisfaction with the post-installation inspection process on a scale of 1 (very dissatisfied) to 5 (very satisfied). One subgrantee rated it at 3 (neither satisfied nor dissatisfied) and another at 5 (very satisfied).

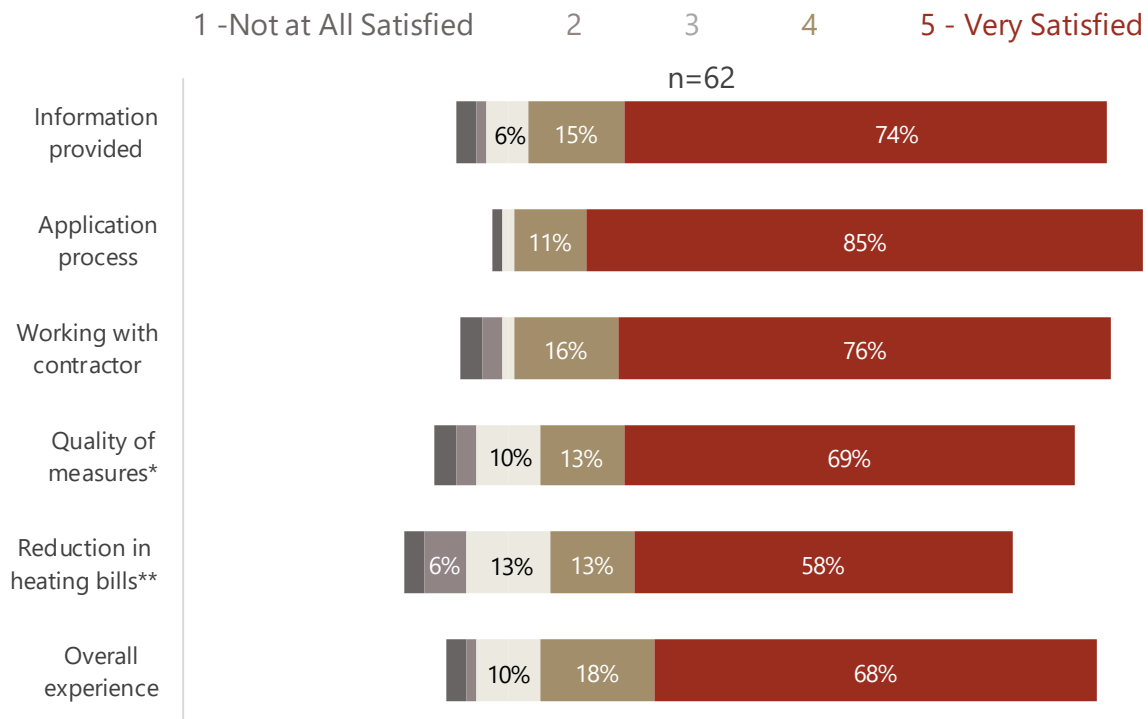
4.2.8 PROGRAM SATISFACTION, LOYALTY, AND OVERALL EXPERIENCE

The team asked subgrantees to rate their satisfaction with the WAP administrative requirements and processes as well as their overall program experience, using a scale of 1 (very dissatisfied) to 5 (very satisfied). Subgrantees rated administrative requirements and processes at 3 (neither satisfied nor dissatisfied) and 5 (very satisfied), and overall program experience at 4 (somewhat satisfied) and 5 (very satisfied).

Process Finding 13: Subgrantees are satisfied with their overall experience with WAP.

Figure 17 depicts the participants’ satisfaction with WAP. Over four-fifths, (86%) of respondents were somewhat or very satisfied with their overall experience. Respondents were especially satisfied with the application process, working with the contractor, and the information about the energy savings opportunities.

Figure 17: Weatherization Assistance Program Participant Satisfaction



*2% of respondents said, 'don't know.'

**6% of respondents said, 'don't know.'

Process Finding 14: 86% of participants are satisfied with their overall experience with WAP. They are most satisfied with the application process.

Eight respondents (13%) expressed dissatisfaction with one or more aspects of the program. Common complaints include no noticeable reduction in energy bills, poor workmanship, and new equipment breaking. One of these respondents explained, "The communication wasn't there. I feel like when they were done here, they didn't want to come back. It damaged my home. I was very disappointed." The second respondent said, "I had to keep calling and asking when they would come. I had to do a lot of follow-up, and one year later, much of the work is still not done." The third respondent commented, "When the auditor came in and evaluated, he pointed out different areas to be fixed, but it was never done."

