2019 EVALUATION REPORT

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

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Prepared for:	Delaware Department of Natural Resources and Environmental Control
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ABBREVIATIONS

AC	Alternating Current
AHRI	Air-Conditioning, Heating, and Refrigeration
CDD	Cooling Degree Day
CO_2	Carbon Dioxide
COPD	Chronic Obstructive Pulmonary Disease
CY	Calendar Year
DC	Direct Current
DE SEU	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
EER	Energy Efficiency Ratio
EIA	Energy Information Administration
EM&V	Evaluation, Measurement, and Verification
EUL	Expected Useful Life
FY	Fiscal Year
GEP	Green Energy Program
GHG	Greenhouse Gas
HDD	Heating Degree Day
HID	High-Intensity Discharge
HOU	Hours of Use
HVAC	Heating, Ventilation, and Air-Conditioning
IPVMP	International Performance Measurement and Verification
kWh	Kilo-Watt hours
Lbs	Pounds
LED	Light Emitting Diode
MERV	Minimum Efficiency Reporting Value
MMBtu	Million British Thermal Units
MW	Mega-Watts
MWh	Mega-Watt hours
NAC	Normalized Energy Consumption
NEB	Non-energy benefit
NO_x	Nitrogen Oxides

NPV	Net Present Value
NTG	Net-to-Gross
NWS	National Weather Service
PUC	Public Utility Commission
PV	Photovoltaic
PY	Program Year
RR	Realization Rate
SREC	Solar Renewable Energy Credit
SO_2	Sulfur Dioxide
TMY	Typical Meteorological Year
TRC	Total Resource Cost
TRM	Technical Reference Manual
UVC	Ultraviolet-C
WAP	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 EcoMetric team) to evaluate two energy efficiency programs and one renewable program offering for calendar year (CY) 2019. 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 savings, peak demand savings, 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 were for prescriptive lighting in CY2019.
- **Green Energy Program (GEP) –** GEP provides funding to promote the use of renewable energy to commercial, non-profit, and residential Delmarva Power and Lighting (DPL) 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 reflect the most up-to-date program and market conditions. EcoMetric used the verified savings to evaluate the cost-effectiveness of DNREC's energy efficiency and renewable energy programs. Approaches used to conduct the impact evaluation include engineering analyses, virtual 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 process evaluations' overall objective is to provide DNREC program staff with recommendations about improving 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, 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 and assess the program processes.

E.2 EVALUATION RESULTS SUMMARY

EcoMetric evaluated 340 different projects spread across the 2018 (WAP) and 2019 (EEIF and GEP) calendar years (CY). Program participants from each of the three evaluated programs – EEIF, GEP, and WAP – indicated they were satisfied with their experience in the programs.

The verified savings and realization rates (RR) for WAP (CY2018), EEIF (CY2019), and GEP (CY2019) are summarized in Table 1 and Table 2.

Table 1: CY2018 - 2019 Reported and Gross Verified Electric and Peak Demand Savings[†]

Program	Reported Energy Savings (MWh)	Peak Demand Savings Reported (MW)	Verified Energy Savings (MWh)	Verified Peak Demand Savings (MW)	Energy Savings RR (%)
EEIF	16,674	NR	16,819	2.79	101%
GEP	NR	NR	400	0.32	NA
WAP*	301	0.06	234	0.04	78%
Total	16,975	0.06	17,453	3.14	103%

Note: Demand realization rates were calculated but are not shown since the verified demand is much higher than the reported demand.
* The evaluation period for WAP was the calendar year 2018
Not Applicable (NA): the program does not track this value
Not Reported (NR): the program does not report this value

Table 2: CY2018 - 2019 Reported and Gross Verified Fossil Fuel Savings

Program	Reported Fossil Fuel Savings (MMBtu)	Verified Fossil Fuel Savings (MMBtu)	Fossil Fuel Savings RR (%)
EEIF	24,462	24,373	100%
WAP*	2,306	1,701	74%
Total	26,768	26,074	97%

* The evaluation period for WAP was the calendar year 2018

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, GEP, and WAP. The net verified savings for each program are shown in Table 3.

Table 3: CY2018 - 2019 Net Verified Savings

Program	Net Verified Energy Savings (MWh)	Net Verified Peak Demand Savings (MW)	Net Verified Fossil Fuel Savings (MMBtu)
EEIF	13,280	2.20	17,061
GEP	2,662	10.68	NA
WAP*	234	0.04	1,701
Total	16,176	12.92	18,762

* The evaluation period for WAP was calendar year 2018
Not Applicable (NA): the program does not track this value

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 program's price. The TRC test considers costs incurred by program participants and Program Administrators in addition to the 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. The EEAC does not oversee GEP, 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: CY2018 - 2019 Program Cost-effectiveness Results

Program	NPV of Program Benefits[2]	NPV of Program Costs[3]	TRC Benefit-Cost Ratio
EEIF	$22,788,108	$7,695,337	2.98
GEP	$9,553,617	$6,938,009	1.38
WAP*	$1,650,743	$1,355,897	1.22
Total	$33,992,468	$15,989,243	2.13

* The evaluation period for WAP was calendar year 2018

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

[2] These benefits include avoided cost of energy, avoided cost of capacity, avoided cost of fossil fuel, and NEBs.

[3] These costs include program administration costs and measure costs.

DNREC EE Portfolio Review

2019 Evaluation At-a-Glance

3 Programs Evaluated

536 Projects Completed

340 Projects Evaluated

Spanning 2018 - 2019

Energy Efficiency Investment Fund (EEIF)

80 Projects Granted **70** Projects Evaluated

101% Energy kWh Realization Rate

2.98 Total Resource Cost Ratio

13,280 MWh | 2.20 MW | 17,061 MMBtu

First Year Net Savings

123,209 tons Lifetime GHG Reduction

Green Energy Program (GEP)

214 Projects Completed **28** Projects Evaluated

1.84 MW Solar PV | 115 Tons Geo-thermal | 160 Gal Solar Hot Water

Verified Capacity

100% Capacity Realization Rate

1.38 Total Resource Cost Ratio

2,663 MWh Avoided Electric Generation

39,546 tons Lifetime GHG Reduction

Weatherization Assistance Program (WAP)

242 Projects Completed and Evaluated

78% Energy Realization Rate

1.22 Total Resource Cost Ratio

$264 Non-Energy Benefits per home

234 MWh | 0.04 MW | 1,701 MMBtu

First Year Net Savings

2,318 tons Lifetime GHG Reduction

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 and renewable energy programs. 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.

The EcoMetric team evaluated DNREC's 2016 – 2018 programs last year. EcoMetric delivered an evaluation report to DNREC in the latter part of CY2019. The evaluation report included actionable findings and recommendations to improve the accuracy of savings calculations and program delivery. Due to the timing of delivering the evaluation report, DNREC may not have fully implemented the recommendations listed in that evaluation report. Therefore, some findings and recommendations from the 2016 – 2018 evaluation report were still relevant for 2019 projects.

E.3.1 EEIF KEY FINDINGS & RECOMMENDATIONS

Finding 2: The ex ante electric savings calculations for the EEIF program were generally accurate. More than 57% 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 23.6% to 576.8%.

While more than half of the sample projects have an electric realization rate of ±10% of 100%, the other electric projects' realization rates varied from 100%. EcoMetric believes that every project which comes through the program should have a detailed technical review of the savings methodology and algorithm inputs by implementation 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 implementation 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 demand 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 7: EcoMetric did not find any discrepancies between the equipment quantities noted in the invoices and the equipment quantities used in the ex ante calculations. Program staff diligently verify the quantity of installed equipment to ensure grants are correctly awarded.

Finding 9: Application documentation for each project included a summary of expected energy savings achieved by the project; however, the savings calculations and summaries are not standardized.

Recommendation 6: *Provide standardized calculator tools for use by applicants and contractors in estimating reported energy savings for each project. These could include the lighting calculator tool developed by EcoMetric in 2019 and additional calculators for non-lighting measures. Such tools should be based on Technical Reference Manual (TRM) algorithms and could be modeled from tools already created for nearby jurisdictions.*

Finding 11: Through the EcoMetric team's review of the project documentation and conversations with the participants during the virtual site inspections, it was clear that program staff ensured an appropriate baseline was used from which to calculate the energy savings. The program is actively addressing the EcoMetric team's findings from the 2016-2018 DNREC evaluation report concerning appropriate baseline selection. Additionally, DNREC hired a third-party implementer with technical expertise to help administer the program.

Process Finding 1: In CY2019, program staff addressed CY2016-2018 Process Recommendations 1 through 5 in the following ways:

- ✓ Removing references to participating contractors on the EEIF home page (after ruling out their interest in being listed)
- ✓ Revising the applications
- ✓ Hiring a consultant to develop an online portal
- ✓ Incorporating into this study research to better understand the target markets

Additionally, in August 2020, EEIF hired a program implementer to be responsible for application processing, marketing activities, delivering grant checks, and conducting site inspections.

Process Finding 4: Contractors and customers found the application easy to complete. The CY2019 contractors identified fewer areas for improvement to the application and approval process than the CY2016-2018 contractors. There is still some room for improvement in processing time.

Process Recommendation 3: *Reassess applicants' perspectives on the application after it has shifted to the online portal to ensure it continues to be easy to complete.*

Process Finding 5: Contractors' main form of marketing is word-of-mouth. Contractors use EEIF as a selling point by telling prospective customers that incentives are available through EEIF. They do not use social media as a primary marketing tool.

Process Recommendation 4: *Consider providing contractors with referrals (when available) and marketing materials to hand out to prospective customers.*

E.3.2 GEP FINDINGS & RECOMMENDATIONS

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

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

Finding 17: EcoMetric could not verify the assumptions and methodology used to calculate the reported energy savings for two solar water heater projects using the files in the project documentation.

The savings calculations for solar water heaters appear to be calculated by contractors using proprietary software. EcoMetric could not verify the calculation methodology and assumptions used to calculate the savings based on the information available in the project documentation. EcoMetric independently verified the savings based on publicly available Technical Reference Manuals.

Recommendation 11: *Consider requiring the customers or the contractors to summarize the energy savings methodology and software modeling inputs if proprietary software is used to calculate savings.*

Process Finding 9: Contractors completing projects through GEP report very high levels of satisfaction with the program, citing ease of application/approval processes and a user-friendly web portal.

Process Recommendation 8: *Further investigate how useful the capability to provide e-signatures on program materials would be to contractors, and whether it's feasible for the program to add this feature.*

Process Finding 10: Most program participants reported being highly satisfied with GEP, including its processes, the contractors they worked with, and the equipment itself. Contractor professionalism, time to receive the incentive, and equipment aesthetics received the highest satisfaction ratings.

Process Finding 11: A little more than half of program participants became aware of the program from a contractor coming to their home, and about a quarter found the program through their own research.

Process Recommendation 9: *Given DNREC's stated goal to increase GEP participation in the coming years, EcoMetric recommends considering additional, targeted marketing efforts beyond contractor-led outreach. While contractors have been the primary source of raising program awareness, a quarter of participants in 2019 found the program by searching for it themselves. This suggests there might be an opportunity to reach additional participants who a) have not yet been visited by a contractor, and b) are not likely to take the initiative to conduct personal research into renewable energy program offerings.*

E.3.3 WAP KEY FINDINGS & RECOMMENDATIONS

Finding 19: EcoMetric combined the per-home saving values from the CY2016-2017 analysis and the CY2018 analysis to yield savings values weighted by the number of homes in each analysis.

Recommendation 13: *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 CY2016 – 2018 Combined and Weighted 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	2,044	0.40	NA
	Manufactured home	1,191	0.09	NA
Natural Gas	Single family	825	0.13	9.9
	Manufactured home	672	0.14	14.3
Other fuel	Single family	1,196	0.17	10.6
	Manufactured home	771	0.17	14.6

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

Finding 20: The EcoMetric team found the overall NEBs value to be $264 per household per year for the CY2016-2019 period ($154 for thermal comfort, $54 for noise, and $56 for health). These point estimates are fairly closely aligned with the conservative values recommended in the CY2016-2018 evaluation (i.e., the lower bound of the confidence interval of the CY2016-2018 estimates).

Recommendation 14: *Adopt the following NEB values: $154 for thermal comfort, $54 for noise, and $56 for health.*

1 EVALUATION METHODOLOGY

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, virtual site inspections, engineering analysis, interval billing analysis, telephone surveys, documentation review, and interviews with DNREC staff, EEIF contractors, and program participants to evaluate DNREC's energy efficiency and renewable energy 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 regulations[4] 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 2019 program year for the EEIF program includes projects completed in the latter half of FY18 and the first half of FY19.

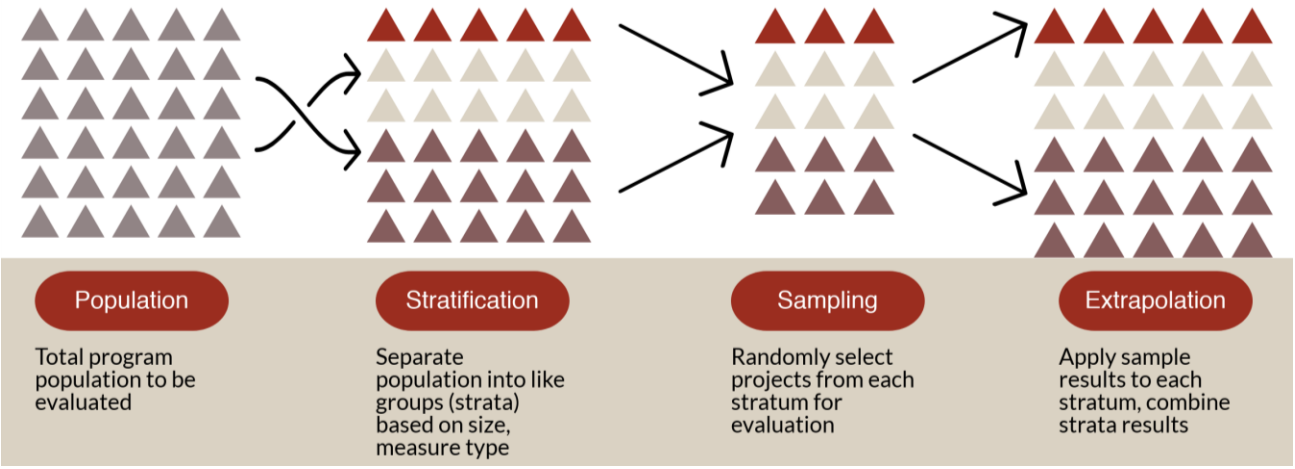
EcoMetric also combined 2019 program year data into one single population for the Green Energy Program (GEP) and Energy Efficiency Investment Fund (EEIF) programs. The Weatherization Assistance Program (WAP) impact evaluation included the calendar year 2018 projects only to ensure sufficient post-

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

weatherization billing data is available from each participant. The NEBs quantification work consisted of a subset of interviews with CY2018 participants and a sample of CY2019 participants.

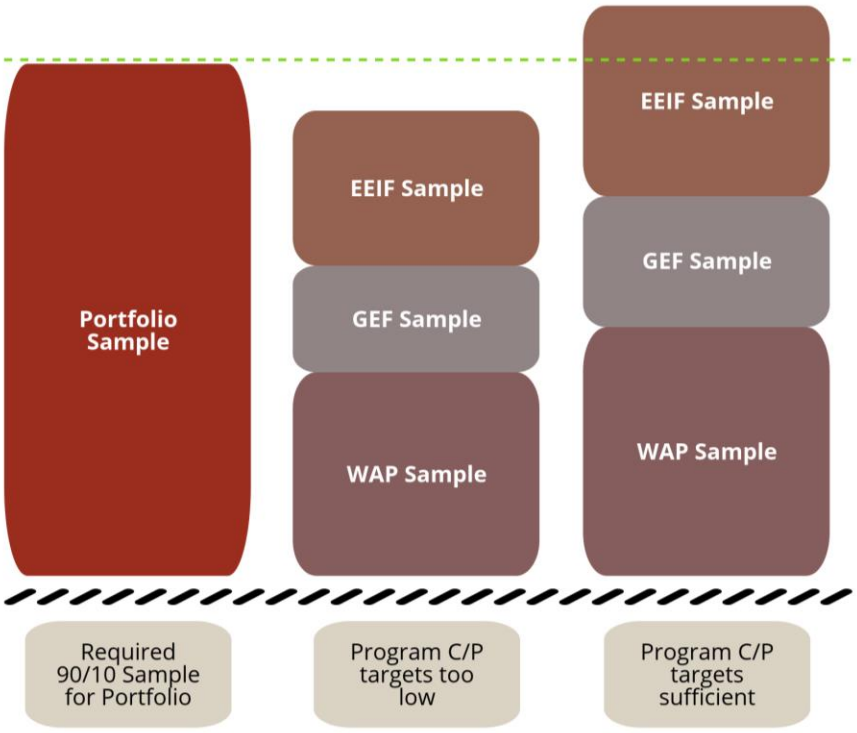
EcoMetric utilized a sampling strategy across different programs. Using a sample allowed the evaluation team to complete a statistically valid review of the program impacts while reducing the number of individual projects or surveys that were required.

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.[5,6] 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%)

C_v = coefficient of variation assumed to be 0.5[7]

[5] 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

[6] 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

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

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

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	80	Sample (90%/5%)	70
GEP	214	Sample (90%/10%)	28
WAP	242	Census	242
Total	536		340

1.1.2 GROSS SAVINGS VERIFICATION

The EcoMetric team used various evaluation methods to verify the savings impacts for each of the programs. The evaluation methods include tracking system review, engineering desk reviews, virtual site inspections, 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.

1.1.3 NET SAVINGS ANALYSIS

EcoMetric calculated the net savings for each program 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.[8]

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.[9]
- **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.

1.1.5 AVOIDED GREENHOUSE GAS EMISSIONS

EcoMetric estimated the economic impact of reductions in greenhouse gas (CO_2, SO_2, and NO_X) emissions achieved by DNREC's programs and included these impacts as benefits in the cost-effectiveness analysis.

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

[9] http://regulations.delaware.gov/AdminCode/title7/2000/2105.shtml#TopOfPage

EcoMetric first determined the estimated pounds of reduced emissions by applying the emissions rates from PJM's 2015-2019 CO_2, SO_2, and NO_X Emission Rates report[10] to the net verified savings values. The 2018-2019 PJM emissions rates are shown in Table 8.

Table 8: 2018-2019 PJM Emissions Rates

GHG	Period	2018	2019
CO_2 lbs/MWh	On-Peak	1,337	1,268
	Off-Peak	1,254	1,171
SO_2 lbs/MWh	On-Peak	0.66	0.65
	Off-Peak	0.68	0.57
NO_X lbs/MWh	On-Peak	1.01	0.72
	Off-Peak	0.68	0.47

EcoMetric then applied monetary values ($/ton) taken from Delmarva Power and Light's 2016 Integrated Resource Plan[11], 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.
- **NOX:** $9,500/ton.

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

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

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

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

[10] https://www.pjm.com/-/media/library/reports-notices/special-reports/2019/2019-emissions-report.ashx?la=en
[11] https://depsc.delaware.gov/wp-content/uploads/sites/54/2017/03/DPL-Public-IRP-113016.pdf

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 values from the DNREC technical advisor.[12]

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

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 derived from the Energy Information Administration (EIA).

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:

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

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

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

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

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.

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

$$NPV\ of\ Avoided\ Cost\ of\ Capacity = Net\ Verified\ Annual\ Peak\ MW\ Reduction \times NPV\ of\ Avoided\ Cost\ per\ MW$$

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.

$$NPV\ of\ Avoided\ Cost\ of\ Capacity = Net\ Verified\ Annual\ Peak\ MW\ Reduction \times NPV\ of\ Avoided\ Cost\ per\ MW$$

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.

$$NPV\ of\ Avoided\ Cost\ of\ Fossil\ Fuel = Net\ Verified\ Annual\ MMBtu\ Savings \times NPV\ of\ Avoided\ Cost\ per\ MMBtu$$

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.

$$NPV\ of\ Lifetime\ NonEnergy\ Benefits = NPV\ of\ Avoided\ Liquid\ Fuel\ Costs + NPV\ of\ Other\ NonEnergy\ Benefits$$

$$NPV\ of\ Avoided\ Liquid\ Fuel\ Costs = Net\ Verified\ Annual\ Liquid\ Fuel\ MMBtu\ Savings \times Gallons\ of\ Fuel\ per\ MMBtu\ of\ Energy \times NPV\ of\ Fuel\ Price\ per\ Gallon$$

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 EcoMetric team performed a process evaluation for EEIF and GEP. The process evaluations' objectives were to provide the programs with opportunities to help meet participation goals, improve the program, and assess participant and contractor satisfaction. The process evaluation consisted of:

- Reviewing program materials and examining the program tracking data to develop contractor and participant interview samples.
- Conducting in-depth telephone interviews with:
    - Program staff to identify developments or changes in the program and how it is administered since the previous evaluation.
    - Contractors (EEIF and GEP) and participants (EEIF) to understand their perspectives on the program and identify the specific social and other media that contractors routinely use for work.
- Conduct surveys with randomly selected GEP participants to understand their participation experience, assess their satisfaction with the program, and identify opportunities for improving program design and delivery.
- Conducting usability testing of the new EEIF application portal to ensure that aspects of the portal function properly and content is designed for simplicity, clarity, and ease of operation.[13]

The sample frame comprised of contractors and businesses that participated in EEIF and GEP during CY2019. Table 9 summarizes the process evaluation data collection activities and sample sizes.

[13] The team provided DNREC with results of the usability testing in July 2020 in a separate memo.

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	In-depth telephone interview	36[14]	6	$50 gift card
Active Contractors	In-depth telephone interview	20[15]	9	$50 gift card
Program staff	In-depth telephone interview	1	1	NA
Green Energy Program (GEP)				
Participating End-Users	Telephone survey	214	27	$20 gift card
Active Contractors	In-depth telephone interview	91	6	$50 gift card
Program staff	In-depth telephone interview	1	1	NA

1.3 NON-ENERGY BENEFITS (NEB)

1.3.1 PHONE SURVEY OF CY2019 PARTICIPANTS

In our previous evaluation spanning CY2016-2018[16], the EcoMetric team conducted a phone survey of 62 WAP participants to monetize three participant non-energy benefits (NEBs)[17]: thermal comfort, noise, and health. From these estimates, the team recommended DNREC adopt NEB values of $155 for thermal comfort, $43 for noise, and $38 for health. These values represented conservative estimates, as they were the lower bound of the 90% confidence interval for the average value of each NEB based on primary research conducted in 2019 among Delaware participants. In the same evaluation, the team recommended conducting a follow-up NEBs study with more surveys to bolster confidence in the values, as this was the first NEBs study for DNREC's WAP program.

As a result, the CY2019 evaluation obtained NEBs estimates from 88 additional WAP participants, creating a total sample of 150 participants spanning CY2016-2019, and thus improving the precision of the individual participant NEBs values by 47% for noise, 48% for thermal comfort, and 50% for health at the 90%

[14] Excludes from the sample 14 participant organizations such as health care facilities, grocery stores, etc., due to the COVID-19 pandemic.
[15] Excludes three contractors who had left their employers since the project was completed.
[16] EcoMetric. "Program Years 2016-2018 Evaluation Report." Prepared for Delaware Department of Natural Resources and Environmental Control. February 13, 2020. www.dnrec.delaware.gov/energy/information/otherinfo/Documents/EEAC/2016-2018-DNREC-Evaluation-Report.pdf
[17] NEBs are commonly characterized by the perspective of the party to whom a particular NEB accrues, including program participants, utilities, and society. 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 at large, such as public health impacts, reductions in greenhouse gas and particulate emissions, economic improvements, and water in the form of water supply chain savings. Utility or program administrator NEBs include benefits such as fewer terminations of service, reconnections, and customer calls. NEBs may also be referred to as Non-Energy Impacts (NEIs).

confidence level. In addition to asking the same NEBs question batteries as the previous evaluation, the team asked additional questions about specific health impacts, indoor air temperatures, and missed days from work to provide further support for the NEB estimates.

The sample frame for the CY2019 supplemental WAP survey was composed of households selected randomly from a total of 831 households that:

- Had not responded to the original CY21016-2019 WAP survey,
- Lived in the home before it was weatherized and still resided there at the time of the survey, and
- Had inspection dates indicating the weatherization was completed between 2016 and November 2019[18]..

Participants received a $20 Walmart gift card as an incentive for completing the survey.

1.3.2 IN-DEPTH INTERVIEWS WITH CY2016-2018 SURVEY RESPONDENTS

The EcoMetric team wanted to better understand the NEB estimates gathered from the original CY2016-2018 participant survey and leverage those insights in the development of the supplemental CY2019 telephone survey. To accomplish that goal, the EcoMetric team conducted in-depth interviews with WAP participants who had reported NEB values greater than the average value for one or more of the three NEBs in the original CY2016-2018 WAP survey. This way, each of the three NEBs equally across 12 clients. The team reached out to 27 participants in the sample and completed 13 interviews rather than 12, a 32% response rate. Participants received a $25 Walmart gift card as an incentive for completing the interview.

[18] This ensured household members had experienced at least one winter in the home since weatherization.

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. 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).

Four types of grants are available through the EEIF program: prescriptive, custom, energy assessment, and combined heat and power. Prescriptive lighting projects comprise the majority of projects supported by EEIF.

Prescriptive: The prescriptive path offers incentives for 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, 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 over standard equipment.

Energy Assessment: Energy assessment grants are available for businesses in need of technical assistance to evaluate their facility for energy-efficient upgrades. This path offers financial assistance to help offset audits, feasibility studies, and project design costs. Grants pay up to 50% of the cost of the audit.

Combined Heat and Power: The combined heat and power path provides incentives for five types of combined heat and power systems, including microturbines, reciprocating engines, gas turbines, steam turbines, and fuel cells. Grant amounts are the lesser of $500 per kW of the installed system or 30% of project costs.

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

In this evaluation, "participants" or "customers" refer to the end-use customers who obtained a grant from EEIF.

2.1 IMPACT EVALUATION

2.1.1 PROGRAM DATABASE REVIEW AND SAMPLING

For the 2019 calendar year (CY), the EEIF program paid grants for 80 completed energy efficiency projects. EcoMetric defined each line in the tracking data as a unique project. Additionally, EcoMetric only considered projects assigned a "complete" status. A summary of CY2019 is shown in Table 10.

