FILED
June 25, 2021
INDIANA UTILITY
REGULATORY COMMISSION

STATE OF INDIANA

INDIANA UTILITY REGULATORY COMMISSION

IN THE MATTER OF THE VERIFIED PETITION OF INDIANAPOLIS POWER & LIGHT FOR APPROVAL OF DEMAND SIDE MANAGEMENT (DSM) PLAN, INCLUDING ENERGY EFFICIENCY (EE) PROGRAMS, AND ASSOCIATED ACCOUNTING AND RATEMAKING TREATMENT, INCLUDING TIMELY RECOVERY, THROUGH IPL'S EXISTING STANDARD CONTRACT RIDER NO. 22, OF ASSOCIATED COSTS INCLUDING PROGRAM OPERATING COSTS, NET LOST REVENUE, AND FINANCIAL INCENTIVES.	)	**CAUSE NO. 45370**

SUBMISSION OF DSM EVALUATION REPORT (Volume 2)

Custom Component

The evaluation team interviewed IPL's program manager and key CLEAResult staff to obtain an overview of the program design and delivery processes and any changes or challenges experienced during 2020.

Program Delivery

Despite the COVID-19 pandemic, IPL and CLEAResult reported that the Custom component ran smoothly in 2020.

Program participants received custom rebates for nonstandard projects involving complex technologies or equipment changes with more than one-for-one replacements. IPL paid custom incentives on a performance basis, offering $0.08 per kilowatt-hour of estimated electric savings for non-lighting projects and $0.07 per kilowatt-hour of estimated electric savings for lighting projects that met the eligibility criteria (minimum cost-effectiveness requirements and lighting fixture listing by ENERGY STAR or the DesignLights Consortium). Neither the incentive levels nor project eligibility requirements changed from 2019 to 2020.

Program Marketing and Outreach

CLEAResult reported that its energy advisors conducted program outreach to contractors and customers, with the heaviest emphasis on contractor outreach in 2020. This represents a change from 2019, when CLEAResult primarily focused on customer outreach. As in 2019, energy advisors divided their outreach by Indianapolis geographic region and assigned large contractors to a specific energy advisor regardless of region. When conducting outreach to customers, energy advisors targeted a business energy manager or facility manager. CLEAResult also promoted the Custom component in its general commercial marketing messages by encouraging customers to contact a Custom representative when planning a project that is not represented on the Prescriptive Rebates program list of measures.

CLEAResult held an in-person trade ally seminar in February 2020, attended by approximately 80 contractors. CLEAResult focused the event on educating contractors about new technologies and explaining how contractors could market the program to customers.

Program Application Process

Custom customers can complete their application via email or an online application portal available for the Custom Incentives program, Prescriptive Rebates program Non-Midstream delivery channel, and SBDI program. The online application portal allows customers and contractors to verify that their equipment meets the program requirements and to track their application status. However, the IPL program manager and CLEAResult reported that most program applications are completed via email rather than the online application portal.

Impact of COVID-19 on Participation and Custom Component Operations

IPL and CLEAResult reported that of all its commercial programs, Custom Incentives participation levels and operations were least impacted by COVID-19 in 2020. Program participation remained stable (77 projects in 2020, 77 projects in 2019, and 80 projects in 2018). Due to the long timeframe often required by capital projects, many customers worked on their project over several months in 2020 or even paused then resumed their projects once Indiana stay-at-home orders were lifted.

The per-project average *ex ante* savings declined by 32% from 2019 to 2020, and 2020 participants completed smaller compressed air, HVAC, lighting, refrigeration, and whole-building projects than 2019 participants. However, the evaluation team cannot determine whether smaller project sizes were due to COVID-19 without knowing the building size of the participant population.

The pandemic impacted how CLEAResult implemented post-installation inspections: due to limited access to facilities, CLEAResult offered program participants the option for in-person or virtual inspections.