Respondent feedback should be interpreted with caution. The program manager noted that WAP participants may receive services from other programs and are not able to distinguish between them. The feedback is still considered to be very valuable, yet all feedback may not be attributable specifically to DNREC's WAP program.

The survey asked participants what, if anything, they would like to see change about the WAP. Table 49 summarizes their responses. Nearly one-half (48%) of respondents said “nothing.” Almost one-quarter (23%) of respondents said they would have liked to have their windows or doors repaired, replaced, or weatherproofed. According to the Three-Year Program Plan, WAP does not install or replace broken windows or doors as a routine energy-saving measure, but they will make small improvements or repairs as needed to comply with weatherization best practices. According to the program manager, homes that are deferred to Pre-WAP regularly receive the needed window and door repair and replacements.

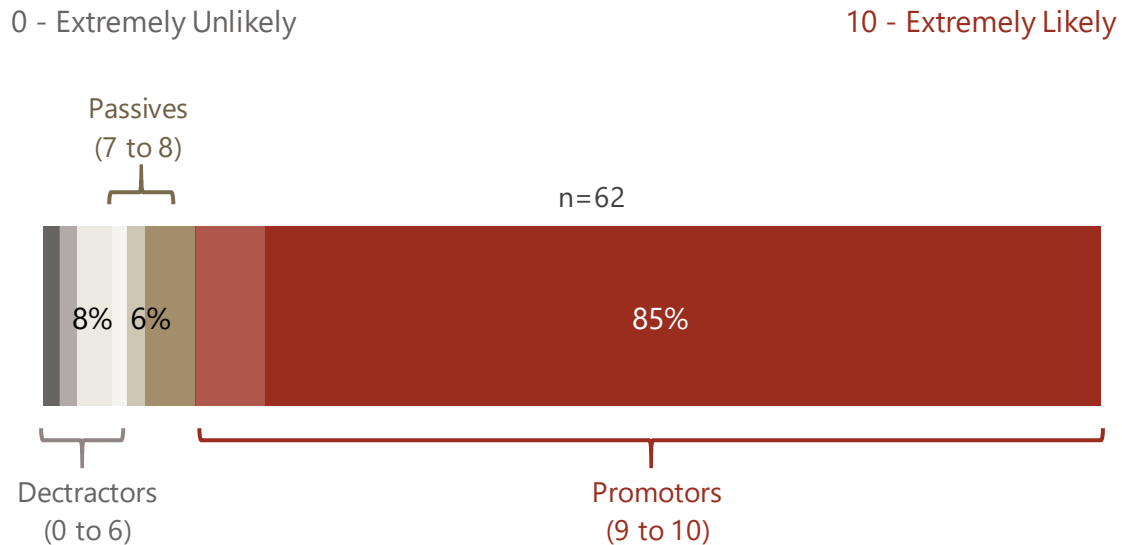
Table 49: Suggestions for Weatherization Assistance Program Improvement

Suggestions for Improvement	Percent* (n=62)
Nothing	48%
Windows and doors	23%
Quality control procedures	13%
Energy savings from upgrades	3%
Clearer communication	3%
Time it takes to install the upgrades	2%
Other	5%
Don't Know	8%

*Percentages sum to greater than 100% because this was a multiple-response question.

Respondents were also asked to rate the likelihood of recommending the WAP program to others. The response scale ranged from 0 to 10, with 0 being “extremely unlikely” and 10 “extremely likely.” This rating is used to calculate the Net Promoter Score (NPS), a well-established measure of customer loyalty. With the NPS, respondents are grouped as promoters (score 9-10), passives (7-8), and detractors (0-6). The NPS is calculated by subtracting the percentage of detractors from the percentage of promoters and presented as a whole number, as shown in Figure 10. The NPS was 77, a very high value. Overall, 85% of customers who participated in the program are “promoters” (Figure 18)—that is, there is a high likelihood that these customers will actively promote the program to other potential participants by word-of-mouth.