Table 10: EEIF 2019 Program Summary

Calendar Year	Projects Completed	Energy Savings (MWh)	Gas Savings (MMBtu)
2019	80	16,674	24,462
Total	80	16,674	24,462

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.*

Compared to previous calendar years, the EEIF program experienced steady participation levels, but the savings increased significantly on a per-project basis. Table 11 shows a comparison of per-project savings from the projects completed during CY2016-2018 and CY2019.

Table 11: Comparison of Per-Project Savings

Calendar Year	2016-2018	2019
Energy (MWh) Savings per-project	75.76	208.43
Gas (MMBtu) Savings per-project	31.98	305.77

Prescriptive projects provide the majority of the electrical savings, while custom projects generate all the natural gas savings and also contributed to the electrical savings. Table 12 summarizes the custom and prescriptive projects completed through the EEIF program during CY2019.

Table 12: EEIF Program Data Prescriptive versus Custom Projects

Calendar Year	Project Type	Projects Completed	Energy Savings (MWh)	Gas Savings (MMBtu)
2019	Prescriptive	77	14,936	0
	Custom	3	1,738	24,462
	Total	80	16,764	24,462

The sample frame for the EEIF program stratifies the projects into prescriptive and custom strata. EcoMetric pulled projects with natural gas savings into a separate stratum to ensure reliable natural gas savings estimates. 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 13.

Table 13: 2019 EEIF Program Sample Frame

Project Type	Strata	Description	Project Population	Energy Savings (MWh)	Gas Savings (MMBtu)
Prescriptive	Certainty	Greater than 500 MWh	9	7,871	0
	Large Probability	200 - 500 MWh	10	3,236	0
	Small Probability	Under 200 MWh	58	3,829	0
Custom - Electric	Certainty	Greater than 500 MWh	1	270	0
	Probability	Under 500 MWh	0	0	0
Custom - Gas	Certainty	Greater than 1,000 MMBtu	2	1,468	24,462
	Probability	Under 1,000 MMBtu	0	0	0
		Total	80	16,674	24,462

A total of 70 sample points was drawn for the EEIF program to exceed a target of 90% confidence and 5% precision. The sample points were allocated first to the certainty stratum, and then to the probability stratum. 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 14.

Table 14: 2019 EEIF Sample Coverage

Project Type	Strata	Sample Points	Sampled MWh	Percent MWh	Sampled MMBtu	Percent MMBtu
Prescriptive	Certainty	9	7,871	47%	0	0%
	Large Probability	10	3,236	19%	0	0%
	Small Probability	48	2,795	17%	0	0%
Custom - Electric	Certainty	1	270	2%	0	0%
	Probability	0	0	0%	0	0%
Custom - Gas	Certainty	2	1,468	9%	24,462	100%
	Probability	0	0	0%	0	0%
Total		70	15,639	94%	24,462	100%

2.1.2 GROSS SAVINGS VERIFICATION

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 virtual site inspections for a sample of custom and prescriptive projects. The virtual site visits allow for additional data collection to supplement engineering desk reviews. During the virtual site inspections, the participant was interviewed to confirm any factors that may impact the installed equipment's energy savings. Table 15 summarizes the number of desk reviews and site inspections that the EcoMetric team completed for the CY2019 evaluation period.

Table 15: Summary of Desk Reviews and Site Inspections

Measure Type	Number of Desk Reviews	Number of Virtual Site Inspections
Prescriptive	58	9
Custom - Electric	0	1
Custom - Gas	0	2
Total	58	12

2.1.2.1 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 installation site.

Each custom and prescriptive project received a document review as part of the engineering desk review. The document review included examining all the project files' information 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 virtual site inspections.

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 are 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 demand 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

2.1.2.2 Virtual Site Inspections

The EcoMetric team completed virtual site inspections of custom and prescriptive projects from the evaluation sample. Each virtual site inspection took place after completion of the desk review for the project. The purpose of the virtual site inspections was to visually confirm installation of the energy-efficient equipment and assess the accuracy with which DNREC documented the project. The virtual inspections were in the place of in-person site inspections, which EcoMetric had initially planned to carry out but could not due to COVID-19 restrictions.

To perform the virtual site inspections, EcoMetric utilized an interactive video application called Streem[19]. A link for a video call was sent to the facility representative via SMS text before the scheduled virtual site inspection. Upon following the link, the facility representative walked through the facility's relevant areas, with the camera on their cell phone recording live video. EcoMetric staff viewed the video stream remotely via laptop computers. The video application allowed EcoMetric staff to annotate on the screen, "point" at equipment that required additional investigation, and capture screenshots.

For each project in the sample, the virtual site inspection included the following:

- Performing an interactive video call with a representative from the facility where the project took place
- Capturing photographs (screenshots) of critical equipment and nameplates as the facility representative toured the site
- Interviewing the facility representative about the project and operation of the affected building equipment or systems
- Requesting additional documentation or data from the facility representative, if necessary

Following each virtual site inspection, EcoMetric compared the findings from the visit to the information provided in application documentation and performed an independent calculation of projected energy savings achieved by the project.

2.1.2.3 Building Simulations

EcoMetric reviewed building simulations and energy models, which customers submitted with two of the custom project applications. The software used to create the models was Trane Air Conditioning Economics (TRACE). For each submission, a contractor – before project installation – developed a baseline model for the building and calibrated the model to its historical energy consumption. Additional models were then

[19] Streem is an augmented reality video call application that is used for business collaboration and remote troubleshooting.

created, with the baseline model as the starting point, to reflect the proposed changes to building equipment or operation involved in the energy efficiency project.

As part of each project review, EcoMetric assessed the accuracy of the inputs and feasibility of the outputs from the building simulation or model. The inputs were compared to project and equipment parameters found in other application documentation. EcoMetric also assessed whether the baseline used in the model was appropriate.

Where necessary, EcoMetric reviewed the building model and project details with the contractor that developed the model.

2.1.3 VERIFIED RESULTS

EEIF projects fall into three categories: prescriptive, custom – electric, and custom – gas projects. As noted in Section 2.1.1, EcoMetric reviewed a sample of the projects completed in CY2019. Table 16 summarizes the electric and gas verified savings from the evaluation sample broken out by project type.

Table 16: EEIF Gross Verified Sample Savings Results

Project Type	# of Projects Completed	Electric Realization Rate	Verified Sample Electric Savings (MWh)	Gas Realization Rate	Gross Verified Gas Savings (MMBtu)
Prescriptive	67	102%	14,218	NA	0
Custom - Electric	1	27%	73	NA	0
Custom - Gas	2	100%	1,467	100%	24,373

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

EcoMetric extrapolated the verified savings from the sample of evaluated projects to the population of EEIF projects completed in CY2019 using appropriate statistical methods. Table 17 shows gross verified energy savings for the population of CY2019 EEIF projects. Overall, the measures achieved an electric realization rate of 100.9%, resulting in 16,819 MWh of first-year electric savings. The gas realization rate was 99.6%, resulting in 24,373 MMBtu of first-year gas savings. The relative precision[20] of the electric savings realization rate was 1.4% at the 90% confidence level. The relative precision of the gas savings realization rate was 0% at the 90% confidence level due to the EcoMetric team evaluating all of the gas savings projects. Gross demand savings totaled 2.79 MW.

[20] 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.

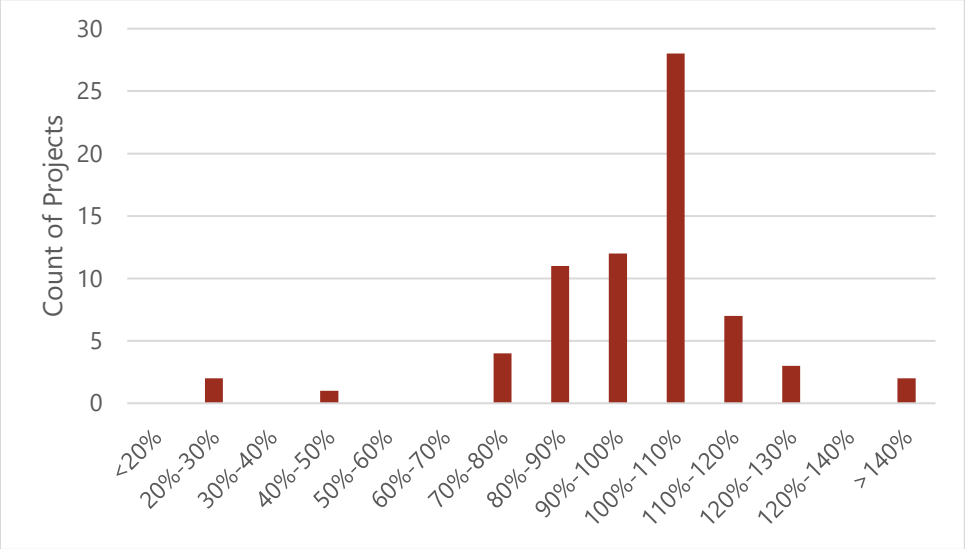
Table 17: EEIF Verified Gross Savings Results

Project Type	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	15,066	1.4%	2.48	0	NA
Custom - Electric	273	0.0%	0.01	0	NA
Custom - Gas	1,480	NA	0.29	24,373	0.0%
Total	16,819		2.79	24,373	

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

Figure 4 shows the distribution of electric realization rates for the EEIF sample. Over 57% of the sampled projects have an electric realization rate between 90% and 110%, highlighting the program's overall accuracy of ex ante electric savings calculations.

Figure 4: Distribution of EEIF Electric Realization Rates



Finding 2: The ex ante electric savings calculations for the EEIF program were generally accurate. More than 57% 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 23.6% to 576.8%.

While more than half of the sample projects have an electric realization rate of ±10% of 100%, the other electric projects' realization rates varied from 100%. EcoMetric believes that every project which comes through the program should have a detailed technical review of the savings methodology and algorithm inputs by implementation staff to ensure consistency and alignment with applicable Mid-Atlantic TRM

algorithms. A considerable 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 implementation 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 77 prescriptive projects completed through the EEIF program achieved 15,066 MWh of gross verified electric savings, accounting for 90% of the program's total electric savings. The prescriptive projects in the sample comprised solely of interior and exterior lighting projects. The evaluation team found that the ex ante electric savings were generally accurate, resulting in an overall electric realization rate of 102% for the prescriptive projects. Realization rates for these prescriptive projects varied from 100% for several overarching reasons.

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 demand factors.

Waste heat factors 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 5: 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 4: *Ensure all projects replacing HID fixtures with LED fixtures use the total input fixture power.*

Finding 6: The project documentation for all of the prescriptive lighting projects included product specification sheets and invoices that enabled the EcoMetric team to verify the type and quantity of installed light bulbs and fixtures.

Finding 7: EcoMetric did not find any discrepancies between the equipment quantities noted in the invoices and the equipment quantities used in the ex ante calculations. Program staff diligently verify the quantity of installed equipment to ensure they award grants correctly.

Finding 8: A portion of the ex ante savings calculations for the prescriptive lighting projects used the same annual hours of use (HOU) for both interior and exterior light fixtures. While interior and exterior lights may operate for a similar number of hours per year, it is usually not the same. The annual HOUs for light fixtures are one of the primary factors that drive energy savings; therefore, it is essential to quantify HOUs by space type or usage groups when possible.

Recommendation 5: *Continue to ensure participants submit documentation and ex ante calculations that clearly define and support the fixture HOUs for each space type where efficient light fixture or bulbs are installed.*

Finding 9: Application documentation for each project included a summary of expected energy savings achieved by the project; however, the savings calculations and summaries are not standardized.

Recommendation 6: *Provide standardized calculator tools for use by applicants and contractors in estimating reported energy savings for each project. These could include the lighting calculator tool developed by EcoMetric, as well as additional calculators for non-lighting measures. Such tools should be based on Technical Reference Manual (TRM) algorithms and could be modeled from tools already created for nearby jurisdictions.*

2.1.3.2 Gross Savings Results for Custom Electric Projects

The evaluation team reviewed the only custom electric project completed in CY2019. The custom project included a variety of HVAC improvements in a commercial building. Since custom non-lighting projects are not bound by the saving algorithms in the Mid-Atlantic TRM, EcoMetric reviewed the savings methodology and technical soundness of algorithm assumptions. While project documentation did include detailed equipment specifications, operation, and energy modeling reports, it did not have any ex ante savings calculations for EcoMetric to review. Therefore, EcoMetric utilized the detailed equipment specifications, operation, and Mid-Atlantic TRM to calculate the verified savings. The verified electric savings for the custom electric project are 73 MWh, resulting in a 27% realization rate.

Finding 10: While the project documentation included a description of the custom calculated energy savings, the documentation did not include an ex ante savings calculation file for the evaluation team to review.

Recommendation 7: *Continue to ensure participants submit documentation and ex ante calculations that clearly explain and support the claimed savings.*

2.1.3.3 Gross Savings Results for Custom Gas Projects

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. There were only two custom gas projects completed through the EEIF program in CY2019. Both of the projects received a virtual site inspection as part of the impact evaluation.

Finding 11: Through the EcoMetric team's review of the project documentation and conversations with the participants during the virtual site inspections, it was clear that program staff ensured an appropriate baseline from which to calculate the energy savings. The program is actively addressing the EcoMetric team's findings from the 2016-2018 DNREC evaluation report concerning appropriate baseline selection. Additionally, DNREC hired a third-party implementer with technical expertise to help administer the program beginning in 2021.

The two gas projects completed in 2019 achieved 24,373 MMBtu of gross verified gas savings, resulting in a 99.6% realization rate. The two gas projects also achieved 1,468 MWh of gross verified electric savings, accounting for 9% of the program's total electric savings. The realization rates for the custom gas projects varied from 100% for the following reasons.

Finding 12: While the documentation contained specification sheets and invoices for one of the custom gas projects, the ex ante savings calculations were missing.

It is important to ensure that participants submit savings calculations that clearly show how they determined savings for custom projects. The savings for custom projects may not utilize a prescriptive savings approach. In the absence of the ex ante calculations, EcoMetric was able to calculate verified savings using a combination of the equipment information and specification sheets in the project documentation and algorithms in the Mid-Atlantic TRM.

Recommendation 8: *Continue to ensure participants submit documentation and ex ante calculations for custom projects that clearly explain and support the claimed savings.*

2.1.4 NET SAVINGS VERIFICATION

The net-to-gross (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 Advisory Council deemed

the NTG ratio for prescriptive projects to be 0.8, and 0.7 for custom projects. Table 18 shows the net savings for the EEIF program. EcoMetric calculated the net verified savings using the equation below.

$$Net\ Verified\ Savings = Gross\ Verified\ Savings\ \times NTG\ Ratio$$

Table 18: 2019 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	15,066	2.48	0	12,052	1.99	0
Custom - Electric	0.7	273	0.01	0	191	0.01	0
Custom - Gas	0.7	1,480	0.29	24,373	1,036	0.20	17,061
Total		16,819	2.79	24,373	13,280	2.20	17,061

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 $9,003,187 for projects completed in CY2019. Table 19 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 19: EEIF Greenhouse Gas Emissions Reductions

Measure Type	2019 Net Verified Electric Savings (MWh)	Lifetime Electric Savings (MWh)	2019 Net Verified Gas Savings (MMBtu)	Lifetime Gas Savings (MMBtu)	Lifetime GHG Reduction (lbs)	Lifetime NPV Savings ($)
Prescriptive	12,052	180,787	0	0	246,528,156	$8,064,747
Custom - Electric	191	2,863	0	0	3,903,585	$145,942
Custom - Gas	1,036	15,545	17,061	219,964	21,197,383	$792,498
Total	13,280	199,194	17,061	219,964	271,629,125	$9,003,187

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 2.98 using the Total Resource Cost (TRC) test. This indicates that the program is cost-effective. The program's cost-effectiveness improved from an already strong TRC ratio in the previous evaluation due to the benefits derived from increased natural gas savings and peak demand reduction in

CY2019. Table 20 provides details on the total benefits and costs which EcoMetric included in the TRC test for the Energy Efficiency Investment Fund program.

Table 20: EEIF Cost-effectiveness Results

Benefit / Cost	NPV of Benefit/Cost
Lifetime Avoided Cost of Energy	$18,391,231
Lifetime Avoided Cost of Capacity	$3,536,765
Lifetime Avoided Cost of Fossil Fuel	$1,000,713
Lifetime Non-Energy Benefits	$0
Total Benefits[21]	$22,928,709
Program Administrative Costs	$406,000
Measure Costs	$7,289,337
Total Costs[22]	$7,695,337
TRC Benefit-Cost Ratio	2.98

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

[21] The benefits accure over the life of the measures.
[22] The costs occur in year zero of the NPV calculation.

2.2 PROCESS EVALUATION

The process evaluation entailed reviewing program materials and conducting in-depth interviews with the program manager and with nine contractors who applied for EEIF grants on behalf of customers. Six organizations (participants) received EEIF grants during CY2019. The team interviewed the program manager to identify developments or changes in the program and how it was administered since the previous evaluation. The purpose of the contractor interviews was to assess the degree to which a wider group of contractors familiar with EEIF share the opinions of the small group of contractors interviewed for the previous evaluation. Table 21 displays the percentage of total CY2019 projects completed by the nine contractors interviewed for the process evaluation. These nine contractors completed 43% of the CY2019 projects, including 42% of the prescriptive projects and 67% of the custom projects.

Table 21: Percent of CY2019 EEIF Projects Completed by Contractors Interviewed for Process Evaluation

Project Type	Total CY2019 Projects	Projects Completed by Interviewed Contractors	Percent of CY2019 Projects Completed by Interviewed Contractors
Prescriptive	77	32	42%
Custom	3	2	67%
Total	80	34	43%

Goals for both the contractor and participant interviews included:

- Obtaining feedback on the application process and a new online portal
- Identifying the specific social and other media used for work
- Identifying opportunities to improve program design and delivery

However, the online portal had not been completed by the time the EcoMetric team conducted the interviews in June and July of 2020. The team selected a small sample size of six participants because a primary goal was to obtain their feedback on the online portal. Since participants had no experience with the portal, the team substituted interview questions about the portal with questions on other topics such as the application process, participation motivations and barriers, and program strengths. Due to the small sample size, participant input on these topics should be considered anecdotal and not be interpreted as representative of all CY2019 participants.

Table 22 displays the six interviewed participants' company type. Three of the six participants were in the commercial property management business; these participants own and manage the properties that received upgrades through EEIF. The other three participants' businesses included hospitality, auto repair, and religious services. These participants occupy the properties that received upgrades through EEIF.

Table 22: EEIF Participant Company Types

Company Type	Participants (n=6)
Commercial property management	3
Auto repair shop	1
Hotel	1
Religious facility	1

In lieu of asking applicants for feedback on the portal, the team conducted a usability assessment of the portal's beta version. The team provided DNREC with the results of the usability testing in July 2020 in a separate memo. High-level findings from the usability testing are included in 2.2.1.6.

2.2.1 PROGRAM DEVELOPMENTS SINCE PREVIOUS EVALUATION

In the previous (CY2016-2018) EEIF process evaluation, the program manager identified goals and objectives for CY2019. These included:

- Develop an online application portal
- Create marketing materials to distribute at outreach events
- Pare down program guidelines and operation procedures
- Update lighting incentives to make sure they reflect market conditions

In addition, the previous evaluation offered the following recommendations to help improve program outcomes:

- **CY2016-2018 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.
- **CY2016-2018 Process Recommendation 2:** As there are no current plans to list participating contractors, remove references to this list on the EEIF home page.
- **CY2016-2018 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.
- **CY2016-2018 Process Recommendation 4:** Consider incorporating suggestions from contractors for the online application, including adding checklists to ensure that all documentation is in place before submitting the application, automating the calculations, automatically sending an email

when the application is submitted confirming the application has been received, and supplying the applicant with the project identification number.

- **CY2016-2018 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.

The remainder of this section summarizes activities related to these recommendations and other program developments since the previous evaluation. In summary, since the last evaluation EEIF addressed the first four recommendations above by implementing several administrative and application changes designed to improve the program. Program staff have also implemented and part of the fifth recommendation by leveraging this study research to better understand the program's target markets and how best to reach them.

Readers should note that the evaluation period, program year (PY) 2019, aligns with the calendar year (CY) 2019. However, DNREC tracks program goals and achievements by fiscal year (FY), which runs from June 1 through May 30. Therefore, the savings and participation goals presented herein are for FY2019, while the evaluation findings are for program activities conducted during CY2019. One additional departure from the evaluation period (CY2019) in this section is discussing the impacts of COVID-19, which began in CY2020. The EcoMetric team asked program staff, contractors, and customers about the pandemic's impact on energy efficiency related activities as part of the ongoing EEIF process research.

2.2.1.1 Program Participation

Two-hundred and twenty-nine organizations participated in the program in FY2019. As shown in Table 23, the EEIF program exceeded its FY2019 participation goal of 172. The EEIF program also exceeded its FY2019 electric and gas energy savings goals. FY2020 energy and participation goals have been established that are slightly greater than the FY2019 achievements.

Table 23: FY2019 EEIF Savings and Participation Goals and Achievements

Metric	FY2019 Goals[1]	FY2019 Achievements[2]	FY2020 Goals[3]
Annual Electric Savings (MWh)	14,651	55,997	57,677
Annual Gas Savings (MMBtu)	48,146	115,319	118,750
Participants	172	229	236

[1]Source: DNREC Three-Year Program Plan, December 7, 2016
[2]Source: EEIF Annual Report, Fiscal Year 2019
[3]Source: EEIF 2020-2022 Energy Efficiency Plan

2.2.1.3 Administration

The program manager was the sole EEIF staff member for most of CY2019, and singlehandedly reviewed all applications for half the year. Due to limited resources, DNREC staff were unable to perform site

inspections on sampled completed grantee projects. DNREC made investments in CY2020 that should allow site inspections to resume. Specifically, DNREC hired a new staff member in March 2020 to serve as the main point of contact for applications and conduct application reviews, and a new program implementer took over EEIF program operations in August 2020. The implementer will be responsible for application processing, marketing activities, delivering grant checks, and conducting site inspections.

Program staff enhanced program tracking practices since the previous evaluation. In the CY2016-2018 tracking data, name of the primary contact listed in the tracking system was the applicant, but the contact information for the primary contact was often that of the contractor. In CY2019 EEIF began tracking the contractor's name separately. In addition, EEIF began tracking information about the funding source for projects.[23]

2.2.1.4 Supported Measures and Equipment

Organizations can apply for grants for prescriptive measures, custom measures, combined heat and power, or energy assessments through EEIF. Prescriptive measures include energy-efficient lighting, lighting control improvements, high-efficiency natural gas heating, water heating systems, and vending misers. The custom path supports a variety of measures for end uses such as heating, cooling, ventilation, water heating, lighting, refrigeration, industrial processes, and energy management systems.

In CY2019 DNREC hired a consultant to review the EEIF incentive levels and recommend adjustments to account for current market conditions. DNREC revised the EEIF prescriptive and custom incentives based on these recommendations. The new incentives took effect in February 2020. Changes to incentives included:

- Reduction in incentive amounts for prescriptive lighting measures
- Addition of 30 prescriptive lighting categories
- Tiers for custom incentives based on the number of end uses
- Addition of custom incentives for SO_X, NO_X, and CO_2 emissions reductions

The EEIF program manager indicated that DNREC is also considering offering incentives for new construction projects in addition to retrofit projects in the future.

2.2.1.5 Marketing

EEIF had no formal mechanism for marketing or outreach at the time of this evaluation. As noted above, in the previous evaluation the EcoMetric team recommended conducting research to better understand target markets for the program. As part of this evaluation, the EcoMetric team conducted the research to

[23] Funding for FY2019 EEIF projects came from several sources, including the Pepco-Exelon merger, the public utilities tax, and Regional Greenhouse Gas Initiative (RGGI) funds.

fulfill this recommendation. It is presented in the section 2.2.4. Additionally, program staff interviewed for the previous evaluation said a goal for EEIF was to create marketing materials to distribute at outreach events. However, in CY2019 DNREC did not have enough resources to create marketing materials. Going forward, the new program implementer will be responsible for all marketing activities, including developing marketing materials, relieving program staff of this responsibility.

The previous evaluation found that four of the five contractors interviewed were interested in being listed as a service provider on the EEIF website. As a result, the evaluation team recommended exploring this action. The program did invite contractors to apply to be listed on the EEIF website; however, no contractors applied to be listed and DNREC discontinued the effort in August 2019.

2.2.1.6 Application and Approval Process

Currently, EEIF applicants still must submit hard copies of their applications and supporting documentation, as described in the CY2016-2018 evaluation and below. 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 staff are responsible for alerting applicants to impediments to pre-approval such as missing information. DNREC staff conduct two technical reviews of each application submitted. Once staff determines that all paperwork has been submitted and project requirements are met for an application, staff submit it to DNREC leadership for pre-approval, and the applicant is notified.

Final approval. When the applicant's project is completed, the applicant submits the final invoices and proof of payment. After DNREC staff review this documentation, the application is passed to leadership for final approval. Once leadership has approved the application, DRNEC awards the grant monies.

In 2019 DNREC hired a consultant to develop an online application portal that will accept applications and documentation electronically. The application portal will allow DNREC to digitize the entire application process. Program staff will be able to communicate with applicants through the portal regarding the status of applications and request any outstanding application materials. The portal will automatically notify program staff when the application is ready for their review, such as between the first and second technical reviews, or between the technical reviews and approval by DNREC leadership. Upon pre-approval, the portal will automatically generate an email containing an official pre-approval letter. Once the portal is operational, paper applications will no longer be permitted. The program manager expects the portal to streamline the application review process by ensuring that applicants are submitting complete, accurate applications, since the portal will not permit an applicant to submit an application if any required information or materials are omitted.

The portal was scheduled to be completed by June 2020, but it was delayed because of the COVID-19 crisis. As part of this process evaluation the team performed usability testing of the beta version of the portal to ensure that all programming aspects functioned properly, and that content was designed for

simplicity, clarity, and ease of operation. The team provided DNREC with results of the usability testing in July 2020 in a separate memo. Key findings from the usability testing include:

- The portal provides applicants with a simple but full-featured platform for submitting accurate, complete applications to the program.
- Website speed and operation were smooth and error-free.
- The portal did not require the applicant to review a summary of key data entered in the application before submission.