Future Program Changes

The IPL program manager and CLEAResult did not mention major changes to the Custom component for future years. However, both that CLEAResult will cross-promote a virtual retro-commissioning offering to commercial customers starting in 2021 or 2022. This cross-promotion will initially be targeted at small and medium businesses who may not be well matched for the existing in-person retro-commissioning program, but could still benefit from retro-commissioning type measures. Uplight will implement the virtual retro-commissioning offering, with CLEAResult acting as the virtual retro-commissioning contractor. This virtual study will be free to customers, and IPL will provide incentives to customers who complete recommendations within three months of their study. For the current in-person retro-commissioning component, IPL partially offsets the cost of the study.

The evaluation team tested 2020 survey respondents' interest in both a virtual and in-person retro-commissioning program offering (see the *Interest in Retro-Commissioning Offerings* section below for more details).

Program Key Performance Indicators

In addition to energy and participation goals, CLEAResult tracked service-level key performance indicators related to delivery of the Custom Component. Table 226 shows the status of CLEAResult's key performance indicators for 2020. CLEAResult achieved all its goals except one: it did not increase the trade ally network by 5% (achieving 4% growth).

Table 226. 2020 Custom Component Service-Level Key Performance Indicators

Service Level	Key Performance Indicator	2020 Result
Quality Assurance Site Verification	100% site verification for self-installed projects with rebate payments ≥$1,000, all projects with rebate payments ≥$20,000, and 10% random for all other projects	Achieved
Trade Ally Network	Increase number of participating Custom Incentives trade allies by 5% annually [a] (from 45 in 2019)	Did not reach goal (47 contractors in 2020)
Days from Custom Application Receipt to Notification of Receipt	Notify 95% of applicants within three business days that an application has been received	Achieved
Custom Application Approval	Send 95% of customers a letter of intent within 15 business days of receiving application	Achieved
Incomplete Notice	Send incomplete notice within five business days of receiving application	Achieved
Rebate Payment	Issue 100% of rebate payments within 20 business days of receiving application	Achieved

Source: December 2020 IPL scorecard and program tracking data.

[a] This was defined by CLEAResult as the number of contractors who participated in the Custom Incentives program.

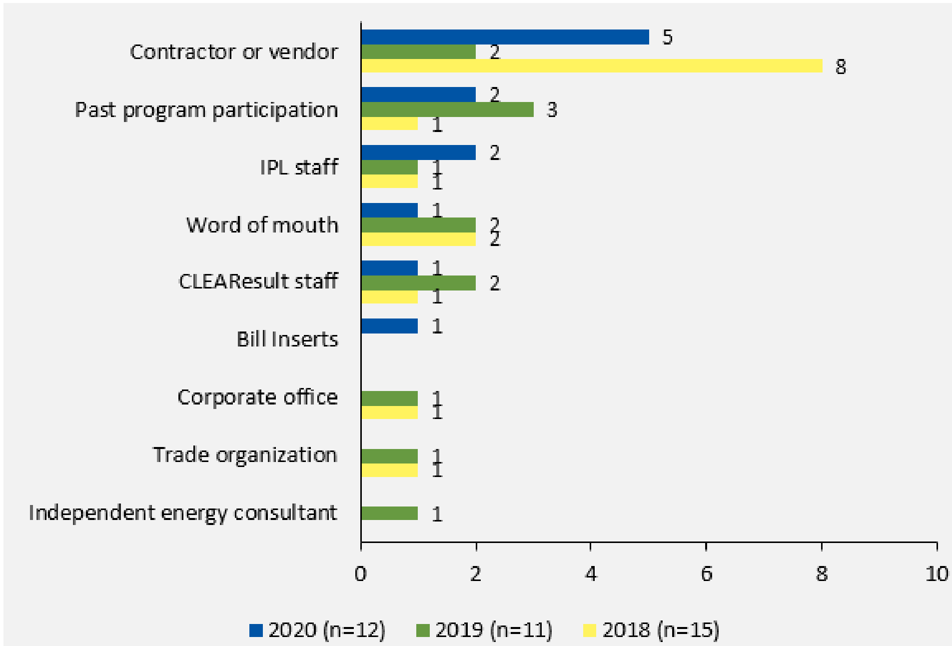
Participant Feedback

In January and February 2020, the evaluation team contacted 45 businesses that participated in the Custom component to complete a phone survey. Thirteen customers responded to the survey, for a 29% response rate, representing 29% of the program component *ex ante* savings. As the number of responses was low for 2020 (and also for 2019, with 11 completed surveys), the evaluation team did not test for statistical differences between the 2019 and 2020 findings. The details and figures presented below show findings by number of respondents rather than by percentages.