Figure 18: Likelihood of Recommending the Weatherization Assistance Program



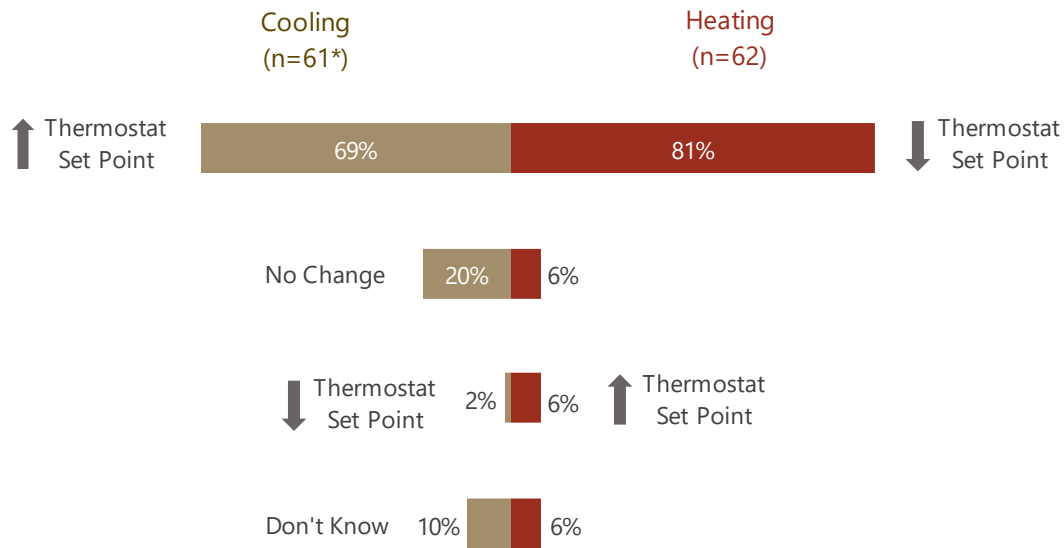
4.2.9 POST-WEATHERIZATION THERMOSTAT SETPOINTS

The EcoMetric team asked WAP participants two questions related to their thermostats.

1. Since receiving the energy efficient upgrades, during the winter have you been able to turn down the temperature setting on your thermostat or run your heating less and still be comfortable?"
2. Since the installation of the energy efficient upgrades, during the summer have you been able to turn up the temperature setting on your thermostat or run your air conditioner for less time and still be comfortable?

Participant responses are depicted in Figure 19. Over two-thirds (69%) of respondents with air conditioning said they had been able to turn up the temperature setting on their thermostat during the summer and still be comfortable. Over four-fifths (81%) of respondents said they had been able to turn down the temperature setting on their thermostat during the winter and still be comfortable.

Figure 19: Weatherization Assistance Program Participant Thermostat Behavior



*One respondent did not have air conditioning.

4.2.10 PLANNED OR POSSIBLE PROGRAM IMPROVEMENTS

According to the program manager, some improvements are in the works:

- ▶ As of April 2019, WAP was beginning to implement the use of Hancock software during the audit to model expected savings from possible measures based on the characteristics of each home and to identify cost-effective measures for the home.
- ▶ DNREC is considering developing a program to install photovoltaic solar panels in low-income homes using DOE funding earmarked for this purpose; the process has been delayed ensuring that DNREC has all of the resources necessary to successfully launch this new program.
- ▶ DNREC plans to seek funding that is “more fluid and efficient.” They would like a funding option that would allow subgrantees to receive a “fiscal responsibility check” and random check-ins by DNREC instead of submitting hundreds of invoices.

APPENDIX A: PROGRAM EVALUATION TEARAWAYS

This section contains Program Evaluation Tearaways that summarize the key findings and recommendations from the impact and process evaluations for each program.



DNREC EEIF Evaluation

2016 - 2018 At-a-Glance

270

**Measures
Granted**

74

**Measures
Evaluated**

Projects Completed Include:

- LED Lighting Retrofits
- Compressed Air
- HVAC Controls
- Premium Efficiency Motors
- Variable Speed Drives
- Boilers
- Heat Pumps
- Furnaces
- Variable Refrigerant Flow Retrofits

101%

Energy kWh
Realization Rate



2.62
**Total Resource
Cost Ratio**



16,250 MWh

Net Verified Electric Savings



1.59 MW

Net Verified Demand Savings



765 MMbtu

Net Verified Gas Savings



177,944 tons

Lifetime
GHG Reduction

Key Impact Recommendations

- Utilize waste heat factors and coincident factors from the Mid-Atlantic TRM to calculate savings for lighting projects.
- Continue to seek input and guidance from the EEIF technical reviewer or evaluators to develop baselines for custom projects.
- Energy savings for fuel switching projects should be the fuel neutral difference between baseline MMbtu and proposed MMbtu.
- Update the application to ensure building type, heating type, and existing lighting fixture power is clearly documented.