During CY2019 the EEIF program manager revised the grant applications to incorporate the new incentive levels that took effect in February 2020. In addition to adjusting incentive levels, the program manager made a number of enhancements to the applications and approval process, including:

- Eliminating redundant questions
- Clarifying instructions
- Adding checklists for application materials
- Allowing energy savings information to be submitted in spreadsheet format
- Reducing the number of utility bills required for prescriptive and energy assessment applications from twelve months to one month
- Instructing pre-approved applicants to register with the state of Delaware as an e-supplier

The program manager reported noticing an improvement in overall processing time as a result of these enhancements. Fewer applications have been rejected due to missing information, and multiple applicants have told the program manager that the new checklists are helpful. (See section 2.2.1.6 for detailed applicant feedback). Having applicants register as an e-supplier allows EEIF to send applicants their grant monies more quickly.

Process Finding 1: In CY2019, staff addressed CY2016-2018 Process Recommendations 1 through 5 in the following ways:

- ✓ Removing references to participating contractors on the EEIF home page (after ruling out their interest in being listed)
- ✓ Revising the applications
- ✓ Hiring a consultant to develop an online portal
- ✓ Incorporating into this study research to better understand the target markets

Additionally, in August 2020, EEIF hired a program implementer to be responsible for application processing, marketing activities, delivering grant checks, and conducting site inspections.

2.2.2 IMPACTS OF COVID-19

2.2.2.1 Program Staff

The team asked program staff how the shutdown due to COVID-19 has affected EEIF.[24] The COVID-19 pandemic has had minimal impact on EEIF administration. DNREC continued operating during the pandemic, with most staff working remotely. The program manager noted that some participants had delayed projects due to difficulties getting contractors into their facilities to install equipment during the pandemic. Program staff observed an increase in the number of comprehensive, multi-measure project applications submitted during the pandemic; however, staff attributed this to the new custom grant incentive structure and not any effects of the pandemic.

2.2.2.2 Contractors

The team asked contractors how the pandemic was impacting their businesses. Contractors' responses ranged from "It's wreaking havoc" to "Other than some schedule changes, there haven't been a lot of changes." All nine businesses have remained open during the pandemic, but two had to institute furloughs and/or wage cuts. All nine contractors have had projects put on hold or delayed. As Delaware started to reopen, contractors had begun resuming some projects with added safety measures, such as social distancing and wearing masks. Other projects were still on hold until customers allow contractors to return to the sites.

Three of the contractors mentioned offering new products in response to the pandemic. Two contractors had begun offering ultraviolet-C (UVC) lighting products (known for their disinfecting properties), and one had begun offering air purifiers. One of the contractors offering UVC lights explained the product in detail. The UVC LEDs are a new offering that serve both to provide lighting and sanitize the air. A small proportion of the light shed by the LEDs is in the UVC range, which is invisible. Once the UVC LEDs are installed, a titanium dioxide solution is sprayed in the space, which, when activated by the UVC light, scrubs the air of viruses and bacteria. Since a small portion of the light shed by these UVC LEDs is invisible, the contractor recommends slightly higher wattage products to customers installing UVC LEDs than to customers installing ordinary LEDs (e.g., 14w UVC LED versus 12w ordinary LED).

Four of the nine contractors suggested changes EEIF could make to help Delaware businesses continue to adopt energy-efficient equipment given the challenges presented by the pandemic. These suggestions are

[24] The COVID-19 pandemic began in in CY2020. The team included these findings in this CY2019 evaluation as part of the ongoing EEIF process research.

summarized in Table 24, and include increasing incentive amounts, expediting the application process, and offering on-bill financing.

Table 24: Contractors' Suggestions for Encouraging Participation During the Pandemic

Suggestions for Encouraging Participation	Contractors (n=4)
Increase incentive amounts	2
Expedite the application process	2
On-bill financing	1

*Includes multiple responses.

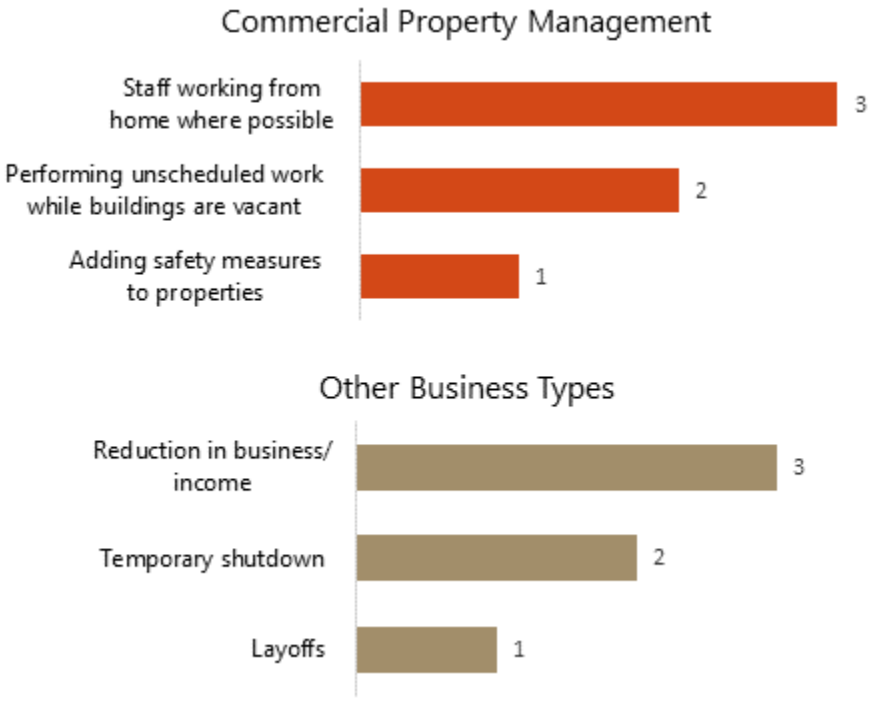
The contractors generally expect business to return to normal after the pandemic is over. Three contractors expect to see a shift in focus from lighting to HVAC measures because of a) the attention the pandemic has brought to indoor ventilation and b) the maturation of the lighting market.

2.2.2.3 Customers

The EcoMetric team asked participants how the shutdown had affected their business. As shown in Figure 5, the ways in which the shutdown affected participants' businesses varied by business type. The commercial property management businesses experienced fewer negative financial impacts. In fact, two of the three commercial property management businesses took the opportunity to perform additional work while their properties were vacant. These participants explained:

- *"We've done some upgrades (painting, landscaping, fixing parking lots). It's been very hard to operate at full scale, but we've done some things that probably weren't even in our budget just to get them done because the tenants weren't there."*
- *"When everyone is at home and there's minimal staff at the sites, it frees up our ability to do these projects without interfering in their day-to-day capacity. Sometimes we have to schedule second shift, third shift, or weekend work, but not now. Now we can get in and do projects in a timely and efficient manner."*

Figure 5: Impacts of Statewide Shutdown on Participants by Business Type



Participants also generally expect business to return to normal after the COVID-19 crisis is over. The commercial property management participants expect some of the changes caused by the pandemic to remain in place once it has passed, such as employers continuing to allow employees to work from home and long-term adoption of safety measures in buildings.

One of the commercial property management participants described safety measures the company was implementing at its commercial properties, some of which have implications for energy usage. These include HVAC filters with high MERV[25] ratings and increased outdoor air supply to buildings,[26] both of which are recommended by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) to limit the spread of infectious diseases. Higher MERV filters cause an increase in static pressure, which increases HVAC system energy consumption slightly. Increased outdoor air supply increases energy use because the outdoor air must be conditioned. Additionally, this participant stated that the company was considering installing ion generators at properties to clean the air of pathogens.

[25] Minimum Efficiency Reporting Values, or MERVs, report a filter's ability to capture larger particles between 0.3 and 10 microns (µm). MERV ratings range from 1 to 16 (https://www.epa.gov/indoor-air-quality-iaq/what-merv-rating-1).
[26] The participant noted that the company would only increase outdoor air supply to new construction buildings, explaining that increasing outdoor air supply to existing buildings would prevent them from achieving conditioning needs during extreme summer and winter conditions.

Another commercial property management participant anticipated that UVC coil irradiation systems installed in HVAC units would become more widely adopted. When directed at HVAC coils, UVC light removes buildup of organic materials that reduce system efficiency. A secondary benefit of this type of system is that it eliminates up to 30% of airborne pathogens.[27] This participant commented:

- *"UV lighting does two things, and one of those things is energy efficiency. I don't know if the program pays for UV lighting on coils, but I could make an argument that through the custom program it's an energy efficiency improvement and they should give money for the lamp."*

Four of the six participants, including all three commercial property management companies, had been planning to participate in EEIF again or make other investments in energy efficiency improvements before the COVID-19 crisis. The pandemic did not affect the three commercial property management companies' plans to invest in energy efficiency improvements. For example, one of these participants explained:

- *"By reducing energy, you make a bigger profit and that increases the net worth of your complex. [The company] would always try to find ways to reduce energy."*

Only one participant, not a commercial property manager, said the pandemic had changed the company's plans to make additional energy efficiency investments. This company had had to shut down temporarily and therefore did not have the funds to make the improvements. The three participants who do not represent commercial property management companies anticipate being able to invest in energy efficiency improvements again in 2021.

Process Finding 2: Contractors' and customers' projects have been put on hold or delayed due to the COVID-19 pandemic, but interviewees expect business to return to normal when it's over. The pandemic has not changed commercial property management companies' plans to invest in energy efficiency.

Process Finding 3: Some contractors and commercial property managers have begun installing new equipment in response to the pandemic, such as UVC lighting and air filtration devices intended to eliminate pathogens. Many of these products will likely increase overall energy consumption. However, one product – an HVAC coil irradiation system - has the potential to increase HVAC system energy efficiency.

[27] Jones, Daniel. 2020. "Limit the Spread of Contagious Diseases and Bacteria with Germicidal UV." HPAC Engineering, 18-21. https://www.dropbox.com/s/27q8asa5phbkepx/HPAC%20ENGINEERING-June%202020%20Limiting%20Disease%20Spread%20with%20Germicidal%20UV-low.pdf?dl=0

Process Recommendation 1: *Monitor trends in equipment installed in response to the pandemic and consider ways that DNREC can encourage the installation of the most efficient types of equipment, and the most efficient models within each type. To this end, DNREC may consider conducting research to better understand the energy implications of this equipment.*

Process Recommendation 2: *For any equipment currently incentivized that improves indoor air quality, ensure that this benefit is included in marketing materials.*

2.2.3 PERSPECTIVES ON APPLICATION AND APPROVAL PROCESS

The EcoMetric team asked contractors and customers for feedback on the application and approval process. EcoMetric asked contractors to identify aspects of the application and approval process that worked well and aspects that did not work well. EcoMetric asked participants who completed their own application to assess its ease and describe any difficulties they encountered.

2.2.3.1 Contractors

Over one-half (five) of the nine contractors typically fill out and submit the EEIF application for their customers. The remaining four contractors fill out most of the application and have their customers fill out the sections applicable to them (e.g., contact and site information). The EEIF program manager noted that the percentage of contractors applying to the program on behalf of customers has remained steady since 2016 at between 60% and 80%.

Overall, contractors were satisfied with the application and approval process. Just over one-half (five) of the contractors were familiar with the revised applications. These contractors acknowledged the improvements and commended them. Contractors familiar with the revised application made the following comments:

- *"I think the program has always run well. The program's always been pretty good."*
- *"Some areas were streamlined. That made it more simple to understand. That was very helpful. They've tried to evolve and help customers."*
- *"The application is pretty clear, but there are a few technicalities we're trying to gain better insight into interpreting the right way."*
- *"It's a simple application and the incentive amounts are great."*

Contractors not familiar with the revised applications shared the following comments about the application and approval process:

- *"The lighting categories are pretty straight forward in terms of what you can get; it is clear about what is available to you."*

- *"I think after we understood the process and got everything squared away, it worked well. There were a few things we didn't understand, and certain parts of the process weren't clear, but the customer support was good."*

Table 25 displays the opportunities for improving the application and approval process contractors identified for the previous and current evaluations. The contractors interviewed for the previous evaluation felt that the pre-approval process could be faster and easier for customers and could have more streamlined documentation requirements. They also noted that the application could be easier to navigate and that increased communication about the status of applications would be helpful.

The CY2019 contractors identified fewer areas for improvement to the application and approval process than the CY2016-2018 contractors did for the previous evaluation. Additionally, CY2019 contractors did not mention many of the areas CY2016-2018 contractors identified as needing improvement, such as the application being confusing or difficult to navigate, having redundant questions, or requiring twelve months of energy bills. However, there is still some room for improvement in the application processing time. Three of the nine CY2019 contractors, compared to four of the five CY2016-2018 contractors, identified this as an opportunity for improvement, citing wait times of up to four months for pre-approval.

The CY2019 contractors identified a few new areas of the application and approval process that could be improved as well. Two of the nine contractors indicated that some items on the applications were still unclear to them, such as the requirements for the new tiers on the custom application. Additionally, two contractors said that requiring pre-approval before starting a project holds them up.

Table 25: Opportunities for Improving the Application and Approval Process

Needs Improvement	CY2016-2018 Count (n=5)	CY2019 Count (n=9)
Long application process or pre-approval time	4	3
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	1
Redundant questions on application	2	--
Difficulty obtaining 12 months of energy bills for application	2	--
Some application items unclear	--	2
Cannot start project until its approved	--	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	--
Difficulty obtaining copy of electrical license	--	1
Difficulty obtaining contractor commitment	--	1

*Includes multiple responses.

2.2.3.2 Customers

Five of the six participants the EcoMetric team interviewed completed some or all of the EEIF application. Similar to the participants surveyed for CY2016-2018 evaluation, these five participants generally found the application to be straightforward and easy to complete. One of these five participants commented that the application would be easier if it were online, which will be the case once the portal is launched.

Process Finding 4: Contractors and customers found the application easy to complete. The CY2019 contractors identified fewer areas for improvement to the application and approval process than the CY2016-2018 contractors. There is still some room for improvement in processing time.

Process Recommendation 3: *Reassess applicants' perspectives on the application after it has shifted to the online portal to ensure it continues to be easy to complete.*

2.2.4 MARKETING AND MEDIA

A recommendation from the previous evaluation was to conduct research to better understand the target markets for the program and how best to reach them. To facilitate this, the team asked contractors and

customers to identify the specific social and other media they routinely used at work. The EcoMetric team also asked contractors if they marketed the EEIF program, and how DNREC could support their efforts to bring in program participants.

2.2.4.1 Contractors

The team asked contractors which social and other media they routinely used for marketing purposes, and which media they used for other purposes (such as industry news and information). Almost one-half (4 of 9) said word-of-mouth was their main form of marketing. Two of the nine contractors did not do any marketing; they simply relied on business from repeat customers. Only one-third (three) of the contractors had any social media presence, and none of them used social media as a primary marketing tool. Table 26 displays the marketing platforms contractors used.

Table 26: Marketing Platforms Contractors Use

Marketing Platform	Contractors (n=9)
Word-of-mouth	4
Facebook	3
Company website	2
None	2
Industry publications	1
Trade shows	1
Online ads	1
LinkedIn	1
Twitter	1
Instagram	1

*Includes multiple responses.

Six of the nine contractors used various forms of media for non-marketing purposes, such as industry news and procurement of supplies. One-half (three) of these six contractors reported conducting web searches and one-third (two) said they reviewed industry publications. Table 27 displays the forms of media contractors used for non-marketing purposes. When asked for names of the specific industry publications they used, the contractors did not offer them.

Table 27: Media Contractors Use for Non-Marketing Purposes

Media Contractors Use	Contractors (n=9)
Web searches	3
None	3
Industry publications	2
LightFair conference	1
LinkedIn	1
Email notifications from program administrators	1
Conversations with vendors	1
Delaware state website	1

*Includes multiple responses.

All nine contractors interviewed said they tell customers about the program. However, only one contractor marketed the program in any way other than word-of-mouth (via emails to customers). This finding was consistent with that of the previous evaluation, in which four of the five CY2016-2018 contractors interviewed said that word-of-mouth was the primary way they generated EEIF projects. Contractors said they often used the program as a selling point to prospective customers, as illustrated by the following comments:

- *"If we know we can target a project and have a good chance to get it, we'll sit down with them to try and work through a sales pitch. And when we do that, we tell them we can get them the rebate."*
- *"Anytime the sales folks go out anywhere, a selling point is that we have an in-house rebate through X or Y that will get as much money as possible. So, in the Delaware area, anytime we're working on sales then it would be promoted. We don't put their logo on anything or anything like that, but their program will be mentioned."*
- *"The promotion we do is when we have a client in the EEIF territory, we let them know about it and actively seek to use it. It's not like we're going out looking for customers and telling them about the program."*

When asked how program staff could help contractors market the EEIF program to customers, one contractor suggested DNREC increase program advertising, one suggested giving contractor referrals, and one suggested implementing a trade ally program. Additionally, one contractor pointed out that some Delaware real estate has out-of-state owners and suggested DNREC target this market. This contractor also recommended emphasizing eligible HVAC equipment in marketing materials due to the attention the COVID-19 pandemic has brought to indoor ventilation.

Process Finding 5: Contractors' main form of marketing is word-of-mouth. Contractors use EEIF as a selling point by telling prospective customers that incentives are available through EEIF. They do not use social media as a primary marketing tool.

Process Recommendation 4: *Consider providing contractors with referrals (when available) and marketing materials to hand out to prospective customers.*

2.2.4.2 Customers

Participants did not report using social media for work-related purposes. Most (5 of 6) participants conducted web searches to seek out products and services. In fact, three of the six participants learned about the EEIF program online. Two participants said they work with regular suppliers and generally do not use media to seek out products or services. Table 28 displays the forms of media participants used for work-related purposes. As with the contractors, when asked for names of the specific industry publications they used, the participants did not offer them.

Table 28: Media Participants Use for Work-Related Purposes

Media Participants Use	Participants (n=6)
Web searches	5
Supplier websites	2
Industry publications	1

*Includes multiple responses.

Process Finding 6: Participants generally rely on web searches or established relationships with suppliers to seek out products and services. One-half (three) of the participants interviewed discovered EEIF online.

Process Recommendation 5: *Consider optimizing the EEIF website to increase its visibility in search engine results (search engine optimization).*

2.2.6 CUSTOMER MOTIVATIONS AND BARRIERS TO PARTICIPATION

The team asked customers for their primary motivation for participating in EEIF, and if they experienced any challenges participating in the program. The three participants in the commercial property management business cited saving money on energy costs as the primary motivating factor, while the three participants representing other business types cited the incentives (two) and the improved work environment (one) as the primary motivating factor. Only one of the six participants experienced challenges participating in the program. This participant explained:

- *"Communications were not as fluent as we're used to for programs like this. I believe that happened because they're [DNREC] understaffed. Then I also think because it was more paper based and less web based, that created execution barriers."*

2.2.7 PERSPECTIVES ON PROGRAM STRENGTHS

2.2.4.3 Contractors

The EcoMetric team asked contractors what they viewed as the program's greatest strengths. As shown in Table 29, the most commonly mentioned strength was the program incentive levels (four), followed by the comprehensiveness of the measures (two), and ease of application (two).

Table 29: EEIF Program Strengths

Program Strength	Contractors (n=9)
Incentive levels	4
Comprehensive measures	2
Ease of application	2
Custom program flexibility	1
Customer service	1
Customer protection	1

*Includes multiple responses.

Some of the contractors' comments on the program's strengths were:

- *"The ease of application and overall customer service is really good."*
- *"The custom program is really great. It's a flexible program that recognizes the performance of a project. We were really impressed by it; it's a model program."*
- *"We're really happy with the program, its structure, the intent it has, and the team that supports it."*

2.2.4.4 Customers

The team asked participants what they saw as the best thing about EEIF. Three participants cited saving on energy costs, while the other three participants said the ease of the process (one), the energy efficiency improvements (one), and program staff expertise (one) was the best thing about EEIF.

Some of the customers' comments on their experience with the program were:

- *"We're satisfied and glad the program is there to continue to use."*
- *"It was pretty simple, very worthwhile. I was very happy with the outcome. I would recommend it."*
- *"The program is great, it's just understaffed."*

2.2.8 SUGGESTIONS FOR PROGRAM IMPROVEMENT

2.2.8.2 Program Staff

The program manager offered the following suggestions for improvements to the program:

- Process all applications before they expire
- Provide applicants with a time estimate for when to expect applications to be reviewed
- Conduct marketing and outreach
- Track the correct person for applications

Changes EEIF made during the last year will likely help accomplish these goals. For example, hiring another staff member and a program implementer should increase EEIF's resource capacity, allowing the program to process applications more efficiently and invest time in marketing and outreach. Additionally, tracking contractor contact information for all applications will help staff reach the correct person.

2.2.8.1 Contractors

The team asked contractors how the program could be improved. Table 30 displays contractors' suggestions for both the previous and current evaluations. Based on these suggestions and other findings described above, it appears that enhancements program staff made during the last year, including developing the online portal, hiring a program implementer, adding checklists to the application, and allowing information to be submitted in a spreadsheet, successfully addressed most contractors' suggestions from the previous evaluation.

In the current CY2019 evaluation, the most common suggested program improvement, mentioned by three contractors, was to speed up the approval process. Two contractors suggested increasing communication and transparency in the approval process: these contractors wanted more timely updates regarding the status of applications they had submitted. One of these contractors commented:

- *"Transparency is the key thing. More transparency into where things stand because we can manage things pretty effectively, even if it's not the news we're looking for, as long as we understand where things are."*

In addition, two CY2019 contractors suggested implementing a trade ally program. These contractors believed a trade ally program would help streamline the application process. Becoming a trade ally typically involves contractor training on program requirements and procedures. Once a company becomes a trade ally, applications can be processed more quickly because the company has "proved its trustworthiness" by completing the training and pledging to adhere to the program requirements.

One contractor suggested notifying contractors of recent process improvements, stating:

- *"I think they made improvements and changes that are good, and they should tell people that. Someone might have done it years ago and thought it was complicated, but they may be more willing to try it if things are easier or more simple."*

Table 30: Contractor Suggestions for Program Improvement

Contractor Suggestions for Improvement	CY2016-2018 Count (n=5)	CY2019 Count (n=9)
Put some of the questions on the application form into spreadsheet format	2*	--
Move application process online	2*	--
Add staff	2*	1
Speed up approval process	1	3
More communication/transparency in approval process	--	2
Implement trade ally program	--	2
In online 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*	1
Allow work to begin before pre-approval	--	1
Notify contractors of recent process improvements	--	1
Notify contractors of incentive updates	--	1
Increase scope of measures	--	1
Have online portal alert contractors by email when there is a note or message about an application on file	1*	--
Online application process that automates calculations	1*	--
Store basic contractor information, such as electrical license and certificate of insurance, online so that contractors don't need to submit it with every application	1	--

*Addressed by enhancements made during the last year.
**Includes multiple responses.

Process Finding 7: Contractors would like faster application processing and increased communication regarding the status of applications.

Process Recommendation 6: *Monitor application processing time once the portal is online. Work with the program implementer to optimize application processing and communication with applicants, including setting contractors' expectations regarding processing time.*

2.2.8.3 Customers

The team asked participants how their experience with EEIF could have been improved. Table 31 displays participants' suggestions for improving the program. Consistent with the previous evaluation, one-half of participants had no suggestions for improving EEIF. Two of the participants' suggestions pertained to the application process. These included 1) automating the application and 2) developing an application instruction manual. The participant who recommended an instruction manual explained:

- *"They can write an instruction manual. As long as it's super-fast, direct, with hyperlinks – an interactive manual that gets you where you need to go - then you'll win; everyone will play. If they can build that they don't need to be on the phone walking people through it. Instead, just send them the guide."*

Two of the suggestions pertained to timeliness: one participant would like to see the duration from start to finish reduced, and another would like to receive the grant monies faster. Finally, one participant, a commercial property manager, suggested increasing incentive amounts. This participant explained that the transaction costs of "chasing the money" were greater than the amount of the grant. This was the same participant who recommended automating the application, noting that automation would reduce the transaction costs to applicants.

Table 31: Participant Suggestions for Program Improvement

Participant Suggestions for Improvement	CY2019 (n=6)
Nothing	3
Application process	2
Time to receive money	1
Duration from start to finish	1
Grant amount	1
Communication	--
Approval time	--
Contractor training	--
Other	--

*Includes multiple responses.

3 GREEN ENERGY PROGRAM RESULTS

The Green Energy Program (GEP) provides funding to promote the use of renewable energy technologies 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 Delaware[28] 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 214 renewable energy projects completed during the 2019 calendar year (CY). EcoMetric defined each project as a unique application[29] and included only projects with the "paid" payment status.

Solar photovoltaic (PV) projects were the most significant measure for the GEP. On an equivalent energy basis[30], solar PV accounts for almost 99% of the installed capacity through the program. Table 32 shows a summary of CY2019 for GEP.

Table 32: GEP 2019 Program Summary

Program Year	Measure	Count	Capacity (MW)	Capacity (Tons)	Capacity (Gallons)
2019	PV	192	1.74	0	0
	Geothermal	20	0	115	0
	Solar Water	2	0	0	160
Total		214	1.74	115	160

The sample frame for GEP breaks out the different measures into separate strata. EcoMetric further segmented each measure type into sub-strata with the appropriate facility type. A summary of the sample frame is shown in Table 33.

[28] http://greengrantdelaware.com/
[29] Application_ID is the variable in the program data which defines unique applications
[30] Simply converting tons to watts for geothermal projects by multiplying tons by 12,000 and dividing by 3412.

Table 33: GEP Sample Frame

Measure	Facility Type	Stratum	Count	Percent (count)	Capacity (MW)	Capacity (Tons)	Capacity (Gallons)	Percent Capacity
Solar PV	Non-Profit	Probability	2	1%	0.06	0	0	4%
	Non-Residential	Probability	6	3%	0.11	0	0	7%
	Residential	Large Probability	51	24%	0.67	0	0	38%
		Small Probability	133	62%	0.89	0	0	51%
Geothermal	Residential	Probability	20	10%	0	115	0	100%
Solar Water	Residential	Probability	2	1%	0	0	160	100%
		Total	214	100%	1.74	115	160	100%

EcoMetric randomly selected projects from the probability strata. The large and small strata for residential solar PV projects separate projects greater than 10 KW (0.01 MW) into the large probability stratum and those less than 10 KW (0.01 MW) into the small probability stratum.

EcoMetric selected a sample of 28 projects, targeting 85% confidence and 15% precision for the program and allocated the sample points to each of the measure and facility type combinations in proportion to their respective installed capacities. The number of samples given to each stratum and the percentage of projects and capacities covered by the sampled projects is shown in Table 34.