Energy Efficiency Awareness

In 2020, contractors were the largest source of awareness for the Custom component, cited by five of 12 respondents. Other sources of program awareness in 2020 included participation in another IPL or Indiana utility program, IPL staff, word of mouth, CLEAResult staff, and a bill insert (Figure 71).

Figure 71. 2020 Custom Component Source of Awareness



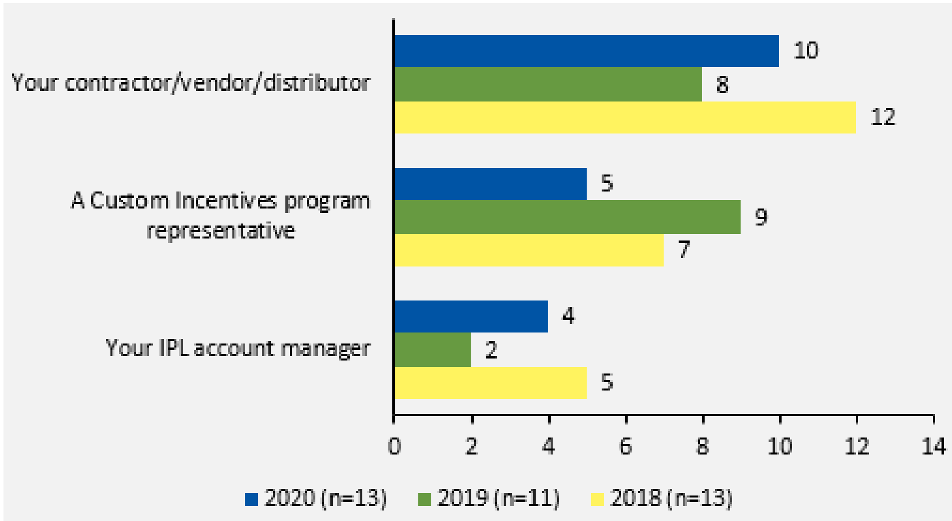
Source: 2018, 2019, and 2020 IPL Custom Component Participant Survey Question B1. "How did you first learn about IPL's Custom Incentives program?" Multiple responses allowed in 2019 only.

Participation Drivers

Custom participants identified the factor that was most important in their decision to participate in the program. Custom respondents were commonly driven to save energy (four respondents, n=13), save money on energy bills (three respondents), and to replace old but still working equipment (two respondents). One respondent each also reported the following drivers: to acquire the latest technology, to obtain the rebate/incentive, to replace broken equipment, and to increase comfort.

To understand the influence of program representatives, Custom respondents shared who helped them plan or initiate their energy efficiency project. Respondents most often met with a contractor, vendor, or distributor (10 respondents). This represents a change from 2019, when respondents most often met with a Custom Incentives program representative (Figure 72).