DNREC EEIF Evaluation

2016 - 2018 At-a-Glance

89% 
Overall Customer Satisfaction

What do customers like about EEIF?

- 94% - Grant amounts
- 88% - Eligible equipment types
- 78% - Grant turnaround time
- 72% - Application Process

Average Contractor Satisfaction



Room for Improvement

Streamline application / pre approval

Regularly communicate project status

Develop targeted marketing

Key Process Recommendations

- Conduct research to better understand the **target markets** for the program and how best to reach them, and then **expand program marketing and outreach** as appropriate.
- Utilize the **EEIF online application portal** to **streamline** the application process for program participants.
- Explore the possibility of **listing on the website the names of contractors** who have completed applications through the program, with appropriate caveats.
- **Maintain open channels of communication** with customers and contractors, as communication is a **major driver of program satisfaction**.



DNREC GEP Evaluation

2016 - 2018 At-a-Glance

1,303

Projects
Completed

31

Projects
Evaluated

100%

Capacity
Realization Rate

237,254
tons
Lifetime GHG
Reduction



0.98

Total Resource
Cost Ratio



9 MW

Verified Solar Capacity Installed



382 Tons

Verified Geothermal Capacity Installed



13,725 MWh

Avoided Electric Generation



11 MW

Avoided Peak Demand Generation

Key Impact Recommendations

- Track annual energy generation in program database.
- For solar PV projects, continue to ensure contractors are **accounting for shading factors** when determining anticipated **Solar PV system performance**. Enforce contractors to list shading parameters on the application.
- Use AHRI certificates rather than nominal values to verify the capacity of installed geothermal heat pump systems.



DNREC WAP Evaluation

2016 - 2018 At-a-Glance

445 Homes Weatherized

380 Homes modeled in billing analysis

153%

Energy kWh Realization Rate



Total Resource Cost Ratio



562 MWh

Net Verified Electric Savings



0.11 MW

Net Verified Demand Savings



4,210 MMbtu

Net Verified Gas Savings

Key Impact Recommendations

Recommended NEBs



\$155 Thermal Comfort



\$43 Noise



\$38 Health

- Use the **savings matrix** to **claim savings** for each weatherized home according to **home type** and **heating type**.



6,889 tons

Lifetime GHG Reduction

Heating Type	Home Type	Per Unit Energy Savings (kWh)	Per Unit Peak Demand Reduction (kW)	Per Unit Energy Savings (MMBTU)
Electric	Single family	2,073	0.42	NA
	Manufactured home	1,023	0.05	NA
Natural Gas	Single family	1,081	0.19	9.6
	Manufactured home	851	0.20	16.2
Other fuel	Single family	1,197	0.21	10.7
	Manufactured home	968	0.22	16.7



DNREC WAP Evaluation

2016 - 2018 At-a-Glance

86%



Overall Customer Satisfaction

What do customers like most about WAP?

- 96% - Application process
- 92% - The Contractors
- 89% - Educational information
- 82% - Measure quality

Average Subgrantee Satisfaction



5

4.5

4.0

- Overall Experience
- Admin Reqs and processes



1



Room for Improvement

- Develop targeted marketing
- Distinguish other programs from WAP
- Offer webinar training to subgrantees and subcontractors

Key Process Recommendations

- Offer webinars as an additional mode of training. Consider adding more issue-specific detail to the WAP procedure manual or developing a detailed issue-specific manual to capture institutional knowledge for subgrantees and subcontractors.
- Develop and implement a marketing strategy for WAP and explore ways to support subgrantees in their marketing efforts.
- Improve program data collection and tracking requirements and expectations. This could include upgrades to the Hancock System to allow for additional data fields.
- Consider opening training to all subcontractor and subgrantee staff, regardless of tenure.