Table 34: GEP Sample Coverage

Measure	Facility Type	Stratum	Sampled Count	Percent Sampled (count)	Sampled Capacity (MW)	Sampled Capacity (Tons)	Sampled Capacity (Gallons)	Percent Sampled Capacity
Solar PV	Non-Profit	Probability	1	38%	0.09	0	0	52%
	Non-Residential	Probability	2					
	Residential	Large Probability	8	11%	0.19	0	0	12%
		Small Probability	12					
Geothermal	Residential	Probability	3	14%	0	20	0	17%
Solar Water	Residential	Probability	2	100%	0	0	160	100%
			28	13%	0.28	20	160	16%

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. The key variables were consistently reported throughout the database and facilitated an efficient review of sampled projects.

Finding 14: Annual energy generation is tracked for Solar PV projects, but the annual energy savings are not tracked for Geothermal or Solar Water Heater projects in the GEP program database.

The EcoMetric team found that based on recommendations made in EcoMetric's 2016-2018 evaluation report, DNREC tracked the annual generation for solar PV projects in 2019. However, DNREC did not track the savings for geothermal and solar water heater projects for CY2019 projects.

Recommendation 9: *Add an estimated energy savings (kWh) data field to the Green Grant Delaware[31] online application portal for geothermal and solar water heating projects to allow for program tracking.*

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 the program data from the program's online web portal.

3.1.2.2 Engineering Desk Reviews

The EcoMetric team completed engineering desk reviews for all projects in the evaluation sample. The reviews used all information included in the project files to assess savings and to ensure that projects consistently follow program rules. EcoMetric also compared the information in the project files to information recorded in the tracking system to verify data accuracy and verify the installed capacity for each sampled project.

EcoMetric independently calculated the generation capacity for each sampled project using the PVWatts®[32] calculator. The PVWatts® calculator requires user inputs, including PV capacity, module

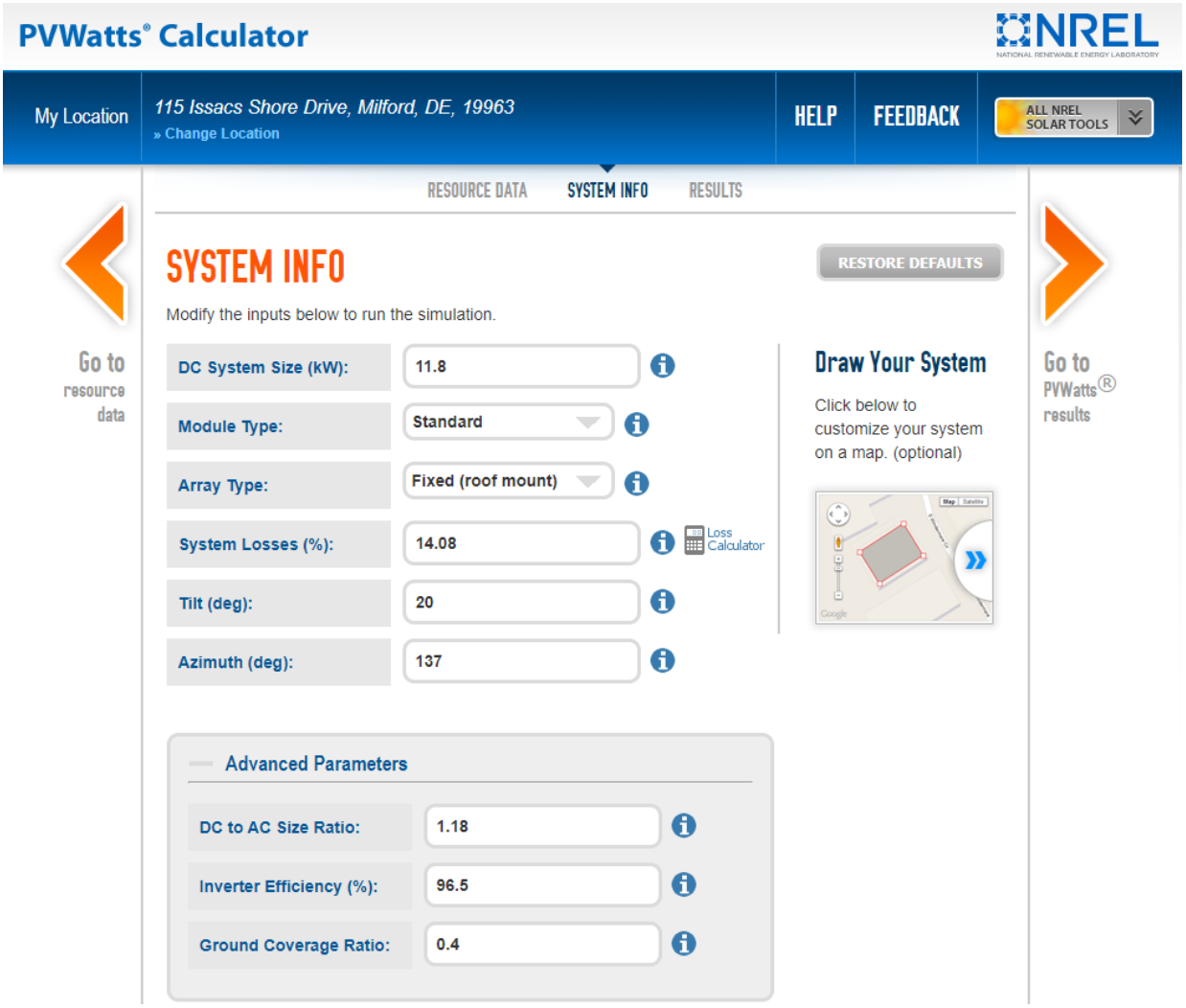
[31] https://greengrantdelaware.com/

[32] https://PVWatts®.nrel.gov/ Estimates the energy production and cost of energy of grid-connected photovoltaic (PV) energy systems.

type (standard, premium, and thin-film), tilt, azimuth, and estimated system losses. Users 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 and can calculate inverter efficiency and size ratio with the information provided in the specification sheets. The calculator also allows the user to draw the solar PV panels on a Google maps interface that generates an appropriate DC system size in kW for the user to enter into the calculator.

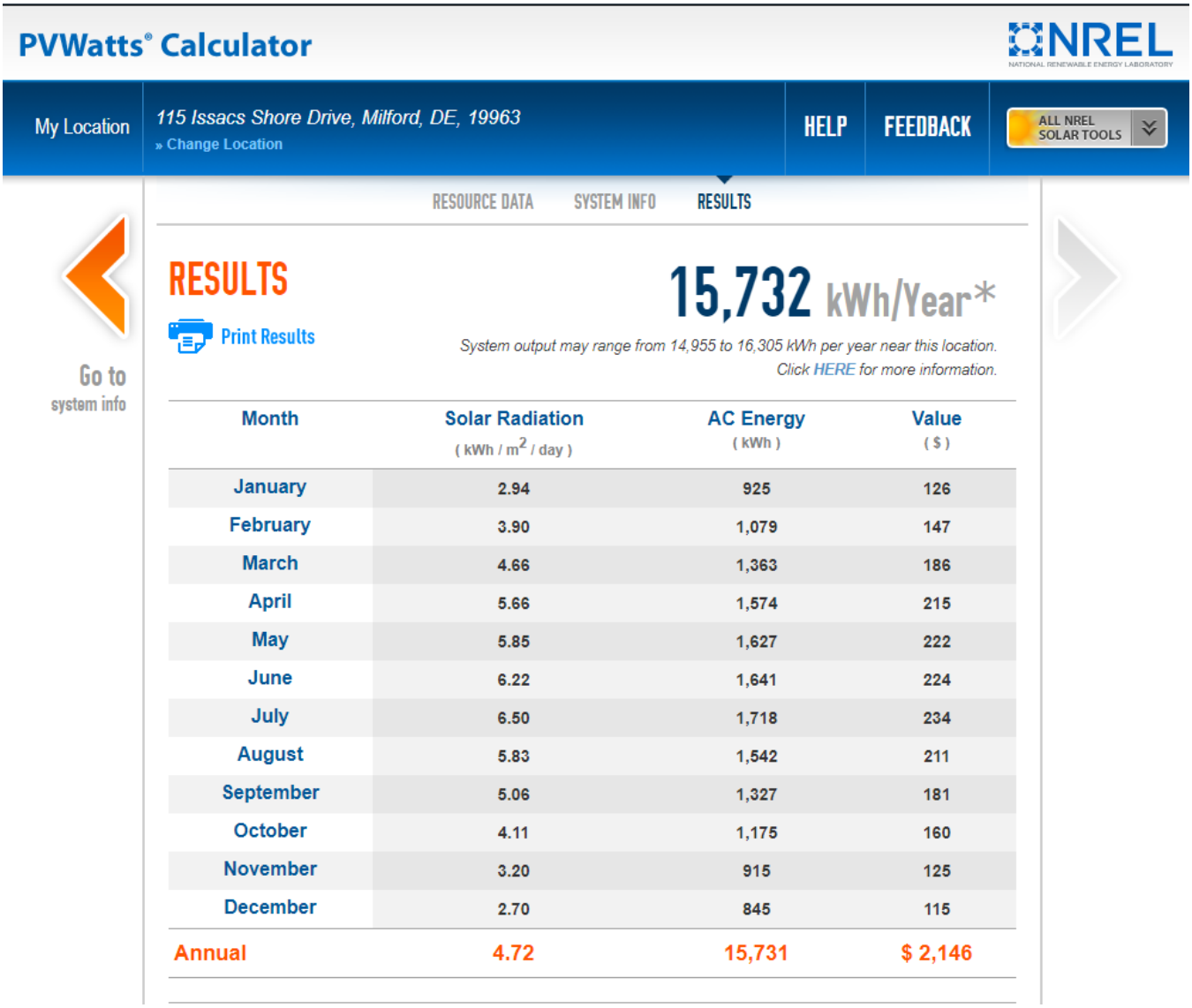
Input parameters entered in the calculator input window below are sourced from GEP project documentation. Figure 6 and Figure 7 below show examples of the PVWatts® inputs such as system capacity, type of modules, mounting, system losses, tilt and azimuth angles of the installed panels. Additionally, details such as DC to AC size ratio and inverter efficiency are captured for the installed system.

Figure 6: PVWatts® Input Window



At the end of the data entry process, the tool calculates results using the input parameters entered. The output is expressed in terms of annual electricity generated by the panels. PVWatts® also allows the user to download monthly or hourly performance data of the panels in the excel workbook format.

Figure 7: Example of Results Window from PVWatts®



PVWatts® Calculator

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

My Location | 115 Issacs Shore Drive, Milford, DE, 19963 » Change Location | HELP | FEEDBACK | ALL NREL SOLAR TOOLS

RESOURCE DATA | SYSTEM INFO | RESULTS

Go to system info

RESULTS

Print Results

15,732 kWh/Year*

System output may range from 14,955 to 16,305 kWh per year near this location.
Click HERE for more information.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	2.94	925	126
February	3.90	1,079	147
March	4.66	1,363	186
April	5.66	1,574	215
May	5.85	1,627	222
June	6.22	1,641	224
July	6.50	1,718	234
August	5.83	1,542	211
September	5.06	1,327	181
October	4.11	1,175	160
November	3.20	915	125
December	2.70	845	115
Annual	4.72	15,731	$ 2,146

EcoMetric used prescriptive methodology mentioned in Measure 3.2.3 Water Source and Geothermal Heat Pumps of the 2016 Pennsylvania Technical Reference Manual (TRM)[33] to estimate savings for the sampled geothermal heat pump projects. EcoMetric used Delaware specific algorithm inputs, such as Full load hours, listed in the Mid-Atlantic TRM to calculate the verified savings. Section 3.1.3.2 provides more details into the verified savings approach.

EcoMetric used prescriptive methodology from Measure 2.3.2 Solar Water Heaters of the 2016 Pennsylvania TRM to estimate savings for the sampled solar water heater projects. To calculate

[33] Pennsylvania Technical Resource Manual, June 2016 (Document)

energy savings, EcoMetric calculated the baseline energy factor using equations listed in "High Efficiency Gas Water Heater" measure from the Mid-Atlantic TRM.

3.1.3 VERIFIED CAPACITIES AND ENERGY SAVINGS (GENERATION)

The Delaware EM&V regulations do not govern GEP, so the program does not track 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. The program achieved a weighted capacity realization rate of 104% for solar PV projects and 100% for geothermal and solar water heater projects completed in CY2019. The solar PV capacity realization rate's relative precision was 2% at the 85% confidence level. The geothermal and solar water heater capacity realization rate's relative precision was 0.0% at the 85% confidence level. The verified capacities and precision values are shown in Table 35.

Table 35: GEP CY2019 Verified Capacities

Measure	Facility Type	Stratum	Verified Capacity (MW)	Verified Capacity (Tons)	Verified Capacity (Gallons)	Relative Precision at 90% Confidence
Solar PV	Non-Profit	Probability	0.06	0	0	0.00%
	Non-Residential	Probability	0.11	0	0	0.17%
	Residential	Large Probability	0.68	0	0	0.80%
		Small Probability	0.99	0	0	4.63%
Geothermal	Residential	Probability	0	115	0	0.00%
Solar Water Heater	Residential	Probability	0	0	160	0.00%

In addition to verifying the system capacities, EcoMetric also verified the energy production from solar PV, energy savings from geothermal heat pumps and solar water heaters, and summer peak demand reduction for all sampled projects. EcoMetric calculated energy generation and demand savings for solar PV projects using the PVWatts® calculator and information provided by customers in GEP grant project documentation using the methodology described in 3.1.3.1.

EcoMetric also calculated energy and demand savings for geothermal projects using the "Ground Source Heat Pumps" methodology in the Pennsylvania TRM and information from the installed units' AHRI certificates, as described in section 3.1.3.2.

Additionally, EcoMetric calculated the savings for solar water heater projects using the "Solar Water Heaters" methodology provided in the Pennsylvania TRM. EcoMetric leveraged project baseline and location-specific parameters in the Mid-Atlantic TRM, as described in sections 3.1.2.2 and 3.1.3.3.

Table 36 shows the verified energy savings (generation) and peak demand savings for the various systems installed through GEP in CY2019.

Table 36: GEP CY2019 Gross Verified Savings (Generation)

Measure	Facility Type	Stratum	Gross Verified Energy Savings (MWh)	Gross Verified Peak Demand Savings (MW)
Solar PV	Non-Profit	Probability	91	0.09
	Non-Residential	Probability	153	0.15
	Residential	Large Probability	932	0.67
		Small Probability	1,453	1.11
Geothermal	Residential	Probability	29	0.02
Solar Water Heater	Residential	Probability	4	0.001
		Total	2,663	2.03

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

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

3.1.3.1 Gross Savings Verification for Solar PV projects

For solar PV projects, EcoMetric used specification sheets for the PV panels and inverters to estimate operating wattages and total wattages for all orientations (azimuth and tilt). Using PVWatts®[34], 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 PV panels' orientations 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 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.

[34] https://PVWatts®.nrel.gov/ Estimates the energy production and cost of energy of grid-connected photovoltaic (PV) energy systems.

3.1.3.2 Gross Savings Verification for Geothermal projects

GEP project documentation included invoices, model numbers, and AHRI (Air-Conditioning Heating and Research Institute) certificates for the installed units. AHRI is an independent third-party testing organization that tests HVAC equipment at standard testing conditions. EcoMetric verified the installed nominal capacity using the AHRI certificates for the geothermal heat pumps. EcoMetric used the "Ground Source Heat Pumps" methodology outlined in the Measure 3.2.3 Water Source and Geothermal Heat Pumps of the Pennsylvania TRM to determine the gross verified energy savings and peak demand reductions. The verified savings calculations used cooling capacity, cooling efficiency, heating capacity, and heating efficiency for the installed units taken from the AHRI certificates. EcoMetric used the baseline efficiencies and Delaware full-load hours from the Mid-Atlantic TRM.

Finding 16: EcoMetric found discrepancies between the nominal capacities of installed systems and the capacities documented in the models' AHRI certificates.

The GEP program records the total nominal cooling tons and efficiency (EER and COP) for the installed geothermal units. Units tested at AHRI conditions mimic performance as closely as possible to their in-field performance. Therefore, the energy savings and demand reductions calculated using capacities and efficiencies listed in AHRI certificates are considered to be more accurate than those computed using nominal manufacturer capacities.

Recommendation 10: *Consider using AHRI testing information available in project documentation rather than nominal values to calculate savings from the installed geothermal heat pump systems.*

3.1.3.3 Gross Savings Verification for Solar Water Heater projects

EcoMetric verified the installed tank capacity using project documentation (invoices and contractor project report). The contractor's savings calculations were based on the T*SOL software[35] but did not provide an equivalent energy factor for the hot water system. EcoMetric used default efficient energy factor values for solar water heaters listed in the Pennsylvania TRM[36] and calculated baseline energy factors (based on tank size) using the Mid-Atlantic TRM's algorithms. EcoMetric calculated energy savings for the projects using the prescriptive methodology listed in the Mid-Atlantic TRM. Although DNREC does not track savings for solar water heater projects in the GEP program

[35] T*SOL is a simulation program that calculates the yield of a solar thermal system dynamically over the annual cycle.

[36] http://www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx

database, EcoMetric noticed that the contractor's calculated savings were higher than the verified savings. EcoMetric could not identify a reason for this difference between the contractor calculations and the verified savings based on the supplied project documentation.

Finding 17: EcoMetric could not verify the assumptions and methodology used to calculate the reported energy savings for two solar water heater projects using the files in the project documentation.

The savings calculations for solar water heaters appear to be calculated by contractors using proprietary software. EcoMetric could not verify the calculation methodology and assumptions used to calculate the savings based on the information available in the project documentation. EcoMetric independently verified the savings based on publicly available TRMs.

Recommendation 11: *Consider requiring the customers or the contractors to summarize the energy savings methodology and software modeling inputs if proprietary software is used to calculate savings.*

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 (NTG) ratio. 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 $1,963,530 for projects completed in CY2019. The sample's verified energy savings were extrapolated to the CY2019 program population following the sampling methodology described in section 3.1.1. The EcoMetric team used the total energy savings from the program population and measured EULs to calculate the lifetime electric savings, lifetime GHG reduction, and lifetime NPV dollar savings. Table 37 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 37: GEP Greenhouse Gas Emissions Reductions

Measure Type	Facility Type	Net Verified Electric Savings (MWh)	Lifetime Electric Savings (MWh)	Lifetime GHG Reduction (lbs)	Lifetime NPV Savings ($)
Solar PV	Non-Profit	91	2,280	2,993,562	$67,367
	Non-Residential	153	3,823	5,019,271	$112,954
	Residential	2,386	59,645	78,300,119	$1,762,065
Geothermal	Residential	29	575	785,930	$18,898
Solar Water Heater	Residential	4	63	85,817	$2,246
	Total	2,663	66,387	87,184,700	$1,963,530

3.1.6 COST-EFFECTIVENESS RESULTS

EcoMetric's cost-effectiveness analysis shows that the GEP has a benefit-cost ratio of 1.38 using the Total Resource Cost (TRC) test. This indicates that the program is cost-effective. The benefit-cost ratio is based on gross verified savings since net verified savings are not applicable for this program. Solar PV costs are on a decline, and lower measure costs have improved the program's benefit-cost ratio since the last evaluation. Table 38 provides details on the total benefits and costs which EcoMetric included in the TRC test for the GEP.

Table 38: GEP Cost-Effectiveness Results

Benefit / Cost	NPV of Benefit/Cost
Lifetime Avoided Cost of Energy	$4,873,912
Lifetime Avoided Cost of Capacity	$4,681,393
Lifetime Avoided Cost of Fossil Fuel	$0
Lifetime Non-Energy Benefits	$0
Total Benefits[37]	$9,555,305
Program Administrative Costs	$277,455
Measure Costs	$6,660,554
Total Costs[38]	$6,938,009
TRC Benefit-Cost Ratio	1.38

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

3.2 PROCESS EVALUATION

Although the Green Energy Program (GEP) has been running since 1999,[39] CY2019 was the first year for which a process evaluation occurred. The process evaluation goal was to understand the program's design and implementation, participation and generation goals, the effectiveness of program processes, and participant satisfaction.

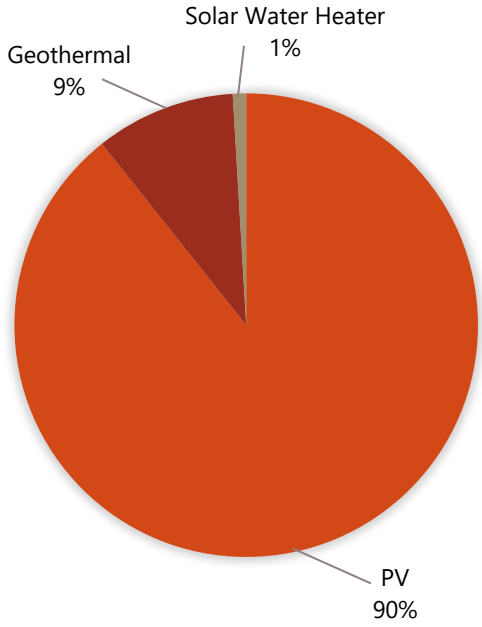
The evaluation entailed in-depth interviews with the program managers, a telephone survey of CY2019 program participants, and in-depth interviews with installation contractors. The team interviewed the program managers to understand the history and goals of GEP and its implementation processes. The participant survey's purpose was to learn about the participant experience receiving an incentive through GEP and to assess satisfaction with several program elements. Contractor interviews were designed to understand how contractors conduct their work and determine program processes' effectiveness.

GEP provides incentives for four renewable energy technology types (solar photovoltaic (PV), solar water heater, wind turbine, and geothermal). However, program participation is currently dominated by solar PV, with 90% (192) of the 214 CY2019 participants installing solar PV systems,

[37] The benefits accure over the life of the measure.
[38] The costs occur in year zero of the NPV calculation.
[39] Per DNREC program website https://dnrec.alpha.delaware.gov/climate-coastal-energy/renewable/assistance/

9% (20) installing geothermal systems, and 1% (2) installing solar water heating. Figure 8 displays CY2019 GEP program participation by installed technology.

Figure 8: CY2019 GEP Total Program Participants by Technology (N=214)



3.2.1 STAFF INTERVIEWS

EcoMetric interviewed two DNREC staff members involved in managing GEP to learn what their goals were for the program, implementation approach, and how they saw the program's future.

The managers explained that the overarching goal of GEP is to promote renewable energy and related technologies in Delaware and described the "big picture" as supporting both the development and deployment of renewable energy in Delaware.

3.2.1.1 Program Administration

The Green Energy Program does not have formal branding. Although it is most commonly known as the Green Energy Program (GEP), it is also sometimes referred to as the Green Energy Fund, Green Energy Endowment Program, and Green Energy Grant Program by different entities such as DNREC, Delmarva Power, and the DE SEU.

The program is delivered almost exclusively through equipment installation contractors, who conduct direct outreach and advertise to neighbors of existing customers. DNREC requires contractors to be licensed and operate in Delaware but does not have a formal trade ally program with specific qualifying criteria. Contractors apply to be affiliated with the program and when approved have their names included on DNREC's website.

DNREC has maintained a GEP web portal for approximately six years to streamline program data entry and tracking. DNREC employs a third party to manage the portal, through which contractors and participants submit applications and project information. During our interview, the program managers reported that the portal functions consistently well.

Program administrators ensure quality control by requiring contractors to submit photographs of installed systems and monitoring customer feedback on contractor quality. GEP has conducted post-installation site inspections in the past but does not do so currently.

3.2.1.2 Program Goals and Metrics

Program managers reported that GEP did not have established participation, electricity generation, or greenhouse gas reduction targets in CY2019. However, they did report tracking number of yearly participants, which had been hovering at about 220 over the previous few years; one of the managers said they'd like to see that number go up to 250.

In terms of metrics, in CY2019, the program tracked number of applications paid out each year relative to the annual budget, as well as kW of installed capacity. The program also monitors and factors in the value of Solar Renewable Energy Credits, which staff reported had decreased in CY2019 from 30% to 26%[40]. The program manager explained that, as a result, DNREC adjusted the grant level to compensate; for example, the federal tax credit amounted to 12 cents per watt of installed capacity, so DNREC raised the grant level to 10 cents per watt.

3.2.1.3 Future Plans for GEP

Looking ahead to future program years, program managers stated a few new goals for GEP: To support Research & Development and technology demonstration projects formally through an RFP process; examine possible changes to the incentive structure; implement a solar energy curriculum program; and work on program advertising.

Process Finding 8: GEP program managers have plans to make some program changes in the next couple years, including supporting R&D and Technology Demonstration projects.

Process Recommendation 7: *Implement the solar energy curriculum program and continue working to further R&D and technology demonstration project efforts.*

[40] Of the cost of the total installed system.

3.2.2 CONTRACTOR EXPERIENCE WITH GEP

The evaluation team completed in-depth interviews with six renewable energy contractors who completed GEP projects in CY2019. The purpose of the interviews was to assess contractors' experience working with GEP to secure incentives for their customers. This included inquiring about their experience with the application and approval process, data tracking and the online portal, calculating energy generation capacity, use of social media, and finally, their perspectives on what worked well and what could be improved.

To recruit for the interviews, EcoMetric contacted the population (25) of CY2019 GEP installation contractors at random and completed interviews with six. Four of the six respondents reported completing projects through the Green Energy Program for more than 12 years. Table 39 presents the breakdown of contractors by project type, generation capacity installed, and percent of CY2019 GEP projects completed by interviewed contractors (43%).

Table 39: Contractor Project Representation

Project Type	Total CY2019 Projects	Total CY2019 Contractors by Measure Type	Projects Completed by Interviewed Contractors	Percent of CY2019 Projects Completed by Interviewed Contractors	PV Generation Capacity Installed (MW)	Geothermal Generation Capacity Installed (Tons)	Solar Water Generation Capacity Installed (Gallons)
PV	192	16	83	43%	1.78	0	0
Geothermal	20	8	8	40%	-	115	0
Solar Water	2	1	0	0%	-	0	160
Total	214	25	91	43%	1.78	115	160

Contractors are very satisfied with GEP overall and offered positive feedback on many aspects of the program. Respondents said DNREC communicates well and is quick answer to questions. One contractor said, "Really a great program. Everything online is smooth and seamless."