Figure 72. Source of 2020 Custom Component Initiation

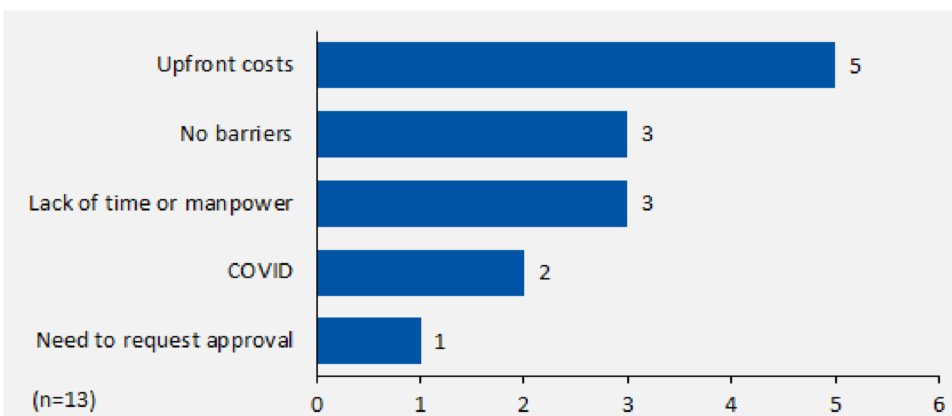


Source: 2020 IPL Custom Component Participant Survey Question B2. "Please tell me who, if anyone, was involved in helping you plan or initiate your energy efficiency project?" Multiple responses allowed.

Participation Barriers

Businesses face many challenges participating in the Custom component. As shown in Figure 73, those who were able to identify a challenge most commonly noted the upfront costs (five out of 13) and a lack of manpower (three respondents).

Figure 73. 2020 Custom Component Barriers to Participation

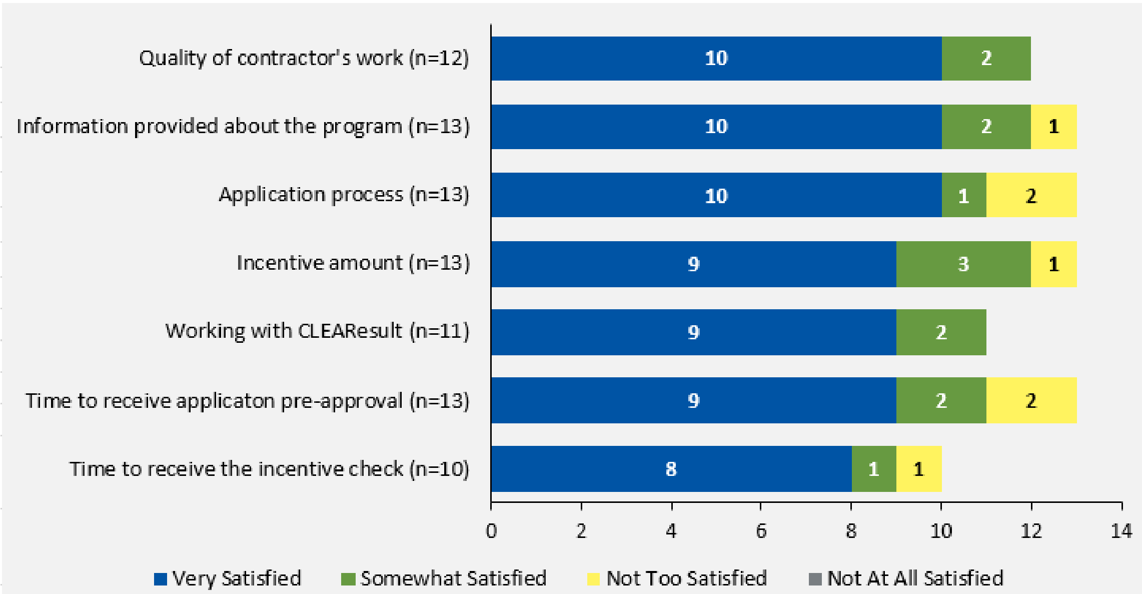


Source: 2020 IPL Custom Component Participant Survey Question G7. "What barriers, if any, do you see to participating in this program?" Multiple responses allowed.

Satisfaction with Program Processes

Custom component respondents rated their satisfaction with several program aspects (Figure 74). Similar to 2019 respondents, the majority of 2020 respondents were *very satisfied* or *somewhat satisfied* with all program aspects. Respondents were most satisfied with the quality of the contractor's work and with information provided about the program, and were least satisfied with the time to receive the incentive check.