> *"Appreciate they have increased the grant amount and have taken off a requirement for commercial. Made very positive steps this year. Very grateful for the program." – GEP contractor*

3.2.2.1 Application and Approval Process

All six of the interviewed contractors reported positive experiences with GEP's online application process and said the portal was very user friendly. One contractor said, "Everything is online, very simple. Enrollment process is straightforward." Four of the six said the application and approval process was typically fast, while two contractors expressed a desire for real-time status updates on the approval process.

When asked if there are any pain points in the approval process, two contractors said gathering customer data & documents can be difficult. Another two said not having to submit an energy audit report would improve the process. Suggested improvements included the ability to easily re-upload a project after it's rejected and having the option for an e-signature through the portal.

3.2.2.2 Net Metering

All four of the responding contractors who completed solar PV projects said the homes they work with are net metered. Three said they are involved in the net metering setup with the utility, and that experiences with this setup varies from project to project.

3.2.2.3 Contractor Social Media Usage

Four of the six contractors EcoMetric spoke with reported using social media professionally. However, only two of these reported using social media heavily for advertising and referrals. In addition to Facebook, which all four social media-active contractors mentioned, and Twitter and Instagram (mentioned by three of the four) one contractor reported using soloarreviews.com, which they said was responsible for most of their new customer leads.

The EcoMetric team asked contractors how, if at all, they would like to see DNREC use social media as it pertains to GEP. Five of six said they would like to see DNREC advertise GEP's solar grants more, and in general post more informational content on social media such as Facebook and Twitter.

Process Finding 9: Contractors completing projects through GEP report very high levels of satisfaction with the program, citing ease of application/approval processes and a user-friendly web portal.

Process Recommendation 8: *Further investigate how useful the capability to provide e-signatures on program materials would be to contractors, and whether it's feasible for the program to add this feature.*

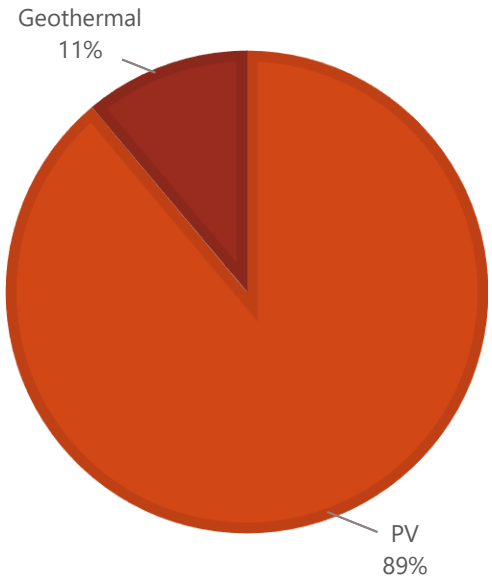
3.2.3 PARTICIPANT EXPERIENCE WITH GEP

The evaluation team surveyed 27 GEP program participants to understand how participants perceive GEP, what their experience was like with program processes, satisfaction with various program aspects, awareness of other energy efficiency programs, and how, if at all, their routines and plans may have changed due to COVID-19.

EcoMetric developed the participant survey using the same methodology as the impact evaluation, stratifying participants by measure type, facility type, and installed solar PV capacity (See section 2.1.1 Program Database Review and Sampling for details). The evaluation team retained Blackstone Group to field the survey by telephone. Blackstone attempted 28 and achieved 27 completed surveys: 24 respondents installed solar PV (89% of respondents) and three installed geothermal systems (11% of respondents). After numerous attempts, Blackstone was unable to reach either of the two solar water participants.

Figure 9 shows survey respondents by installed technology, which were proportionate to the population of CY2019 GEP participants.

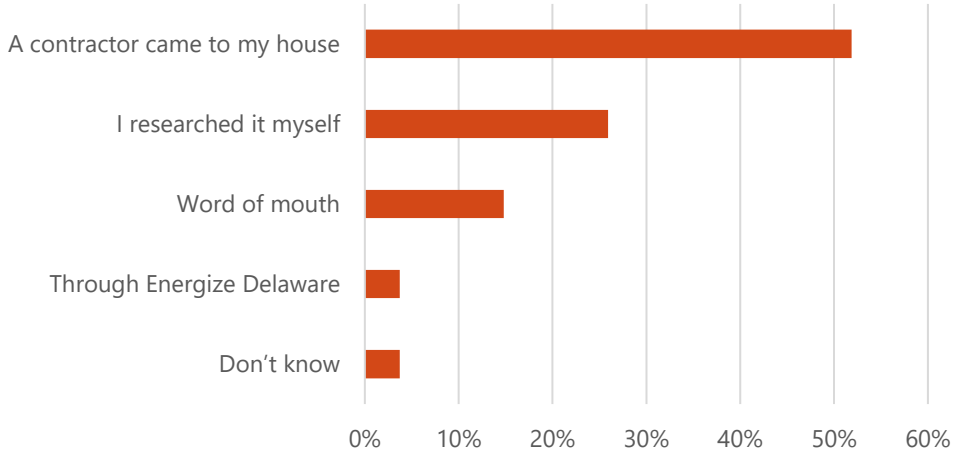
Figure 9: Participant Survey Respondents by Installed Technology (n=27)



3.2.3.1 Awareness of GEP and Other Programs

About half (14 of 27) of respondents said they learned about the program from a contractor coming to their home. About a quarter of respondents found the program through their own research, and others through word of mouth. One participant reported learning of the program through Energize Delaware (Figure 10).

Figure 10: How Participants Learned of GEP (n=27)

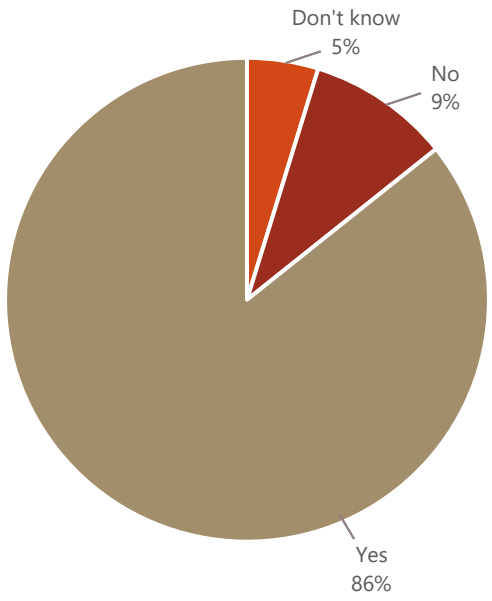


When asked about the benefits of renewable energy, most participants said they understood the benefits and wanted to take advantage of the incentives available to them. "I did it (participated in the program), one to save energy, but the big incentive was the elective to give the 30% tax credit on the cost", said one respondent.

Net Metering

About three-quarters of survey respondents (20 of 27) said their homes were net metered, and of those, 86% (18 of 22) reported the contractor who installed their equipment educated them on how net metering with their utility works (Figure 11).

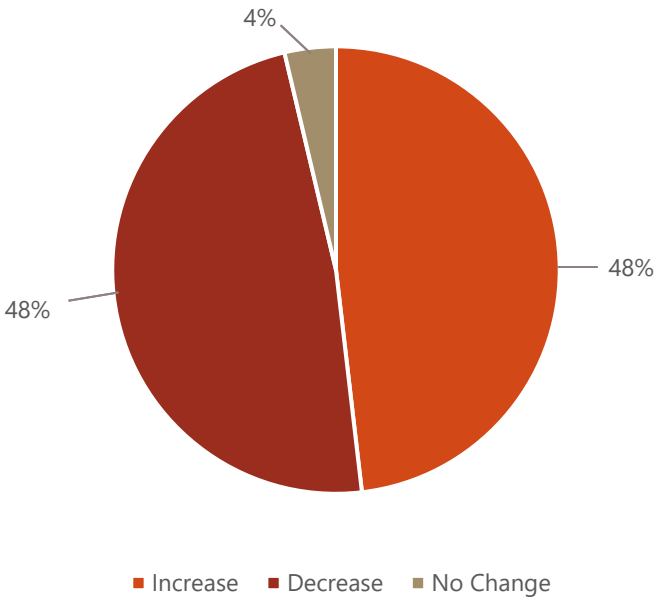
Figure 11: Did the Contractor Educate You About Net Metering with the Utility? (n=22)



3.2.3.2 Effects of COVID-19

The EcoMetric team found that the COVID-19 pandemic has affected home energy consumption for 96% of respondents. Thirteen participants reported an increase in home energy consumption, while exactly the same number (13) reported a decrease in consumption, and one reported no change.

Figure 12: How, if at all, as the COVID-19 pandemic affected your home energy consumption? (n=27)

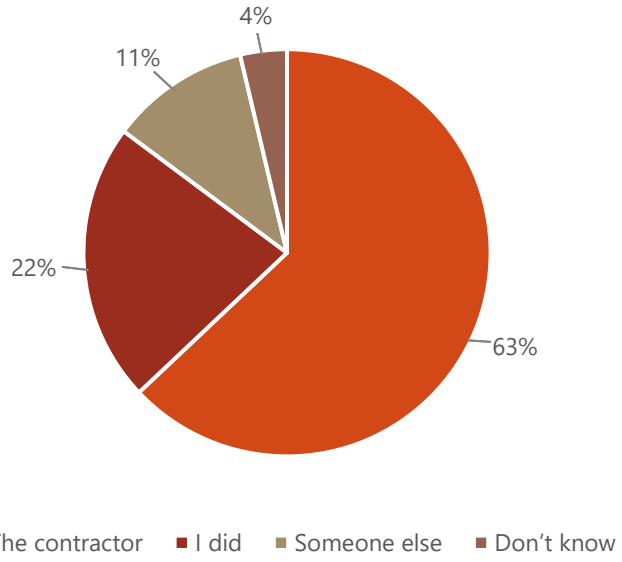


The majority of participants stated that COVID-19 had *not* affected their decision-making around energy efficiency. One respondent said, "It hasn't changed it, we are still trying to be energy conscious regardless of the situation." Only 5 of 27 of respondents said COVID-19 had affected their decision-making, with one saying, "Actually, it has, because if we go to a permanent work from home solution, I've considered selling both of our cars and buying an electric car since I wouldn't have to leave the house really."

3.2.3.3 Program Processes

The EcoMetric team asked participants who submitted the required forms to DNREC to receive the incentive. As Figure 13 shows, nearly two-thirds (63%) of respondents replied that the contractor submitted the forms. Another 6 (of 27) submitted the forms themselves and three reported "someone else" submitted them.

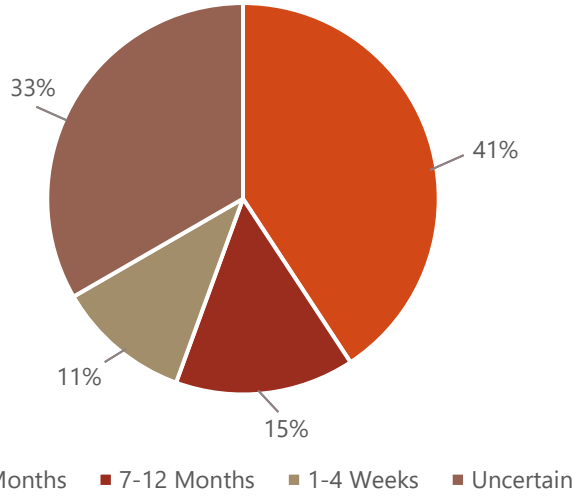
Figure 13: Who Submitted Forms Related to Incentive (n=27)



When asked how long their project approval process took, 59% (16) reported it took more than one month, while 30% (8) reported 2-4 weeks. Three respondents were uncertain how long it took.

The EcoMetric team also asked participants how long it took to receive their project incentive, and 41% said it took between 1-6 months. Smaller percentages of respondents reported both shorter (1-4 weeks) and longer (7-12 months) durations. A third of respondents were uncertain of the length of time and unable to answer.

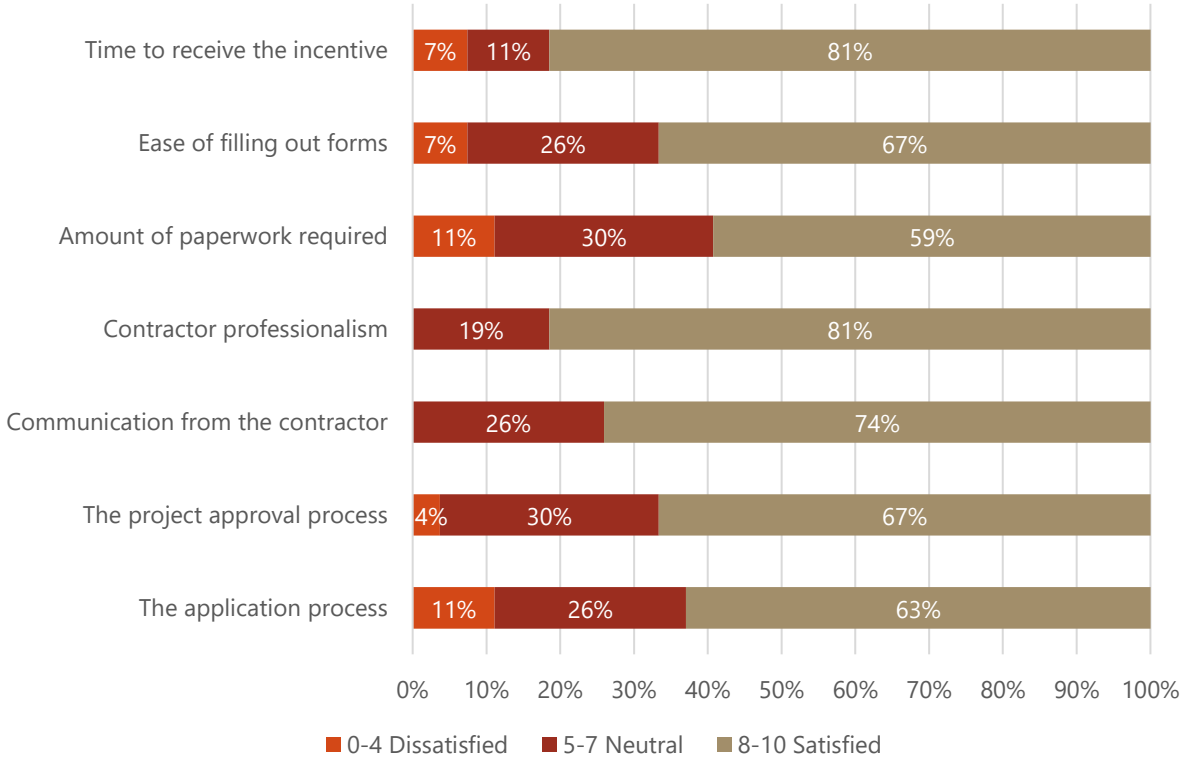
Figure 14: Time to Receive Incentive (n=27)



3.2.3.4 Participant Satisfaction with GEP

EcoMetric asked respondents to rate their satisfaction with different aspects of the program, such as applications, approvals, working with the contractor, and quality of communication on a scale of 0 (very dissatisfied) to 10 (very satisfied). Figure 15 presents the respondents' satisfaction ratings in three numeric groupings that the evaluation team has categorized as follows: 0-4 (dissatisfied); 5-7 (neutral); and 8-10 (satisfied). Across every category, participants were largely satisfied with GEP. Participants reported highest levels of satisfaction with contractor professionalism and the time it took to receive the incentive. Communication from the contractor also received high ratings.

Figure 15: Participant Satisfaction with GEP Program Elements (n=27)



The EcoMetric team found that overall, survey participants were satisfied with the application process, with 63% of survey participants providing a rating of 8 or higher. Respondents who reported not being satisfied said the process was very long and confusing. 67% of respondents were very satisfied with the project approval process. Those who reported not being satisfied with the project approval process said they experienced delays.

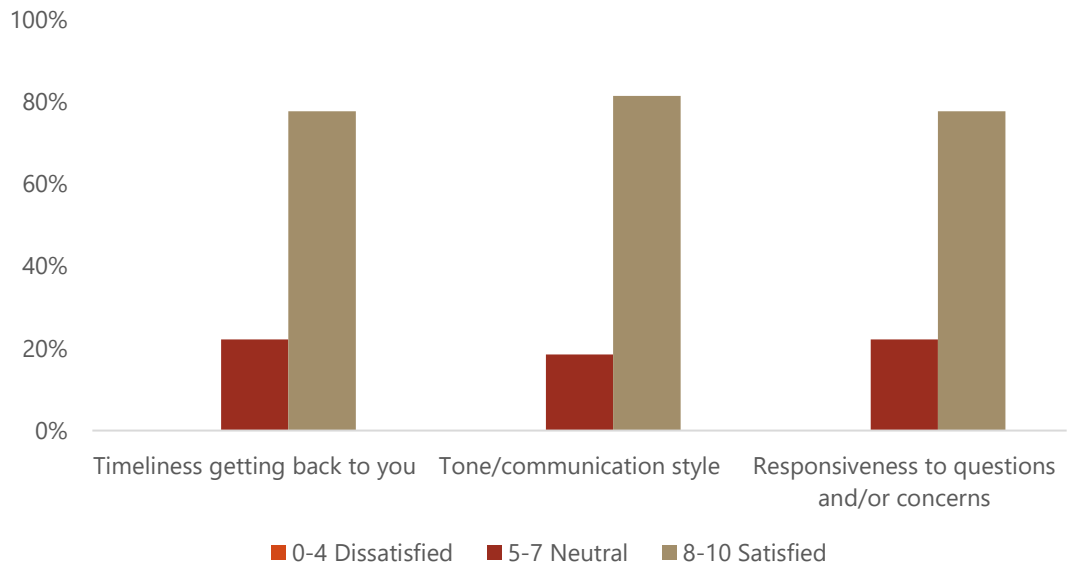
The majority of survey participants were very satisfied with the amount of paperwork required, with 59% providing a rating of 8 or higher. Respondents who reported not being satisfied mentioned the time it took to fill out, and amount of paperwork required. Most (67%) survey participants were

very satisfied with the ease of filling out forms; those who reported not being satisfied with the ease of filling out forms said the process was complicated and technical.

Although the majority of participants reported satisfaction with the program's processes, some survey respondents did report some issues that DNREC may want to monitor and follow up on. For example, a minority of participants found the application process confusing and did not feel that help was readily available. And while satisfaction with the contractors was extremely high for most respondents, one expressed frustration with lack of professionalism from their contractor. Again, these issues did not represent the typical program experience, but should be noted.

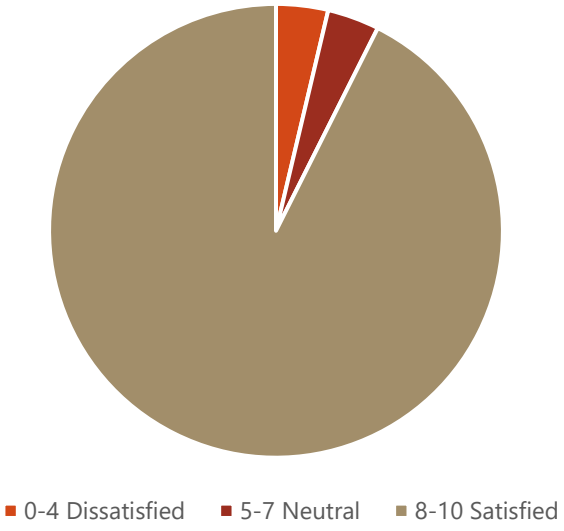
Figure 16 displays participant satisfaction ratings with aspects of working with their installation contractor. Overall, participants were highly satisfied with their contractors.

Figure 16: Participant Satisfaction with Installation Contractor (n=27)



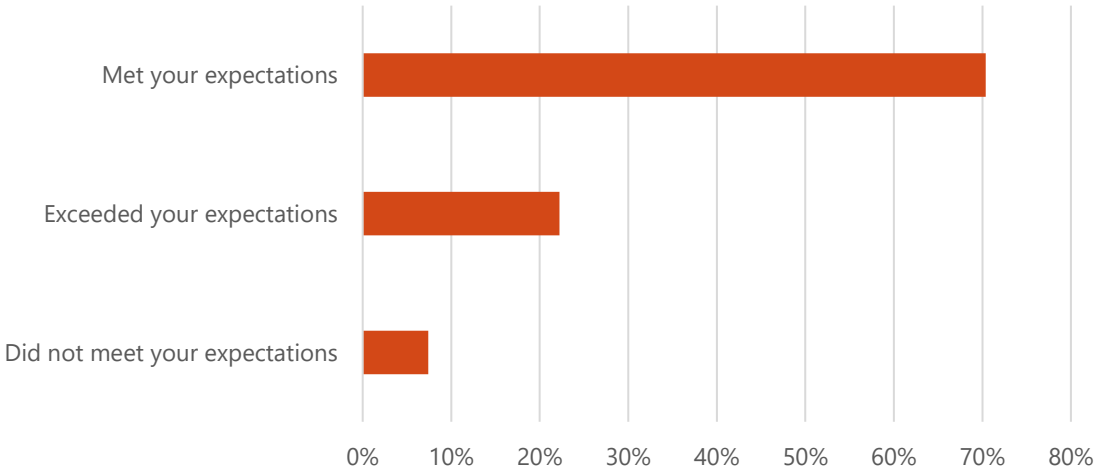
The EcoMetric team asked participants how satisfied they were with the aesthetics of their equipment. Nearly all (93%) rated the aesthetics very highly, between 8-10. The lone respondent who reported being dissatisfied did not provide a reason for that rating.

Figure 17: Satisfaction with aesthetics of the installed equipment (n=27)



Similarly, the majority of survey respondents reported being satisfied with the energy performance of the installed equipment, with 70% of survey participants saying the installed equipment met expectations, and 22% saying their equipment exceeded expectations.

Figure 18: Participant Satisfaction with Energy Performance of Installed Equipment (n=27)



Finally, participants overwhelmingly (26 of 27) reported being willing to recommend GEP to others. One participant said, "Everything went very smooth, the contractor was very professional, courteous and clean."

Another participant said, "I just think it was a great program for the money you're saving and once you own the system if you ever sell your house you're basically selling it with free electric, it's a great program, and other people we've recommended it to have liked it too."

> "I whole-heartedly endorse the program and told others about it, and I tell them to go to the DNREC website and get started." – GEP participant

Process Finding 10: Most program participants reported being highly satisfied with GEP, including its processes, the contractors they worked with, and the equipment itself. Contractor professionalism, time to receive the incentive, and equipment aesthetics received the highest satisfaction ratings.

Process Finding 11: A little more than half of program participants became aware of the program from a contractor coming to their home, and about a quarter found the program through their own research.

Process Recommendation 9: *Given DNREC's stated goal to increase GEP participation in coming years, EcoMetric recommends considering additional, targeted marketing efforts beyond contractor-led outreach. While contractors have been the primary source of raising program awareness, a quarter of participants in 2019 found the program by searching for it themselves. This suggests there might be an opportunity to reach additional participants who a) have not yet been visited by a contractor, and b) are not likely to take the initiative to conduct personal research into renewable energy program offerings.*

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 their homes' safety. 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 completing the work, all homes receive a final inspection conducted by a Building Performance Institute (BPI)-certified quality control inspector. A sample of all serviced homes is also inspected by the State Program Monitor, who serves as the state's weatherization technical expert.

4.1 IMPACT EVALUATION

The EcoMetric team evaluated homes weatherized through WAP during the 2018 calendar year (CY). The evaluation period is different from the other programs due to the billing analysis requiring one year of post weatherization billing data.

4.1.1 PROGRAM DATABASE REVIEW AND SAMPLING

DNREC weatherized a total of 242 homes through WAP during CY2018. As part of the scope of work, EcoMetric also analyzed the usage of a comparison group that comprised of 140 homes of future program participants that have not yet received weatherization services. The comparison group helped the EcoMetric team identify externalities affecting energy use changes among CY2018 WAP participants.

EcoMetric's billing regression included analyzing a census of homes weatherized in CY2018 and participant homes that are enrolled in the program and will receive weatherization services in the future. Monthly pre and post weatherization utility bills were reviewed for as many projects as were made available to EcoMetric, and the estimated per-home savings were applied to all CY2018 participant homes.

4.1.2 GROSS SAVINGS VERIFICATION

4.1.2.1 Data Collection

The EcoMetric team calculated the gross verified savings using data from multiple sources. WAP program staff provided multiple databases that included participant information, utility information, inspection dates, home characteristics, treatment measures, and installation dates for participant homes.

WAP program staff also provided tracking information for the comparison group analysis. This information allowed the EcoMetric team to compare home and fuel type characteristics between program participants and future participants selected for the comparison group. Public data records research from New Castle, Kent, and Sussex counties provided home characteristic information for the comparison group when home audit details were not available.

EcoMetric coordinated with five electric and two natural gas utilities to obtain historical participant billing data. The billing analysis models calculated verified gross savings by leveraging historical billing data in addition to local demographic information and 30-year normalized weather data.

4.1.2.2 Reported Savings

During the previous evaluation, EcoMetric conducted a census billing analysis of all CY2016-2017 participants to verify program level and per-home savings values. The previous evaluation report recommended that WAP use the verified CY2016-2017 per-home savings to estimate future program savings. Accordingly, EcoMetric assumed that the reported savings were the CY2016-2017 per-home evaluation results.

In CY2018, the program reported 2,276 MMBtu in natural gas and other fossil fuel savings, 301 MWh in electric savings, and 0.06 MW in peak demand savings. Table 40 summarizes the non-electric and electric savings for CY2018.

Table 40: WAP Reported Savings Summary

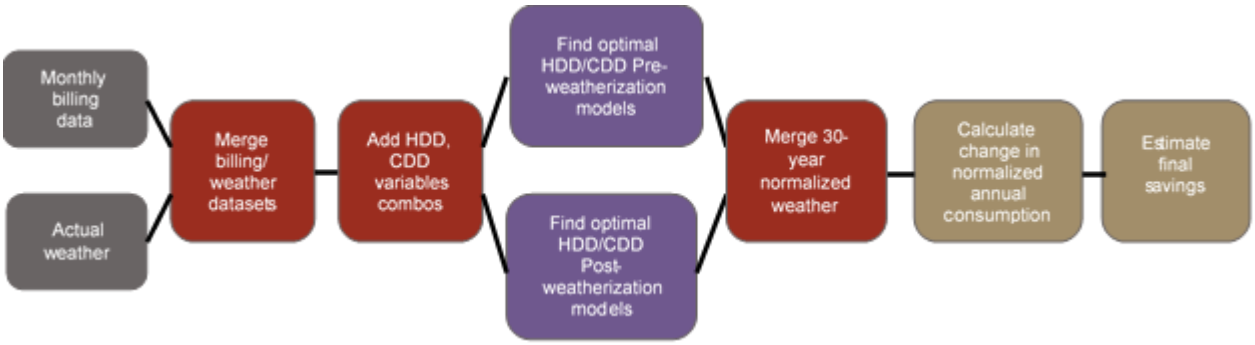
Calendar Year	Projects Completed	Fossil Fuel Savings (MMBtu)	Electric Savings (MWh)	Demand Savings (MW)
2018	242	2,276	301	0.06
Total	242	2,276	301	0.06

4.1.2.3 Data Preparation and Billing Analysis

EcoMetric utilized a two-staged utility billing data analysis (DOE UMP[41]) to calculate savings achieved during CY2018. The billing model calculated whole-home savings based on primary home heating fuel type (electric, natural gas, or other fossil fuel).

Figure 19 summarizes the overall billing analysis process flow.

Figure 19: WAP billing analysis project flow



DNREC staff and utility partners provided comprehensive and complete datasets. EcoMetric applied standard billing data screens to remove abnormal and out of range records where we found the following;

- Zero values for the month,
- Billing month length was less than 19 or greater than 35 days,
- Less than 12 months of available monthly bills, either pre or post measure installation, were available for a specific home.

After cleaning the billing data using the data screens listed above, the final dataset included between 12 and 16 months of pre and post weatherization consumption for each home. The final analysis dataset included 195 homes or 81% of the 242 CY2018 participants. Similarly, the comparison group's final dataset included 103 future WAP program participants with similar heating fuel, home types, and energy usage patterns.

[41] Li, M.; Haeri, H.; Reynolds, A. (2018). The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-70472. http://www.nrel.gov/docs/fy18osti/70472.pdf

EcoMetric used weather data from one of three National Weather Service[42] stations in the Delaware region listed below. The model calculated the distance from each home to each of the weather stations to find the closest weather station from which to reference historical weather data.

- New Castle County Airport,
- Dover AFB,
- Salisbury-Ocn Wico Regional Airport (northern Maryland)

The first stage of the billing analysis calculates the optimal relationship between home energy consumption (utility bills) and local weather data. To account for extreme weather from year-to-year, EcoMetric normalized the predicted home energy consumption with 30-year weather averages. EcoMetric completed this calculation for pre and post weatherization periods.

The second stage of the billing analysis combines first stage weather normalized consumption results with home characteristics such as size, primary heating fuel, and home type to estimate the final per home savings averages.

EcoMetric also analyzed a comparison group to help explain non-weather related trends for current or future participants, such as employment trends, income, or energy prices. The comparison group analysis followed the same two-staged billing analysis described in this subsection.

4.1.2.3.1 Detailed Description of Billing Analysis Calculation

EcoMetric converted daily average temperature data into heating degree (HDD) and cooling degree (CDD) day values. Degree day calculations convert average daily temperature into variables that help identify outdoor air temperatures where a home's cooling or heating systems mostly likely turn on. Monthly billing HDD variables were calculated for every base temperature between 40-70°F and CDD base values between 60-80°F. The following equations show the derivations of HDD and CDD values;

$$HDD = \max(\text{Temp}_{Base} - \text{Temp}_{Avg}, 0) \quad (1)$$

where $\text{Temp}_{\text{Base}}$ varies and Temp_{avg} = the average of the high and low temperature for the day. For example, when calculating HDD at temperature base = 65 °F, if the average daily temperature is 60 °F, HDD = 5 for the day. The formula for CDD is similar, except the average and base temperature

[42] Weather accessed via direct API access to National Oceanic and Atmospheric Administration (NOAA) weather data servers

terms are reversed to capture that cooling is needed when the outdoor temperature exceeds the base temperature.

$$CDD = \max(\text{Temp}_{Avg} - \text{Temp}_{Base}, 0) \quad (2)$$

For example, when calculating CDD at temperature base = 65 °F, if the average daily temperature is 70 °F, CDD = 5 for the day. The HDD and CDD values were estimated for each day in the associated billing period and then summed to a billing period total.

The first stage of modeling required EcoMetric to run participant specific regression models for each possible combination of HDD and CDD base temperatures, retaining only the best performing pair. The team repeated the optimal model selection process for each participant and independently for both pre and post weatherization periods. Following statistical best practices, EcoMetric used model R-square values were used to score, rank, and retain the best model parameter combinations.

Equation (3) shows the electric kWh regression model form used to calculate the best HDD and CDD parameter combination. EcoMetric leveraged the same model form for finding optimal model combinations pre and post weatherization.

$$KWH_i = \beta_0 + \beta_1 HDD_i + \beta_2 CDD_i + \varepsilon_i \quad (3)$$

where;

KWH_i	= Billed kilowatt-hours for month i divided by the number of days in the billing period
HDD_i	= Heating degree days base (40-70 degrees F base) for month i
CDD_i	= Cooling degree day base (60-80 degrees F base) for month i
$\beta_0, \beta_1, \beta_2, \varepsilon$	= Coefficients determined by the regression model and error term (ε)

Equation (4) lists the natural gas (in therms) billing data regression model form used to calculate the best HDD only parameter for each participant. Similar to electric, EcoMetric used the same model form for finding optimal model combinations pre and post weatherization.

$$THERM_i = \beta_0 + \beta_1 HDD_i + \varepsilon_i \quad (4)$$

where;

$THERM_i$ = Billed therm for month i divided by the number of days in the billing period

HDD_i = Cooling degree day base (60-80 degrees F base) for month i

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

EcoMetric used the results from Equations (3) and (4) to estimate each home's pre and post normalized energy consumption. Equations (5) and (6) show how the coefficients from equations (1) and (2) calculate normalized energy consumption (NAC) before and after weatherization.

$$NAC_j = \beta_0\, 365.25 + \beta_{1,j} HDDNorm_j + \beta_{2,j} CDDNorm_j + \varepsilon_j \quad (5)$$

$$NAC_j = \beta_0\, 365.25 + \beta_{1,j} HDDNorm_j + \varepsilon_j \quad (6)$$

where;

NAC_j = Normalized annual consumption for participant j

$HDDNorm_j$ = 30-year average annual heating degrees for participant j at optimal degree day

$CDDNorm_j$ = 30-year average annual cooling degrees for participant j at optimal degree day

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

Equation (7) calculates the change in NAC between the pre and post periods for each participant:

$$\Delta NAC_j = NAC_{pre} - NAC_{post} \quad (7)$$

EcoMetric estimated final per home savings values by including home size, primary fuel type, and housing type in the regression model. Equation (6) displays the final model form.

$$\Delta NAC = \beta_0 + \beta_1 SQFT + \beta_2 Part + \beta_3 Part * ElecSF + \beta_4 Part * ElecMH + \beta_5 Part * OthSF + \beta_6 Part * OthMH + \varepsilon_j \quad (8)$$

where;

ΔNAC = Change in normalized annual consumption for participant

$SQFT$ = Home size in square feet

$Part$	= Indicator for participant status (= yes, 2 = no (comparison group))
$ElecSF$	=Primary heating fuel electric and single family home (1 = yes, 0 = no)
$ElecMH$	=Primary heating fuel electric and manufactured/mobile home (1 = yes, 0 = no)
$OthSF$	=Primary heating fuel other fossil and single family home (1 = yes, 0 = no)
$OthMH$	=Primary heating fuel other fossil and manufactured/mobile home (1 = yes, 0 =
$\beta_0 - \beta_6, \varepsilon$	= Coefficients determined by the regression model and error term (ε)

EcoMetric calculated verified peak demand savings by combining weather dependent summer cooling savings and additional non-weather dependent savings from water heaters, improved ventilation, and efficient lighting. Regional space cooling load shapes[43] identified that 23% of total annual WAP project cooling savings occur between the 1-7 pm weekday hours between June and August. The team calculated average demand savings by taking the resulting annual cooling savings and divided by the typical number of weekday peak hours in the summer (390).

4.1.3 VERIFIED SAVINGS

The 242 homes weatherized through WAP during CY2018 achieved 234 MWh of gross verified first-year electric savings. The verified per-home savings were generally in line with the reported savings for electrically heated homes and single family homes heated with other non-natural gas fossil fuels, such as oil or propane. Verified kWh savings for natural gas and other fossil fuel manufactured homes were less than the reported savings, resulting in an electric realization rate of 78%. Verified savings for homes heated with natural gas were also consistent with the billing

[43] Ontario Independent Electricity System Operator annual cooling load shapes were used to determine percent of cooling load occurring during Jun-Aug on-peak hours (1-7pm)

analysis completed for CY2016-2017 homes during the previous evaluation. Table 41 compares reported and verified per-home energy (kWh) and fossil fuel (MMBtu) savings.

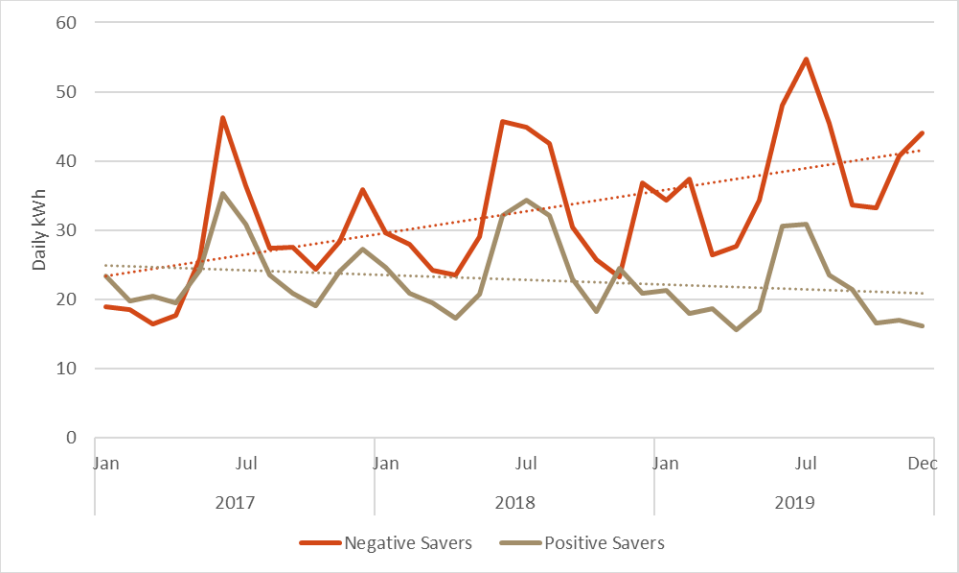
Table 41: WAP Reported and Verified Per-Unit Savings Estimates

Heating Type	Home Type	Reported Per Project Energy Savings (kWh)	Verified Per Project Energy Savings (kWh)	Reported Per Project Energy Savings (MMBtu)	Verified Per Project Energy Savings (MMBtu)
Electric	Single family	2,073	1,986	NA	NA
	Manufactured home	1,023	1,528	NA	NA
Natural Gas	Single family	1,081	314	9.6	10.6
	Manufactured home	851	314	16.2	10.6
Other fuel	Single family	1,197	1,193	10.7	10.6
	Manufactured home	968	377	16.7	10.6
Total		1,244	969	13	11

Forty-two percent (42%) of the CY2018 natural gas heated homes showed negative or near zero verified electric savings. These homes' energy consumption data (utility bills) showed increased air conditioning and space heating during the post weatherization period, resulting in negative or near zero verified savings.

Figure 20 compares average daily energy (kWh) consumption across all billing months extending between 2017 through 2019 for natural gas heated homes to help visualize the impact of increased post weatherization energy consumption. The red and beige lines represent homes with negative and positive savings, respectively. The dashed trend lines represent the average trend for all of the homes in each of the groups. The red dashed line shows a trend of increasing average daily energy consumption (negative savings) throughout the evaluation period. The beige dashed line indicates a gradual decrease in average daily energy consumption (positive savings).

Figure 20: Natural gas heated homes kWh usage across pre and post weatherization period



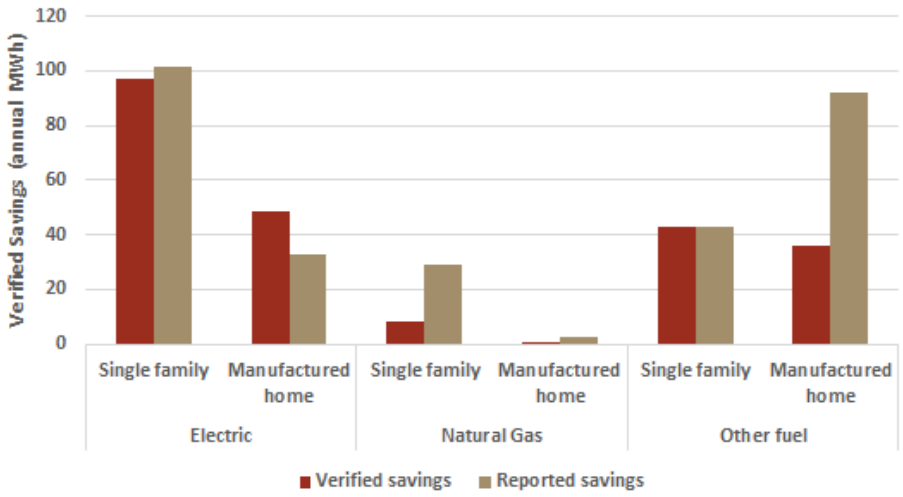
Similarly, 40% of the manufactured homes heated with fossil fuels other than natural gas showed increased summer and winter usage during the evaluation period. EcoMetric believes that supplemental heating fuel use among participants and expanding air conditioning use negatively impacted savings during the post weatherization period.

Finding 18: The per-home energy savings EcoMetric calculated for homes weatherized through the program in CY2018 are less than the per-home savings calculated for weatherized homes in CY2016-2017.

Recommendation 12: *To better understand and explain savings trends and variations for weatherized homes, EcoMetric recommends that the program collect participants supplemental heating fuel availability and usage behaviors during the initial home audit.*

The CY2018 analysis sample size was less than half of the number of participants included in the 2016-2017 analysis, potentially contributing to larger swings in per-home savings between the two separate analyses periods. Finally, only three natural gas heated manufactured homes went through the program in CY2018. To account for the small amount of natural gas heated manufactured homes, EcoMetric combined these homes with the 27 single family natural gas heated for savings analysis. As a result, natural gas heated single family and manufactured per-home CY2018 verified energy (kWh) and natural gas (MMBtu) savings are the same. Figure 21 compares the reported CY2016-2017 and verified CY2018 per-home savings across all primary heating fuel and home types.

Figure 21: Comparison of Reported and Verified Per-Home WAP Savings



The CY2018 billing analysis did not differentiate between weather-related versus non-weather-related gas or electric savings due to the limited number of completed projects. Table 42 summarizes the CY2018 verified electric savings.

Table 42: WAP CY2018 Electric Realized Savings Summary

Heating Type	Home Type	Program Projects	Reported Energy Savings (MWh)	Verified Energy Savings (MWh)	RR for Energy	Reported Peak Demand Reduction	Total Verified Peak Demand Reduction (kW)	RR for Peak Demand
Electric	Single family	49	102	97	96%	0.020	0.018	89%
	Manufactured home	32	33	49	149%	0.002	0.006	359%
Natural Gas	Single family	27	29	8	29%	0.005	0.001	17%
	Manufactured home	3	3	1	37%	0.001	0.000	16%
Other fuel	Single family	36	43	43	100%	0.007	0.004	54%
	Manufactured home	95	92	36	39%	0.021	0.007	33%
Total/Average		242	301	234	78%	0.06	0.04	64%

Average peak demand (kW) reduction per home were 0.15 kW (0.00015 MW) while ranging between 0.03 kW (0.00005 MW) for electrically heated manufactured homes and 0.42 kW (0.00042 MW) for electrically heated single family dwellings.

The billing analysis of gas savings for natural gas heated homes resulted in verified savings of 317 MMBtu. Verified savings were less than reported savings resulting in realization rates of 94% for the combined analysis of single family and manufactured homes. Other fossil fuel heated homes'

realization rates ranged between 63% for manufactured homes and 99% for single family homes. Table 43 summarizes the verified fossil fuel savings.

Table 43: WAP 2018 Fossil Fuel Realized Savings Summary

Heating Type	Home Type	Population	Reported MMBtu Savings	Verified MMBtu Savings	RR for MMBtu Savings
Electric	Single family	49	NA	NA	NA
	Manufactured home	32	NA	NA	NA
Natural Gas	Single family	27	259	285	110%
	Manufactured home	3	49	32	65%
Other fuel	Single family	36	384	380	99%
	Manufactured home	95	1,584	1,004	63%
Total/Average		242	2,276	1,701	79%

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

The EcoMetric team's billing analysis included calculating average per-home verified energy savings, demand savings, and fossil fuel savings for each home type and primary heating fuel type. Table 44 shows the updated per-home savings matrix based on the combined analysis of the CY2016-2017 and CY2018 evaluations of WAP. EcoMetric weighted the savings by number of program years corresponding to each billing analysis.

Finding 19: EcoMetric combined the per-home saving values from the CY2016-2017 analysis and the CY2018 analysis to yield savings values weighted by the number of homes in each analysis.

Recommendation 13: *Use the saving matrix in Table 44 to claim savings for each weatherized home according to the home type and primary heating fuel type.*

Table 44: WAP CY2016 – 2018 Combined and Weighted 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	2,043	0.40	NA
	Manufactured home	1,191	0.09	NA
Natural Gas	Single family	825	0.13	9.9
	Manufactured home	672	0.14	14.3
Other fuel	Single family	1,196	0.17	10.6
	Manufactured home	771	0.17	14.6

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 net-to-gross (NTG) ratios for income-qualified programs.[44] The NTG ratio for all income-qualified programs is 1.0. Table 45 and Table 46 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.

$$Net\ Verified\ Savings = Gross\ Verified\ Savings\ \times NTG\ Ratio$$

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

Table 45: WAP CY2018 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	97	0.02	97	0.02
	Manufactured home	1.0	49	0.01	49	0.01
Natural Gas	Single family	1.0	8	0.00	8	0.00
	Manufactured home	1.0	1	0.00	1	0.00
Other fuel	Single family	1.0	43	0.00	43	0.00
	Manufactured home	1.0	36	0.01	36	0.01
Total			234	0.04	234	0.04

Table 46: WAP CY2018 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	285	285
	Manufactured home	1.0	32	32
Other fuel	Single family	1.0	380	380
	Manufactured home	1.0	1,004	1,004
	Total		1,701	1,701

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 $131,535. Table 47 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 47: WAP Green House Gas Emissions Reductions

Heating Type	Home Type	Net Verified Electric Savings (MWh)	Lifetime Electric Savings (MWh)	Net Verified Gas Savings (MMBtu)	Lifetime Gas Savings (MMBtu)	Lifetime GHG Reduction (lbs)	Lifetime NPV Savings ($)
Electric	Single family	97	1,555	NA	NA	1,066,137	$27,437
	Manufactured home	49	781	NA	NA	2,121,852	$54,606
Natural Gas	Single family	8	135	32	507	20,540	$529
	Manufactured home	1	15	285	4,559	184,856	$4,757
Other fuel	Single family	43	686	NA	NA	936,446	$24,099
	Manufactured home	36	572	NA	NA	780,917	$20,097
Total		234	3,746	317	5,065	5,110,748	$131,525

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

4.1.6 NON-ENERGY BENEFITS (NEB)

In the CY2016-2018 evaluation, the EcoMetric team monetized three participant NEBs: thermal comfort, noise, and health, and recommended DNREC adopt NEB values of $155 for thermal comfort, $43 for noise, and $38 for health (a total of $236). These values represented conservative estimates, as they were the lower bound of the 90% confidence interval for the average value of each NEB based on primary research conducted with Delaware WAP participants[45]. The team recommended DNREC adopt the lower-bound estimates because the CY2016-2018 evaluation was the first time NEBs were monetized in Delaware and because the average values appeared high compared to results observed in other jurisdictions.[46] The team also recommended DNREC conduct a follow-up NEBs study with more surveys to reduce uncertainty in the initial NEBs values and further investigate the reasons for higher benefits observed by Delaware's WAP participants compared to other jurisdictions.

In fulfillment of this recommendation, the EcoMetric team conducted in-depth interviews with 13 2016-2018 participants, and a supplemental telephone survey with 88 additional CY2019 WAP

[45] The 90% confidence interval defines the range of values within which it is 90% certain the actual average value of a particular statistic for the whole population is included.
[46] EcoMetric. "Program Years 2016-2018 Evaluation Report." Prepared for Delaware Department of Natural Resources and Environmental Control. February 13, 2020.

participants to (1) increase the precision of the CY2016-2018 NEB estimates and (2) provide additional evidence of the NEBs. Respondents verified which measures WAP had been installed in the home and compared current home conditions to those before the energy efficiency upgrades, focusing on again on thermal comfort, noise, and health.

4.1.6.1 Calculating CY2016-2019 NEB Values

To ensure consistency of results, the EcoMetric team fielded NEBs questions to CY2019 participants with the same wording and the same order, as in the original CY2016-2018 survey. This report combined the responses to the NEBs questions for respondents to both the original CY2016-2018 survey and the supplemental CY2019 survey.

To calculate the NEB estimate, the EcoMetric team first asked WAP participants if they had experienced positive, negative, or no changes to thermal comfort, noise, or health since their participation in WAP.

Most respondents (83%) observed improvements in their thermal comfort following participation, while smaller shares observed improvements in noise (47%) and household health (37%) (Table 48). A small percentage of respondents (3%) observed a negative change to household health, and even fewer (1%) observed a negative change in their thermal comfort and the noise they hear from outside the home or from appliances/equipment inside the home.

Table 48: WAP Participant Observations of Non-Energy Impacts, CY2016-2019

CY2016-2019 (n = 150)			
Type of Impact	Thermal Comfort	Noise	Health
Positive	83%	47%	37%
Negative	1%	1%	3%
No Impact	15%	51%	57%
Don't Know	1%	1%	3%

Next, interviewers presented respondents who had experienced positive or negative impacts with an estimate of the annual savings their household could expect from the measures they installed. Interviewers asked how much, in terms of dollars, the change added or took away from the value of living in their home each year, relative to their expected energy bill savings[47]. Their average

[47] 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.

estimates, shown in the first set of rows of Table 49 (*Responses, Including Outliers)*, are the *initial* NEB values.

Following best practices established by a 2011 evaluation for Massachusetts[48], the team then scaled the values to adjust for potential overlap and double counting among the NEBs and removed outliers that fell beyond three standard deviations of the mean. To scale the values, interviewers asked respondents who reported more than one NEB to think of all the impacts – comfort, noise, and health - *combined* to estimate the *total* value relative to bill savings. Analysts then changed the individual NEBs values proportionally to sum to each respondent's *total* NEBs estimate (i.e., the normalized estimate). The second set of rows in Table 49 *(Scaled, Outliers Removed)* show the average of each normalized NEB value.

Next, the team applied the realization rate from the billing analysis to the NEBs values[49]. The third set of rows in Table 49 *(Adjusted Estimates, Post Billing Analysis)* show the adjusted NEBs point estimates: $154 for thermal comfort, $54 for noise, and $56 for health.

Table 49: WAP Non-Energy Benefits – Preliminary and Final Average Values CY2016-2019

Value		Thermal Comfort (n=142)	Noise (n=141)	Health (n=141)
Responses, Including Outliers	Dollar (per household)	$400	$119	$217
	% of bill savings	88%	26%	48%
Scaled, Outliers Removed	Dollar (per household)	$218	$77	$79
	% of bill savings	48%	17%	17%
Adjusted Estimates, Post Billing Analysis	Dollar (per household)	$154	$54	$56
	% of bill savings	46%	16%	17%

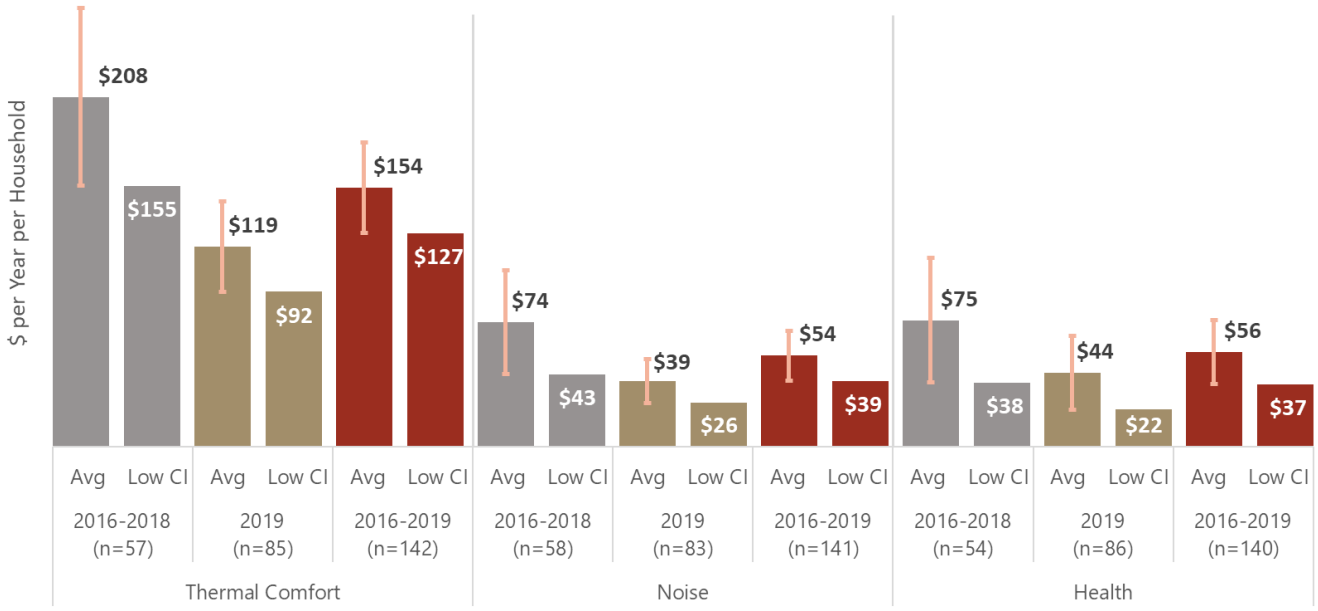
Note: Sample sizes exclude respondents unable to estimate values. Scaled values exclude outliers more than three standard deviations from the mean.