Figure 74. Participant Satisfaction with 2020 Custom Component Aspects

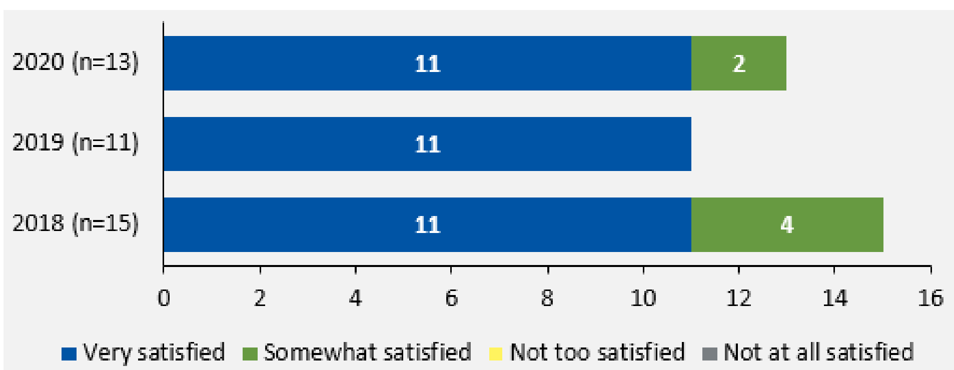


Source: 2020 IPL Custom Component Participant Survey Question F1. "Please rate your level of satisfaction with each of these components."

Overall Satisfaction and Benefits of Program Participation

For the Custom Incentives program overall, all 13 of the 2020 respondents reporting being *somewhat satisfied or very satisfied.* In 2019, all 11 respondents were *very satisfied* (Figure 75).

Figure 75. Overall Satisfaction with 2020 Custom Incentives Program



Source: 2020 IPL Custom Component Participant Survey Question F1 and 2018 and 2019 Component Participant Surveys Question H1.h. "How satisfied are you with the program overall?"

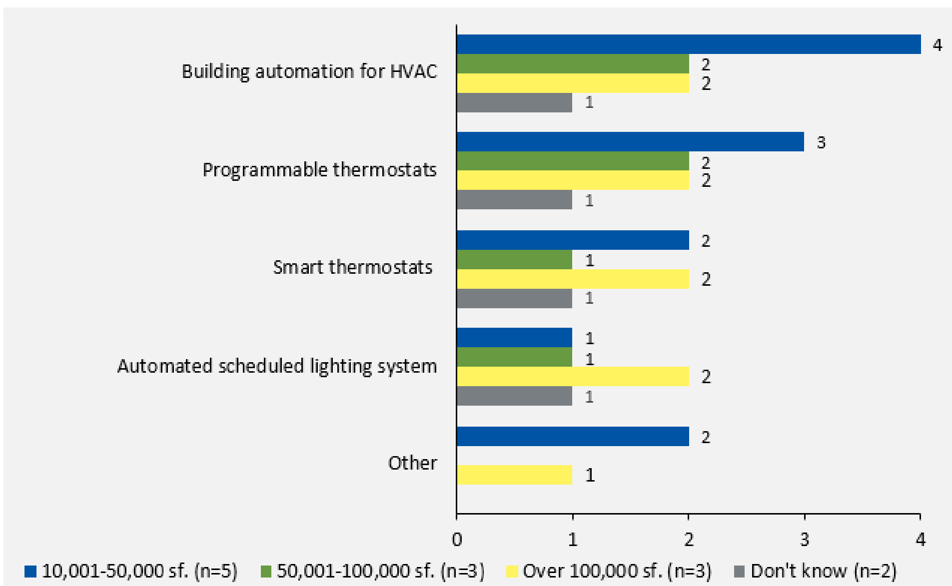
Suggestions for Improvement

Most respondents (nine of 13) did not offer recommendations to improve the program. The remaining four respondents gave the following recommendations (one per respondent): better communication, higher incentives, faster rebate turnaround time, and clarification about the roles of IPL versus CLEAResult. The one respondent who suggested better communication said the program should offer an alternative program representative to contact in case the first representative is out of the office.