Figure 22 shows each NEB estimate with the 90% confidence interval for the average value point estimates for CY2016-2018, CY2019, and all the program years combined (CY2016-2019). In the CY2016-2018 evaluation[50], the EcoMetric team recommended that DNREC adopt the confidence

[48] Three[3] and NMR. "Massachusetts Special and Cross-Cutting Research Area: Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts (NEIs) Study." Prepared for Massachusetts Program Administrators. August 15, 2011.
[49] The realization rate for CY2019 was 64%; the realization rate for CY2016-2018 was 91%.
[50] EcoMetric. "Program Years 2016-2018 Evaluation Report." Prepared for Delaware Department of Natural Resources and Environmental Control. February 13, 2020. www.dnrec.delaware.gov/energy/information/otherinfo/Documents/EEAC/2016-2018-DNREC-Evaluation-Report.pdf

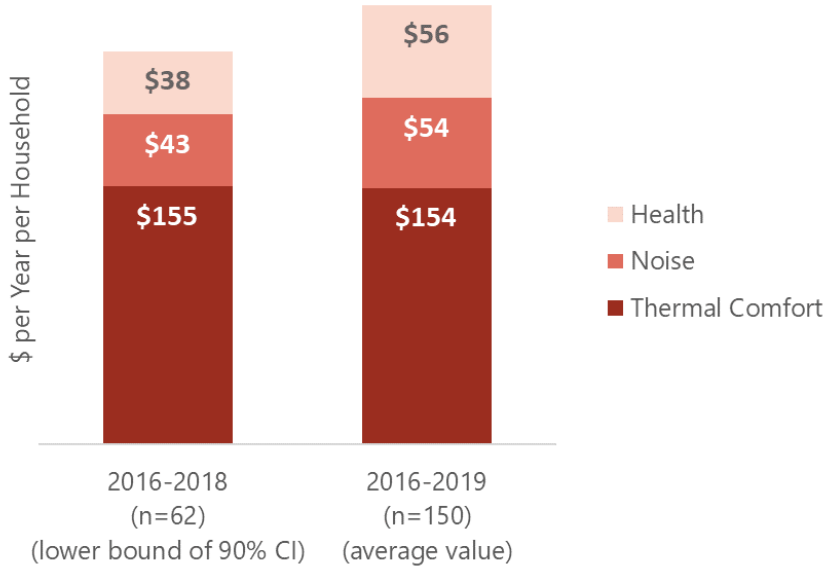
interval's lower bound because the point estimates of the average values appeared high compared to results observed in other jurisdictions. As the figure indicates, when the additional 88 CY2019 WAP clients are added to the CY2016-2018 data, the precision of the NEB point estimates increases as indicated by the size of the confidence intervals (the pink bars) decreasing. The point estimates of the combined CY2016-2019 results align well with the conservative values recommended in the CY2016-2018 evaluation (i.e., the lower bound of the confidence interval of the CY2016-2018 estimates).

Figure 22: Weatherization Assistance Program Non-Energy Benefits – Confidence Intervals



Due to the increased precision and the parity with the previous estimates, the EcoMetric team recommends that DNREC adopt the CY2016-2019 point estimate (average value) of each NEB. These values are **$154 for thermal comfort, $54 for noise, and $56 for health,** as shown in Figure 23**.** The total NEBs value of **$264 per household per year** represents an increase of $28 from the value recommended in the previous evaluation.

Figure 23: WAP Non-Energy Benefits Values – CY2016-2018 versus CY2016-2019



Finding 20: The EcoMetric team found the overall NEBs value to be $264 per household per year for the CY2016-2019 period ($154 for thermal comfort, $54 for noise, and $56 for health). These point estimates align well with the conservative values recommended in the CY2016-2018 evaluation (i.e., the lower bound of the confidence interval of the CY2016-2018 estimates).

Recommendation 14: *Adopt the following NEB values: $154 for thermal comfort, $54 for noise, and $56 for health.*

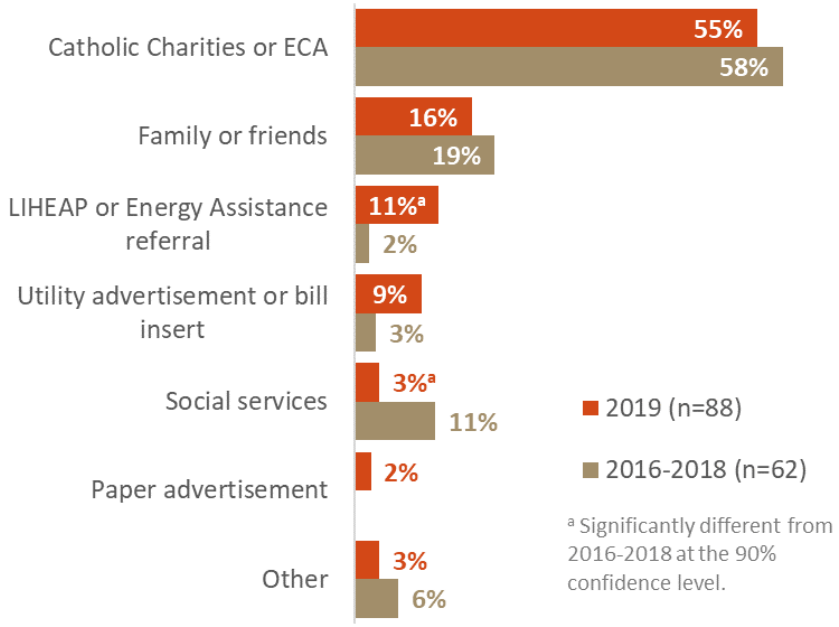
4.1.6.2 Supplemental WAP participant Survey Results

The following section details the findings of the 2019 supplemental phone survey the EcoMetric team conducted with 88 WAP participants. In addition to asking participants to quantify the non-energy benefits derived from the weatherization services they received through the program, the team asked questions about specific health impacts, indoor air temperatures, and missed days from work to provide further support for the estimates. The first set of questions, about program awareness and drivers of participation, was asked in both the original CY2016-2018 survey and the supplemental CY2019 survey; the remaining questions were asked only in CY2019 and supplement the NEB estimates.

4.1.6.2.1 *Program Awareness and Drivers of Participation*

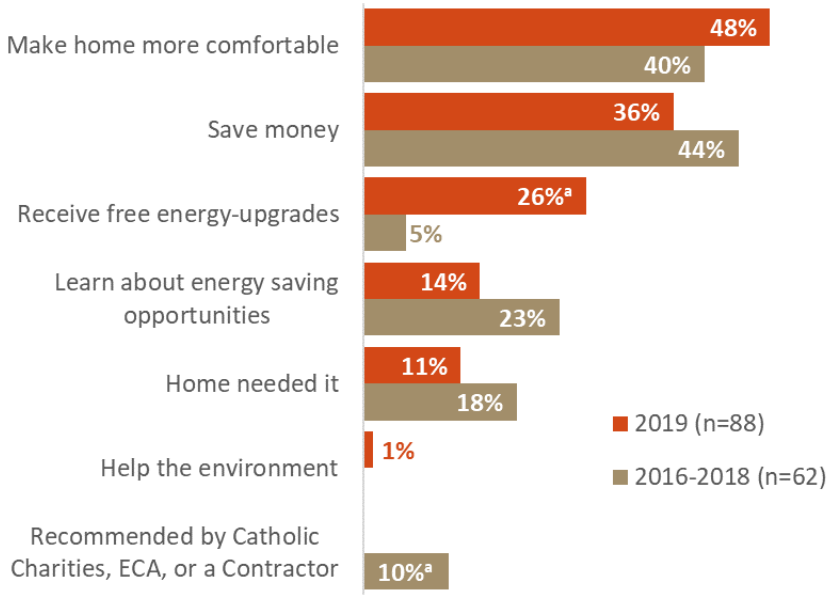
When asked how they had first heard about WAP, over one-half of respondents (55%) reported having heard about WAP through Catholic Charities or the Energy Coordinating Agency (ECA), the program's subgrantees that are responsible for administering WAP and delivering WAP services to eligible customers. This finding is similar to CY2016-2018 (Figure 24).

Figure 24: Means of First Hearing about WAP



As in the previous evaluation, the EcoMetric team asked respondents why they had decided to have a home energy audit. In CY2019, the main reasons respondents decided to have a home energy audit were to make their homes more comfortable (48%) and save money (36%). These findings were similar to those from the previous evaluation. However, more than one-quarter of CY2019 participants (26%) cited the free energy-upgrades as one of the main reasons they received the audit, a statistically significant increase over the percentage (5%) that said the same in last year's survey (Figure 25).

Figure 25: Motivation for Receiving the Home Energy Audit



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

4.1.6.2.2 Comfort and Health Impacts

Weatherization measures, such as air sealing and insulation, can directly change homes' physical condition, resulting in improvements in resident health and safety, reductions in energy and other costs, and a more resilient home during extreme weather events.[51] Weatherization improves

[51] U.S. Department of Energy. "Home Rx: The Health Benefits of Home Performance." December 2016. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Home%20Rx%20The%20Health%20Benefits%20of%20Home%20Performance%20-%20A%20Review%20of%20the%20Current%20Evidence.pdf

thermal performance and decreases drafts, which can reduce risks of indoor thermal stress.[52,53,54] For example, weatherization can reduce exposure to known asthma triggers, such as mold, dust, and extreme temperatures, thereby reducing the incidence of acute asthma symptoms. By improving comfort and generally improving living conditions, household members of weatherized homes have been found to get more sleep (e.g., temperatures are more comfortable in the winter and summer, the infiltration of outdoor noise is reduced). In addition to getting more sleep, there is the possibility of weatherization measures contributing to general health improvements and work productivity[55]. As a result, energy efficiency improvements can lead to cost savings beyond energy bill savings, such as reducing medical costs and the cost of missing days of work due to illness.

[52] Scott Pigg, Dan Cautley, Paul Francisco, Beth A. Hawkins, and Terry M. Brennan. Weatherization and Indoor Air Quality: Measured Impacts in Single Family Homes Under the Weatherization Assistance Program. No. ORNL/TM-2014/170. Oak Ridge National Lab (ORNL), Oak Ridge, TN (United States), 2014. https://weatherization.ornl.gov/wp-content/uploads/pdf/WAPRetroEvalFinalReports/ORNL_TM-2014_170.pdf

[53] Bruce E. Tonn, B., Beth Hawkins, B., Erin Rose, E., and Michaela Marincic, M. 2017. "Energy and Non-Energy Impacts of Weatherizing Low-Income Multifamily Buildings: Summary of Results from the Evaluations of the U.S. Department of Energy's Weatherization Assistance Program". Three3, Inc., Knoxville, TN, September 2017.

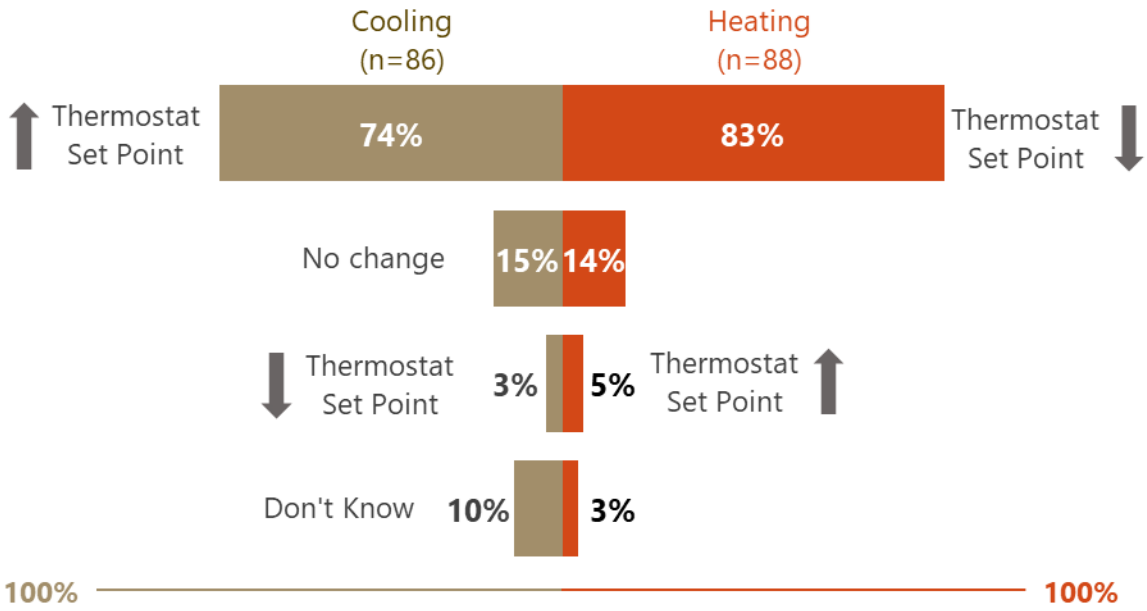
[54] E4TheFuture. "Occupant Health Benefits of Residential Energy Efficiency." November 2016. https://e4thefuture.org/wp-content/uploads/2016/11/Occupant-Health-Benefits-Residential-EE.pdf

[55] Three[3] and NMR. "Massachusetts Special and Cross-Cutting Research Area: Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts (NEIs) Study." Prepared for Massachusetts Program Administrators. August 5, 2016. http://ma-eeac.org/wordpress/wp-content/uploads/Low-Income-Single-Family-Health-and-Safety-Related-NonEnergy-Impacts-Study.pdf

4.1.6.2.3 *Thermal Comfort*

The EcoMetric team asked participants several questions about perceived thermal comfort to provide context and support for measuring this critical NEB. The EcoMetric team first asked participants if they could turn the temperature setting up during the summer and down during the winter and still be comfortable. Almost three-quarters (74%) of respondents with air conditioning said that since receiving the energy-efficient upgrades, they could raise their thermostat temperature setting during the summer and still be comfortable. More than four out of five (83%) respondents said that, since receiving the upgrades, they had been able to turn down the temperature setting on their thermostat during the winter and still be comfortable. These results support the thermal comfort NEB findings and suggest that improved comfort may have resulted in energy-saving thermostat-setting behavioral changes among a sizable majority of the clients.[56]

Figure 26: Weatherization Assistance Program Participant Thermostat-Setting CY2019



*One respondent did not have air conditioning and one respondent was not able to confirm whether they had air conditioning.

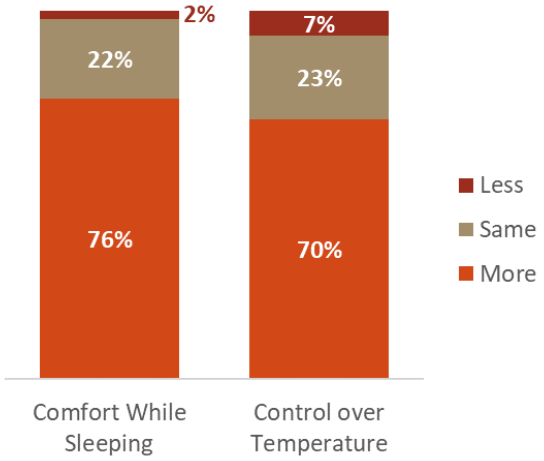
EcoMetric also asked participants to compare the comfort level for sleeping in the home as well as the control they had over the temperature in the home before and after the energy efficiency improvements had been made. Most respondents (76%) felt the home was more comfortable for sleeping compared to before the energy efficiency improvements; more than one-fifth (22%) felt

[56] Because of the way the questions were worded, is not possible to use them to assess the rate at which clients changed their thermostat setting post-weatherization.

the same level of comfort. Similarly, most respondents (70%) felt they had more control over the temperature in their homes compared to before (Figure 27).

Six respondents (7%) noted they felt they had less control over the temperature in their home. However, five of these six indicated that the number of days the temperature in their home had felt unsafe or unhealthy had stayed the same or decreased, and the need to seek medical care due to the home being too cold or too hot/humid had stayed the same. One participant who felt they had less control over the temperature noted someone in the household had needed to seek medical care due to the temperature in the home being too hot/humid and that this was an increase since before the improvements had been made (Figure 27).

Figure 27: Change in Comfort While Sleeping and Level of Temperature Control (n=88)



4.1.6.2.4 Thermal Stress

Thermal stress caused by extreme indoor thermal conditions (i.e., temperature, humidity, drafts) can have significant adverse effects on health and mortality, particularly for the following populations:[57]

- Elderly persons, pregnant women, and toddlers/infants
- Individuals with chronic medical conditions, mental disorders, or mobility impairments
- Any individual with inadequate food, clothing, or heating/cooling systems.

Weatherization can decrease an individual's chance of being subjected to dangerous temperatures by addressing inadequate insulation and heating systems and reducing excessive drafts in the home through air sealing. Reduction in unsafe indoor temperatures through weatherization can

[57] Ibid.

shift hospitalizations and other critical care cases to less urgent cases. A reduction in hospital cases results in a reduction in risk of mortality.[58]

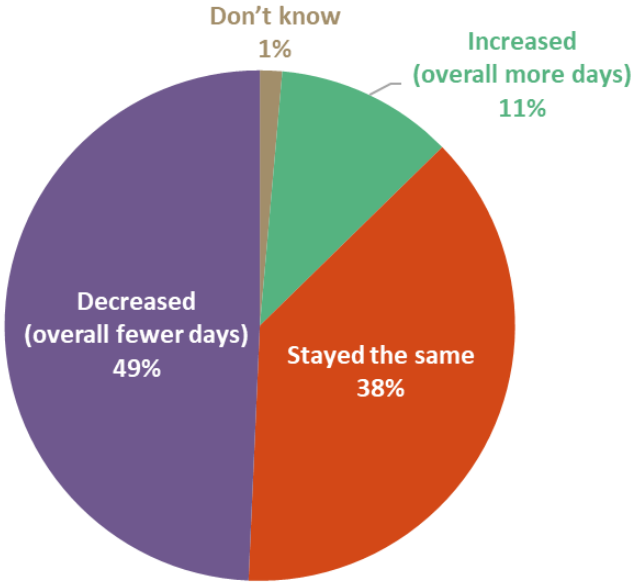
The team asked participants if the number of days the home temperature had felt unsafe or unhealthy had changed since weatherization. EcoMetric found a reduction in the prevalence of unsafe or unhealthy temperatures in the home since the weatherization. Of the 71 respondents who said this question was applicable[59], nearly one-half (49%) reported a *decrease* in the number of days their home had felt unsafe or unhealthy due to temperature since before their home was weatherized. (Figure 28)

Eight respondents (11%) indicated an increase in the number of days the temperature felt unsafe or unhealthy. Of note, all eight stated that they had experienced a positive change in their home's comfort and that the temperature was more comfortable for sleeping since the weatherization upgrades. Seven indicated they now have more control over the temperature, and one said their level of control had remained the same. Looking at these responses collectively, the EcoMetric team presumes that these eight respondents misunderstood this question and likely experienced a decrease or no change in the number of days the home's temperature felt unsafe or unhealthy.

[58] NMR Group and Three[3]. "Low-Income Multifamily Health- and Safety-Related NEIs Study (TXC50) Preliminary Findings Report." Prepared for Massachusetts Program Administrators. October 15, 2018. http://ma-eeac.org/wordpress/wp-content/uploads/TXC50-Low-Income-Multfamily-Health-and-Safety-NEI-Preliminary-Findings-Report_15OCT2018.pdf

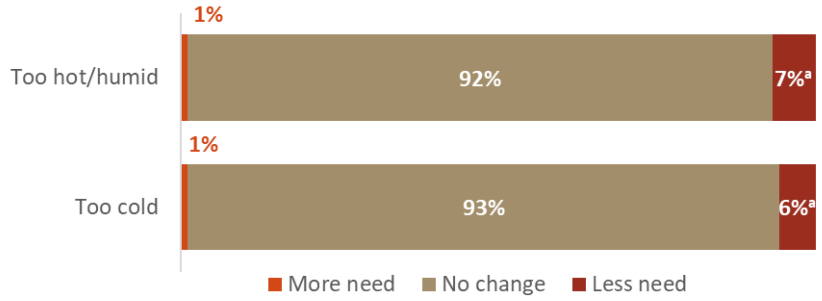
[59] Nearly 20% of respondents felt that this question was not applicable; i.e. their home had not felt unsafe or unhealthy at any time.

Figure 28: Change in Number of Days Temperature in Home Unsafe or Unhealthy (n = 71)



Also, the EcoMetric team found reductions in households seeking medical care because of unsafe or unhealthy temperatures in the home. When asked if anyone in the home had needed to seek medical care due to the temperature being too cold in the winter or too hot/humid in the summer, 6% of respondents reported reductions in seeking medical care from the home being too cold and 7% from the home being too hot/humid. Only 1% of respondents reported that a household member had needed to seek medical care because of the home temperature since participating in WAP. While these percentages may seem small, they are statistically significant at the 90% confidence level, providing evidence that weatherization contributes to reductions in the percent of households seeking medical care due to unsafe home temperatures.

Figure 29: Change in Household Need to Seek Medical Care Due to Home Temperature



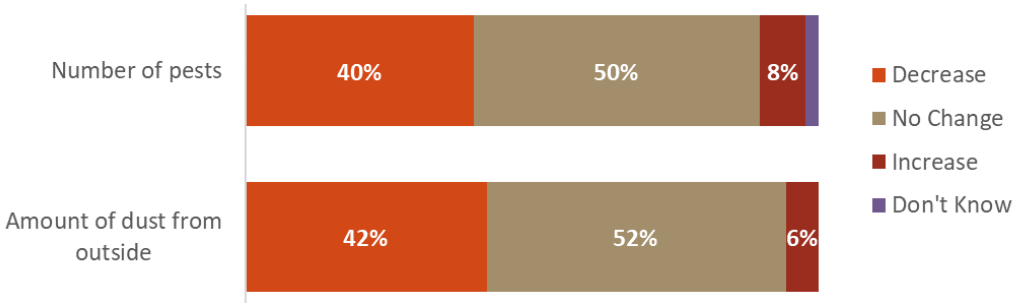
[a] Significantly different from zero at the 90% confidence level.

4.1.6.2.5 *Asthma, Allergies and Other Ailments*

The team also asked about other health conditions that weatherization may impact. EcoMetric asked respondents if, since the energy efficiency improvements had been made, they had noticed a change in two common asthma triggers: the amount of dust in the home and the number of pests/insects in the home. Approximately two-fifths of respondents noticed a decrease in the amount of dust in the home (40%) and the number of pests/insects in the home (42%).

Five (6%) respondents noted an increase in the amount of dust from outside since prior to participating in WAP; the survey did not allow for these respondents to explain their responses further, though one of the five also reported the respiratory health of someone in their household had gotten worse compared to before the improvements had been made. (Figure 30).

Figure 30: Changes in Environmental Conditions (n=88)



In addition to reducing known asthma triggers, the EcoMetric team found some evidence of reductions in households seeking medical care due to specific health conditions after energy efficiency improvements were made and when the stay-at-home order for Delaware residents was announced in March 2020. The team asked respondents to compare the need to seek medical care due to Asthma, COPD, Emphysema, or other health conditions since the weatherization.

Table 50 shows that most respondents reported they had not needed to seek medical care during this time and that this was similar to before participating in WAP. Notably, two participants who had *not* needed to seek medical care during this time reported that this represented a comparative decrease in their need to seek medical care since before weatherization.

Most respondents (92%) did not need to seek medical care after the energy efficiency improvements were made. Among the few respondents who had sought medical care during this time, most said their need to do so had not changed (75%). One respondent reported that their need to seek medical care for asthma had decreased compared to before weatherization. Two respondents indicated an increased need to seek medical care for asthma conditions, though the reason for this increase is unknown.

Table 50: Change in Household Need to Seek Medical Care

Needed to Seek Medical Care	Health Condition	n	Decreased (overall less need to seek medical care)	Stayed the same	Increased (overall more need to seek medical care)	Don't know
Yes (counts)	Asthma	5	1	2	2	0
	COPD	4	0	4	0	0
	Emphysema	1	0	1	0	0
	Other Health Conditions*	6	0	5	0	1
No (%)	Asthma	83	1%	99%	0%	0%
	COPD	84	0%	99%	0%	1%
	Emphysema	87	0%	100%	0%	0%
	Other Health Conditions*	82	1%	99%	0%	0%

*Other health conditions included: allergies, autoimmune disorders, GI bleed, high blood pressure, diabetes, and pneumonia

The EcoMetric team also asked if anyone had experienced a change to their allergies or respiratory health since energy efficiency improvements had been made. Thirteen respondents (15%) reported someone in the household had experienced a change to allergies, with 10 of 13 reporting the condition had improved. Fourteen respondents (16%) reported a change to respiratory health, with 9 of 14 citing improvement.

Table 51: Changes in Health Conditions

Change	Allergies	Respiratory Health
n	*13*	*14*
Improved	10	9
Stayed the Same	0	2
Gotten Worse	3	3

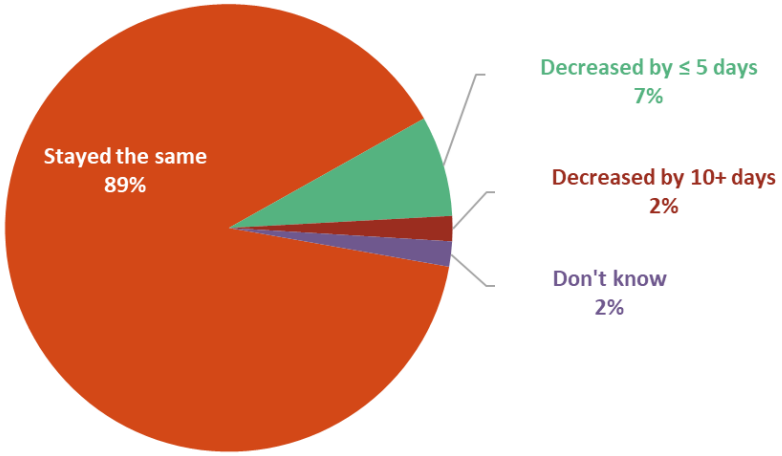
4.1.6.2.6 Missed Days from Work

Other research on weatherization has found that improvements in the health of employed and school-aged household members can reduce missed days of work and school, which directly and positively impact household budgets.[60] To assess whether the weatherization WAP participants received had any effect on days missed from work, the team asked respondents to only focus on days missed after the energy efficiency improvements were made and before the stay-at-home order for Delaware residents was announced in March. Nearly two out of every five (38%) respondents reported they had not been working during that time period.