Interest in Retro-Commissioning Offerings

To assess the ability for IPL's Custom customers to participate in the Retro-Commissioning component, the evaluation team asked the 2020 Custom respondents which buildings controls are in their facilities. Of the response options provided to respondents, HVAC BAS and automated scheduled lighting systems are most applicable to in-person retro-commissioning due to the higher savings potential of these controls compared to other controls; however, it is possible to include programmable and smart thermostats in a virtual retro-commissioning offering. Manual lighting controls and lighting occupancy sensors are not normally included in retro-commissioning. Most Custom respondents' facilities contain at least one control type that is applicable to a retro-commissioning (Figure 76). Nine of 13 respondents have HVAC BAS, eight have programmable thermostats, six have smart thermostats, and five have an automated scheduling lighting system. Four of the five facilities sized between 10,001 and 50,000 square feet contained several control types. Of these four facilities, two are religious organizations and two are real estate or property management organizations. One of the 13 respondents leases their facility, which contains BAS for HVAC, manual lighting controls, and programmable thermostats.

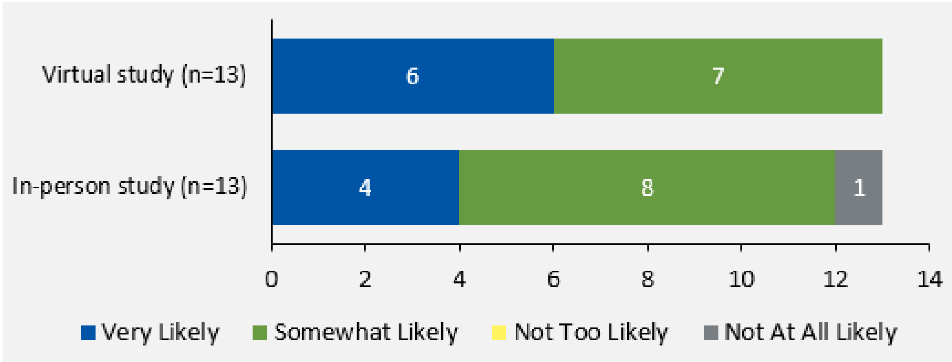
Figure 76. 2020 Custom Facility Control Systems



Source: 2020 IPL Custom Component Participant Survey Question G1. "Which of the following control systems does your facility have?" Multiple responses allowed.

Respondents rated their likelihood to consider participating in an in-person or virtual retro-commissioning study. Twelve of 13 respondents said they would be *very likely* (four respondents) or *somewhat likely* (eight respondents) to participate in an in-person study. Respondents were more likely to participate in the virtual study option, with six respondents being *very likely* and seven being *somewhat likely* to consider participating (Figure 77). The one respondent who was not likely to consider an in-person study explained that uncertainty exists around his company's future due to COVID-19.

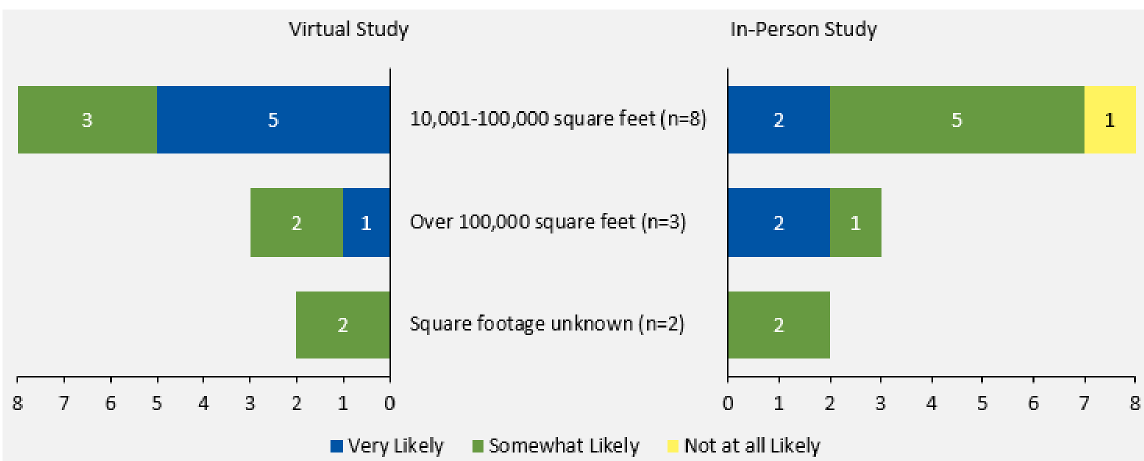
Figure 77. 2020 Custom Respondent Likelihood to Consider Participating in Retro-Commissioning



Source: 2020 IPL Custom Component Participant Survey Questions G2 and G4. "How likely are you to participate in an in-person retro-commissioning study program?" and "How likely are you to participate in a virtual retro-commissioning study program?"