Of those (n=55) who had been working, five (9%) indicated a *decrease* in the number of days of work missed because of illness during this timeframe, with four (7%) reporting a decrease of 5 days or fewer , and one (2%) reporting a decrease of 10 or more days. This difference is statistically significantly at the 90% confidence interval, indicating that weatherization had an impact on missed days of work and school among these participants. (Figure 31).

[60] Three[3] and NMR. "Massachusetts Special and Cross-Cutting Research Area: Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts (NEIs) Study." Prepared for Massachusetts Program Administrators. August 5, 2016. http://ma-eeac.org/wordpress/wp-content/uploads/Low-Income-Single-Family-Health-and-Safety-Related-NonEnergy-Impacts-Study.pdf

Figure 31: Change in Days of Work Missed (n=55)



The team estimated a conservative monetary value for the five participants who indicated a decrease in the number of missed days of work because of illness. By applying the Delaware hourly minimum wage and the percentage of low-income workers without sick leave (51%) to the estimated number of fewer days, the team found that respondents saved an average of $166 per year by not missing work (Table 52).[61]

Table 52: Estimated Avoided Lost Wages Due to Reduction in Missed Days of Work (n=5)

Respondent	Fewer Missed Days of Work	Avoided Lost Wages*
1	1	$ 37.74
2	2	$ 75.48
3	4	$ 150.96
4	5	$ 188.70
5	10+	$ 377.40
Average	4	$ 166.06

* Assumptions: $9.25/hour (Delaware minimum wage) and 51%

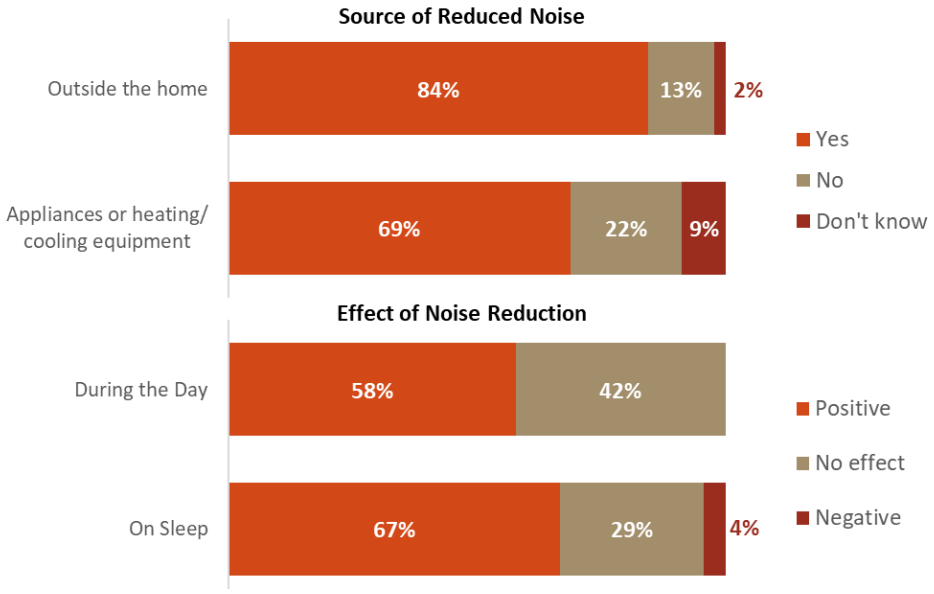
4.1.6.2.7 Noise Impacts

The survey also asked about any changes in the noise level in the home since participating in WAP. The majority of respondents reported that since the energy efficiency improvements, they had noticed a positive change in the noise they hear from outside the home (84%) or from appliances, heating, or cooling equipment inside the home (69%). Two-thirds (67%) of these respondents felt

[61] Percentage of workers in the lowest 25th percentile for average wage earnings provided by the U.S Bureau of Labor Statistics, https://www.bls.gov/news.release/ebs2.t06.htm#ncs_nb_table6.f.2

that the reduction in noise has had a positive effect on their sleep at night and nearly three out of five (58%) felt it had also had a positive effect on them during the day. (Figure 32)

Figure 32: Source and Effect of Noise Reduction (n=45)



4.1.6.3 Follow-up Participant Interview Results

The EcoMetric team conducted in-depth telephone interviews (IDIs) with 13 respondents from the first participant survey (conducted in 2018) to better understand the nature of the NEBs. The sample for this part of the evaluation was restricted to respondents who had reported NEB(s) values greater than the average value in the original CY2016-2018 analysis. The findings from these interviews (1) informed the design of questions for the supplemental CY2019 phone survey and (2) provided further support and anecdotal evidence for the final quantified NEBs values.

The team asked follow-up questions regarding the specific NEB(s) for which the participant had reported a greater-than-average value: thermal comfort, noise, and/or health. The team also asked the participant a few questions about any changes they had noticed in their energy bills since the

WAP energy efficiency upgrades had been installed. Table 53 shows the measures these participants received through WAP.

Table 53: Weatherization Measures Installed

Measures	Count (n=13)
Insulation (wall, ceiling, etc.)	13
Ventilation Measures	13
Water Heater Pipe or Tank Insulation	13
Air Sealing	12
Duct Insulation or Sealing	12
Light Bulbs	10
Programmable Thermostat	6
Heating System Maintenance	5
Water Saving Equipment	2

The team conducted the IDIs in May 2020, during the COVID-19 pandemic. Since day-to-day life changed drastically in March 2020, EcoMetric asked interviewees to respond to these questions thinking about impacts experienced through February 2020, prior to the Delaware stay-at-home order.

4.1.6.3.1 Comfort

The team interviewed nine respondents who noted in the original CY2016-2018 WAP survey that their home's draftiness or comfort improved after receiving the energy efficiency upgrades.

When asked how comfort had changed during the winter months specifically, participants mentioned improved heat retention, increased or improved ability to use one or more rooms, and that their home now heats up faster.

Table 54: How Comfort has Improved - Winter Months

Responses *(multiple response)*	Count (n=9)
Improved heat retention	8
Increased or improved ability to use one or more rooms	5
Home heats up faster	5
Greater control over temperature	4
Reduced drafts	3
Temperature is better for sleeping	3

Respondents noted the following:

- *"If you want to keep the house closed up and put on the A/C or heat, the heat stays in the house better."*
- *"I'm using my computer room now. I always kept that door shut because it was always cold in there. Now I open it up and I go in. In fact, I leave it open all the time. I used it before, but very little."*
- *"The attic door hatch is in my son's room, too. They put weatherstripping around that and it made all the difference in the world for keeping the draft out. We don't have a very old house either; they just did a tremendous job."*

Participants mentioned the same improvements to comfort when asked how comfort had changed during the summer months: improved cold retention, increased or improved ability to use one or more rooms, and that their home now cools down faster.

Table 55: How Comfort has Improved - Summer Months

Responses *(multiple response)*	Count (n=8)
Improved cold retention	4
Increased or improved ability to use one or more rooms	4
Home cools down faster	2
Reduced humidity	1
Improved air quality	1
No change	1

Respondents observed the following:

- *"I don't have my air on right now and it's 90 degrees and it is cool in here. That says something. It stays a little cooler in the summer."*
- *"I use my bedroom a lot more because that's the coolest room in the house now."*

4.1.6.3.2 Noise

The team interviewed eight respondents who noted in the original CY2016-2018 WAP survey that there was less noise in their home after receiving the energy efficiency upgrades. When asked the ways in which their home is quieter, respondents mentioned reduced noise from outside the home and reduced noise from appliances or heating and cooling equipment.

Table 56: How the Home is Quieter after WAP

Responses *(multiple response)*	Count (n=8)
Reduced noise from outside the home	6
Reduced noise from appliances or heating/cooling equipment	2

Respondents noted the following:

- *"I used to hear a lot of noise when the wind was blowing outside. And I notice that I see the trees moving, but I don't hear it anywhere near as loud as before."*
- *"When people are outside talking, I don't hear them as much. Some of the neighbors have very loud mufflers on their cars. I still hear them, but they don't seem to bother me a bit."*
- *"We no longer hear the air handler and the pump running like we did before. My son says he doesn't hear the garage door opening and closing anymore because they put so much insulation in the attic wall that separates it from his room."*

The team also asked these respondents to elaborate on how the change in noise level has affected their daily life. Four out of eight respondents reported improved sleep; respondents also mentioned improved productivity, attitude, and general improvement to their daily life.[62] Three respondents said the change in noise level had not affected their daily life.

[62] NMR Group and Three[3]. "Low-Income Multifamily Health- and Safety-Related NEIs Study (TXC50) Preliminary Findings Report." Prepared for Massachusetts Program Administrators. October 15, 2018. http://ma-eeac.org/wordpress/wp-content/uploads/TXC50-Low-Income-Multfamily-Health-and-Safety-NEI-Preliminary-Findings-Report_15OCT2018.pdf

Table 57: How Change in Noise Level Affects Daily Life

Responses *(multiple response)*	Count (n=8)
Improved sleep	4
Improved productivity	2
Improved attitude	1
Improved in general	1
Not affected	3

Two participants explained:

- *"Yes, I can sleep all night; that's what counts. Because I wake up refreshed and ready to go. I wasn't able to sleep through the night before the weatherization. After they put the insulation on the roof and the floor, the house got quiet and I could just sleep."*
- *"It may affect my attitude, too. My attitude might be better than before the upgrades."*

4.1.6.3.3 Health

The team interviewed six respondents who noted in the original CY2016-2018 WAP survey that household members' health conditions, such as frequency or intensity of colds, flus, or other conditions like asthma or arthritis, had improved after the energy efficiency upgrades. These respondents mentioned relieved allergies, a reduced frequency of illness, and relieved asthma since weatherizing their home. Additionally, when asked directly, three interviewees confirmed a reduced amount of dust in the home and two confirmed a reduced number of pests or insects in the home since the energy efficiency upgrades (both are common asthma triggers).[63,64,65,66]

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[63] Three[3] and NMR. "Massachusetts Special and Cross-Cutting Research Area: Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts (NEIs) Study." Prepared for Massachusetts Program Administrators. August 5, 2016. http://ma-eeac.org/wordpress/wp-content/uploads/Low-Income-Single-Family-Health-and-Safety-Related-NonEnergy-Impacts-Study.pdf

[64] U.S. Department of Energy. "Home Rx: The Health Benefits of Home Performance." December 2016. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Home%20Rx%20The%20Health%20Benefits%20of%20Home%20Performance%20-%20A%20Review%20of%20the%20Current%20Evidence.pdf

[65] E4TheFuture. "Occupant Health Benefits of Residential Energy Efficiency." November 2016. https://e4thefuture.org/wp-content/uploads/2016/11/Occupant-Health-Benefits-Residential-EE.pdf

[66] NMR Group and Three[3]. "Low-Income Multifamily Health- and Safety-Related NEIs Study (TXC50) Preliminary Findings Report." Prepared for Massachusetts Program Administrators. October 15, 2018. http://ma-eeac.org/wordpress/wp-content/uploads/TXC50-Low-Income-Multfamily-Health-and-Safety-NEI-Preliminary-Findings-Report_15OCT2018.pdf

Table 58: How Health has Improved

Responses *(multiple response)*	Count (n=6)
Relieved allergies	3
Reduced amount of dust in the home	3
Reduced number of pests or insects in the home	2
Reduced frequency of illness	1
Relieved asthma	1

One respondent affirmed:

- *"With dust, I think of pollen as well. When I'm outside in the pollen, that bothers me, but when I come inside, that's much better for me. [The energy efficiency upgrades] probably contributed to that because of the tighter house – less pollutants or things coming in. More so during the winter, it feels tighter overall."*

4.1.6.3.4 Energy Bill

Ten out of thirteen interviewees noticed a reduction in their energy bills since the energy efficiency upgrades, with most reporting they have been better able to afford food, medicine, unexpected medical costs, and other necessities.

Table 59: Impact of WAP on Energy Bills

Responses *(multiple response)*	Count (n=13)
Reduction in Energy Bills	10
Better able to afford food, medicine, or other necessities	9
Better able to afford unexpected medical costs	5

Respondents noted the following when talking about the impact WAP has had on their energy bills and ability to afford necessities:

- *"My electric bill dropped 25%. My highest electric bill was no more than $80 and that was during a cold spell. It was usually about $110 before the energy efficiency upgrades."*
- *"In the winter they dropped about $20 and in the summer, they dropped $60 a month. Our A/C doesn't run nearly as much."*
- *"It definitely gives me room, the savings helps. It's like peace of mind. Like, ok, I know I'm not going to have a huge bill because I'm doing a number of things to help with that. So, yeah, I guess it could give me a little extra room to not have to worry about affording food or something like that."*

Notably, when given the opportunity to provide any final comments, all thirteen respondents had positive things to say, from encouraging others to take part in the program to expressing appreciation for their energy efficiency upgrades.

- *"I appreciated them doing [the upgrades] for me. I was glad that we qualified. It definitely has made a difference."*
- *"They did a fantastic job. I'm pleased and happy with the work they did. It really improved my life."*

4.1.7 COST-EFFECTIVENESS RESULTS

EcoMetric's cost-effectiveness analysis shows that the Weatherization Assistance Program has a benefit-cost ratio of 1.22 using the Total Resource Cost (TRC) test, indicating the program is cost-effective. The cost effectiveness of the program from the TRC perspective declined slighting from the previous evaluation, largely due to a decline in savings achieved and the associated benefits derived from the avoided costs of energy, capacity and fossil fuels. Table 60 provides details on the total benefits and costs which EcoMetric included in the TRC test for the Weatherization Assistance Program.

Table 60: WAP Cost-effectiveness Results

Benefit / Cost	NPV of Benefit/Cost
Lifetime Avoided Cost of Energy	$324,017
Lifetime Avoided Cost of Capacity	$61,091
Lifetime Avoided Cost of Fossil Fuel	$23,821
Lifetime Non-Energy Benefits	$1,241,814
Total Benefits[67]	$1,650,743
Program Administrative Costs	$1,355,897
Measure Costs	$0
Total Costs[68]	$1,355,897
TRC Benefit-Cost Ratio	1.22

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

[67] The benefits accure over the life of the measure.
[68] The costs occur in year zero of the NPV calculation.

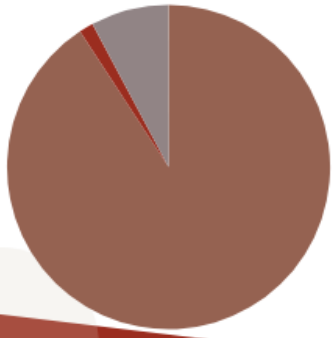
APPENDIX A: PROGRAM EVALUATION TEARAWAYS

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

ENERGY EFFICIENCY
INVESTMENT FUND
2019 Evaluation At-a-Glance

80 Projects Granted

70 Projects Evaluated



Net Electric Savings

- Prescriptive Lighting (91%)
- Custom Gas (8%)
- Custom Electric (1%)

13,280 MWh
Net Verified Electric Savings

2.20 MW
Net Verified Demand Savings

17,061 MMbtu
Net Verified Gas Savings

2.98
Total Resource Cost Ratio

101%
Energy kWh Realization Rate

123,209 tons
Lifetime GHG Reduction

Key Impact Recommendations

Continue to ensure participants submit documentation and ex ante calculations that clearly explain and support the claimed savings.

Provide standardized calculator tools for use by applicants and contractors in estimating ex-ante energy savings for each project.

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

ECOMETRIC

ENERGY EFFICIENCY INVESTMENT FUND 2019 Evaluation At-a-Glance

Key Process Findings

Contractors and customers found the application easy to complete.

EEIF incentives are a primary selling point contractors use with prospective customers.

50% of interviewed customers discovered EEIF online.

#1 Suggestion for Improvement

Customers - Nothing

Contractors - Speed up approval process

Program Strengths from Contractors' Perspective

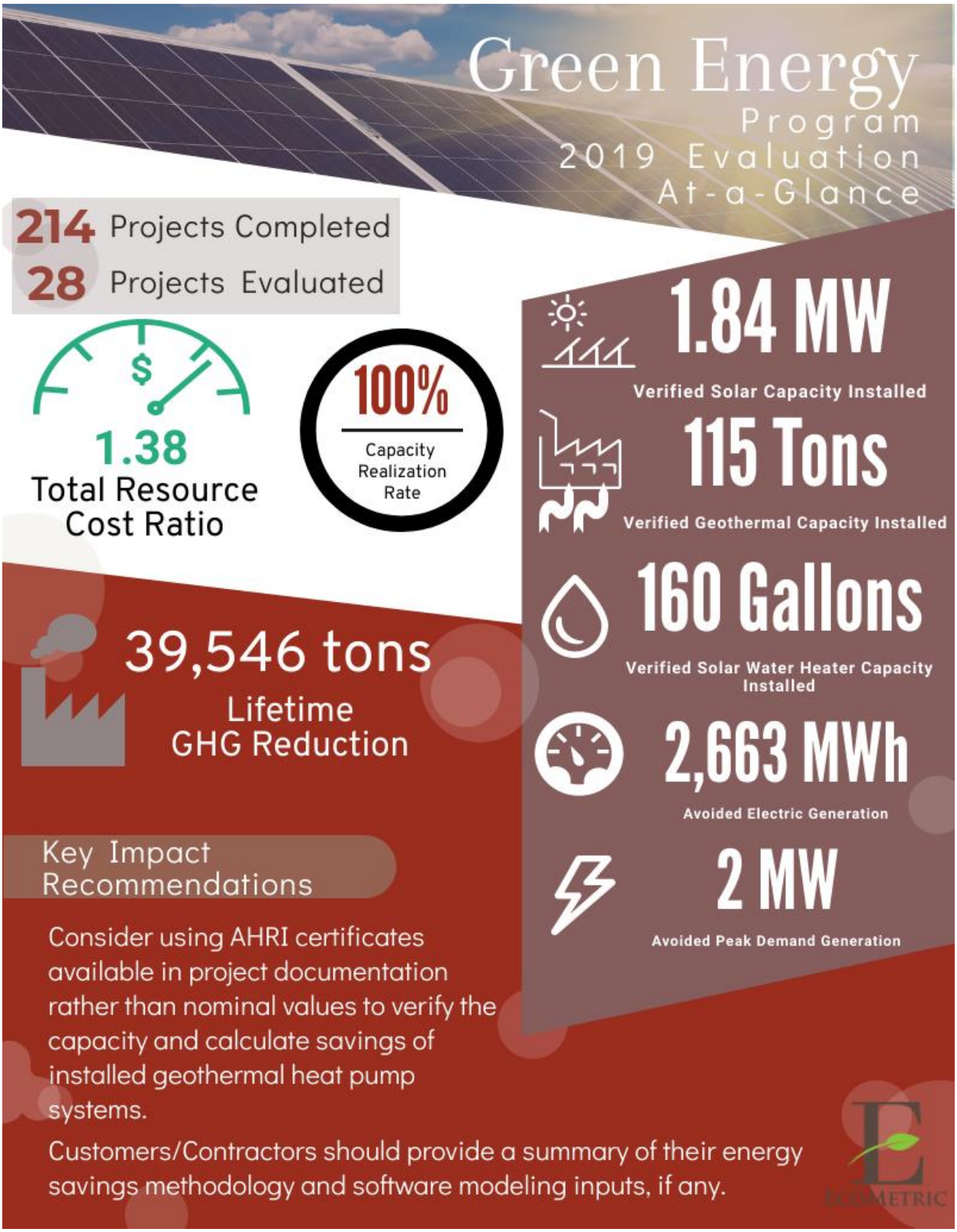
1. Incentive Levels
2. Comprehensive measures
3. Ease of application
4. (tied) Custom program flexibility
4. (tied) Customer service
4. (tied) Customer protection

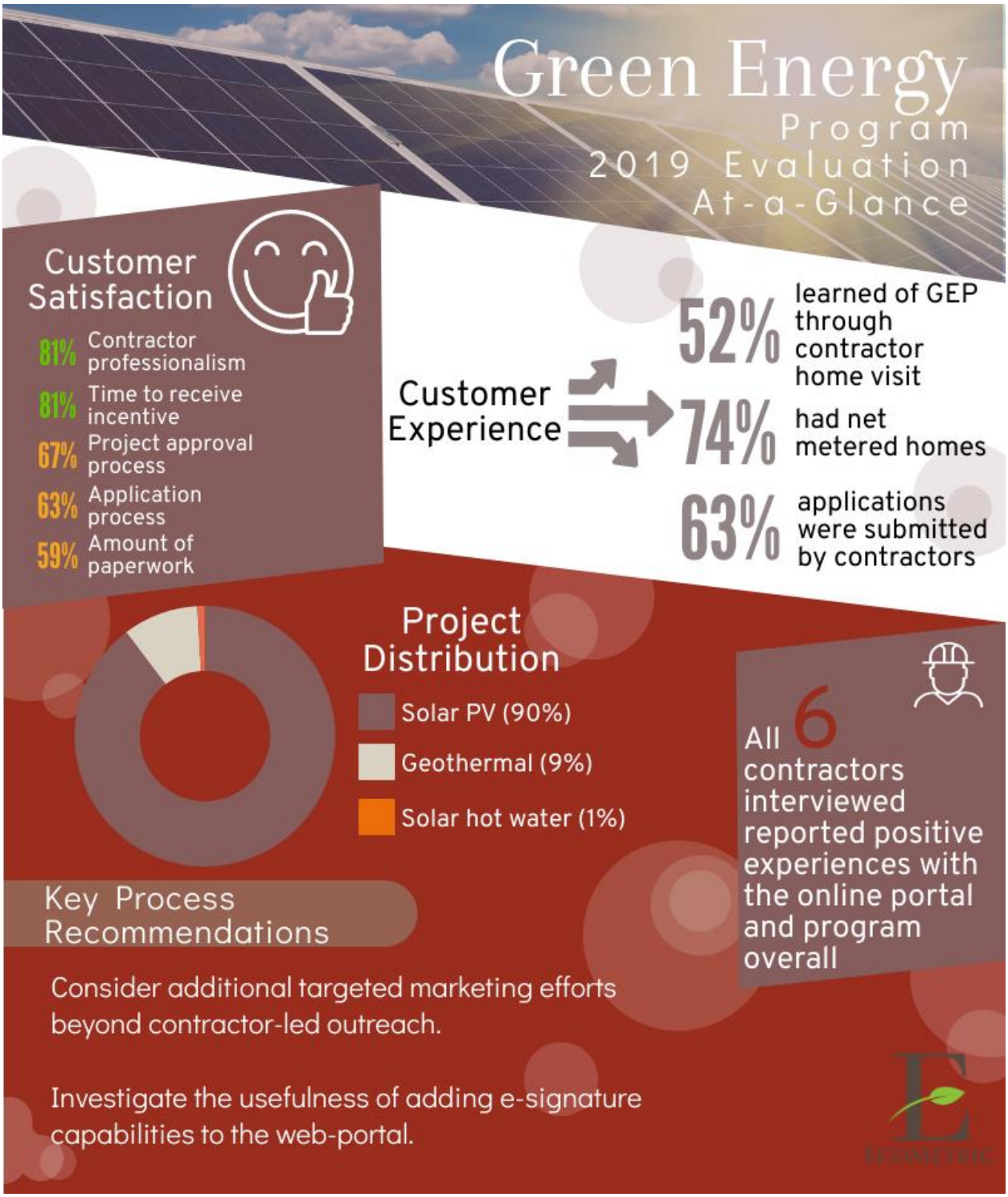
Key Process Recommendations

Reassess applicants' perspectives on the application after it has shifted to the online portal to ensure it continues to be easy to complete.

Monitor application processing time once the portal is online.

Consider providing contractors with referrals (when available) and marketing materials to hand out to prospective customers.

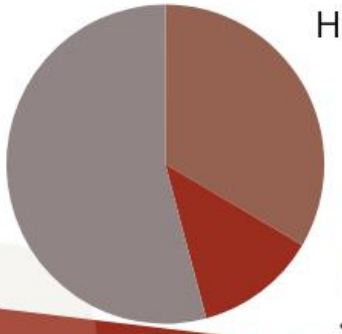

Green Energy
Program
2019 Evaluation
At-a-Glance
214 Projects Completed
28 Projects Evaluated
1.38
Total Resource Cost Ratio
100%
Capacity Realization Rate
1.84 MW
Verified Solar Capacity Installed
115 Tons
Verified Geothermal Capacity Installed
160 Gallons
Verified Solar Water Heater Capacity Installed
2,663 MWh
Avoided Electric Generation
2 MW
Avoided Peak Demand Generation
39,546 tons
Lifetime
GHG Reduction
Key Impact Recommendations
Consider using AHRI certificates available in project documentation rather than nominal values to verify the capacity and calculate savings of installed geothermal heat pump systems.
Customers/Contractors should provide a summary of their energy savings methodology and software modeling inputs, if any.


Green Energy
Program
2019 Evaluation
At-a-Glance
Customer Satisfaction
81% Contractor professionalism
81% Time to receive incentive
67% Project approval process
63% Application process
59% Amount of paperwork
Customer Experience
52% learned of GEP through contractor home visit
74% had net metered homes
63% applications were submitted by contractors
Project Distribution
Solar PV (90%)
Geothermal (9%)
Solar hot water (1%)
All 6 contractors interviewed reported positive experiences with the online portal and program overall
Key Process Recommendations
Consider additional targeted marketing efforts beyond contractor-led outreach.
Investigate the usefulness of adding e-signature capabilities to the web-portal.

Weatherization Assistance Program 2019 Evaluation At-a-Glance

242 Projects Completed

242 Projects Evaluated



Home Heating Type

- Other Fuels* (55%)
- Electric (33%)
- Natural Gas (12%)

*Propane, Oil, Kerosene

234 MWh
Net Verified Electric Savings

0.04 MW
Net Verified Demand Savings

1,701 MMbtu
Net Verified Fossil Fuel Savings

1.22
Total Resource Cost Ratio

78%
Energy kWh Realization Rate

2,318 tons
Lifetime GHG Reduction

Non Energy Benefits

- Thermal Comfort: $154
- Noise: $54
- Health: $56

Key Impact Recommendations

Use this savings matrix to claim savings for each weatherized home:

Heating Type	Home Type	Per Unit Energy Savings (kWh)	Per Unit Peak Demand Reduction (kW)	Per Unit Energy Savings (MMBTU)
Electric	Single family	2,044	0.40	NA
	Manufactured home	1,191	0.09	NA
Natural Gas	Single family	825	0.13	9.9
	Manufactured home	672	0.14	14.3
Other fuel	Single family	1,196	0.17	10.6
	Manufactured home	771	0.17	14.6