The evaluation team examined whether respondent firmographics correlated to interest in either retro-commissioning offering. Respondents whose facilities are sized between 10,001 and 100,000 square feet expressed more interest in the virtual study than those whose facilities are sized over 100,000 square feet (Figure 78). Twelve of the 13 respondents own their facilities; the one respondent who leases their facility is not likely to consider the in-person study due to uncertainty about the future of the company but is very likely to consider the virtual study. The evaluation team did not observe a correlation between respondent industry sector and their likelihood to consider participating in either offering.

Figure 78. 2020 Custom Respondent Likelihood to Participate in Retro-Commissioning by Facility Size



Source: 2020 IPL Custom Component Participant Survey Question G4 and 2018 and 2019 IPL Custom Component Participant Surveys Question G2. "How likely are you to participate in a [virtual/in-person] retro-commissioning study program?"

The team also asked respondents what barriers they foresee to participating in retro-commissioning. The largest barrier mentioned was the upfront costs to participate or to implement recommendations, cited by five of 13 respondents. Three respondents identified lack of staff time and lack of resources as barriers, and three other respondents said there are no foreseeable barriers.

Respondents identified what information they would require before signing up for either retro-commissioning offering. Respondents most commonly requested general program information (seven of 13) and return-on-investment details (four of 13). Two respondents each also wanted to know the required upfront investment, timeframe of the offerings, and required time commitment.

Impact of COVID-19 on Plans for Future Energy Efficiency Projects

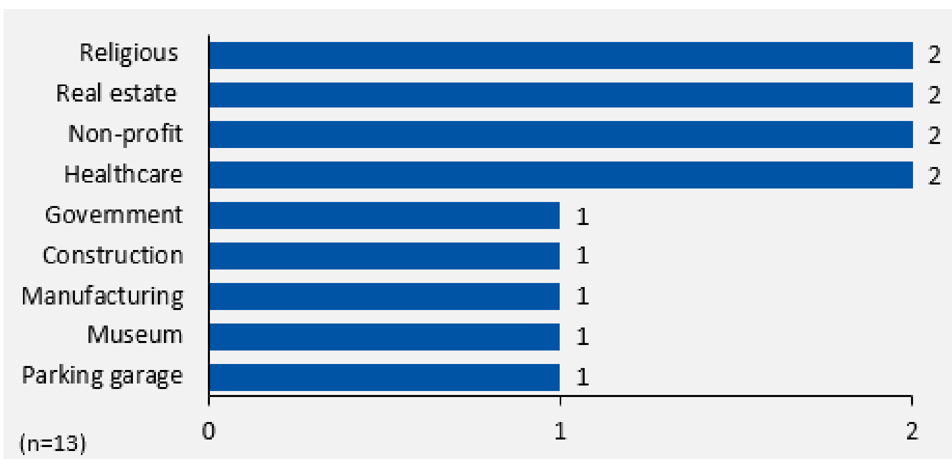
The evaluation team asked respondents how COVID-19 has impacted any of their plans for future projects. Six of 11 respondents reported that the pandemic did not impact their plans. However, for the other five respondents, COVID-19 reduced their interest in or ability to pursue future energy efficiency projects for various reasons:

- Decreased budget (one respondent)
- Business priorities had changed (three respondents)
- Equipment delays (one respondent)

Participant Firmographics

The evaluation team asked survey respondents about various aspects of their business and the facility in which they operate. The 2020 respondents represent diverse industries, as shown in Figure 79.

Figure 79. 2020 Custom Incentives Program Respondents by Business Sector

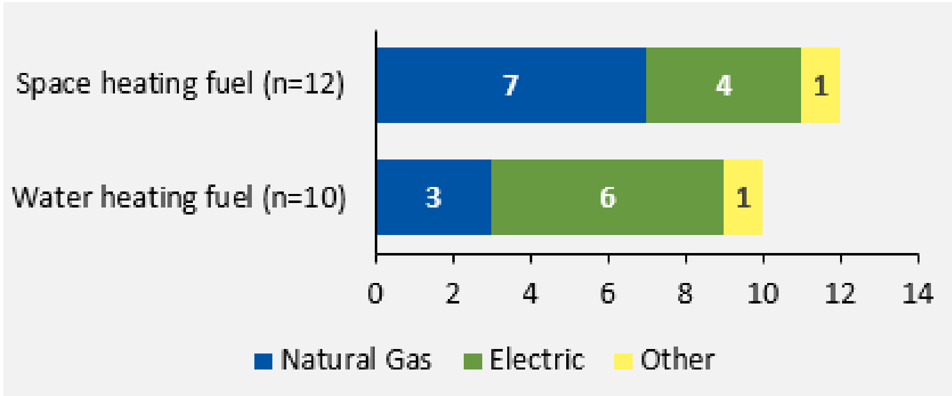


Source: 2020 IPL Custom Component Participant Survey Question H1. “What industry is your organization in?”

Overall, the 2020 survey respondents had smaller facility sizes than the 2019 survey respondents: nine of 11 respondents in 2019 represented facilities sized more than 50,000 square feet, compared to six of 11 respondents in 2020. Three respondents in 2020 made improvements in a facility over 100,000 square feet, while three made improvements in a facility between 50,001 and 100,000 square feet and five made improvements in a facility between 10,001 and 50,000 square feet.

When asked, contractors most often reported using natural gas for space heating (seven of 12) and electric for water heating (six of 10; see Figure 80).

Figure 80. 2020 Custom Incentives Program Respondents Main Fuel Type for Space and Water Heating



Source: 2020 IPL Custom Component Participant Survey Questions H3 and H4. "What is the main fuel type used for [space] heating the facility?" and "What is the main fuel type used for water heating at the facility?"

Retro-Commissioning Component

The evaluation team interviewed IPL's program manager and key Heapy staff to obtain an overview of the program design and delivery processes and any changes or challenges experienced during 2020. IPL and Heapy reported that the program operated smoothly in 2020. Program participation in the second year of the program was robust, with 17 buildings from 10 unique customers.

The Retro-Commissioning incentive structure has two parts:

- The customer may select to work with any qualified Retro-Commissioning provider. IPL reimburses the vendor directly for up to 50% of the study cost, once the study is completed and all agreed-upon measures have been implemented, through a tiered reimbursement structure. There is an option to perform a self-study rather than have a vendor complete the study for the customer. This situation is applicable for customers who have an in-house team capable of performing this work, or when the work has already been contracted separately from this incentive. In self-study cases, the study is not incentivized.
- Customers who implement viable, identified energy efficiency measures may receive Retro-Commissioning or prescriptive rebates, depending on the measures identified. There are two predefined categories for prescriptive rebates, while Retro-Commissioning incentives are available for nonstandard projects involving complex technologies or equipment changes with more than one-for-one replacements.

IPL's intent for the program component is to identify and provide rebates for Retro-Commissioning measures on a performance basis ($0.06 per kilowatt-hour) once electric savings have been verified by Heapy Engineering after implementation. For 2020 IPL increased the study rebate from 20% to 50%, and increased the performance incentive from $0.04 to $0.06. IPL intends to modify the 2021 incentives to 75% for the study and back to $0.04 for the performance.

Because Retro-Commissioning is a new program offering, IPL is closely evaluating the cost-effectiveness of the savings achieved against the cost outlay of the component and, as a result, expects to continue to adjust the incentives each year. IPL's incentive structure stipulates that the study incentive will be reduced if the M&V phase illustrates that the project does not achieve the savings goals proposed in the study report. This situation did not occur in 2019 but did occur on several occasions in 2020. In those instances, IPL did reduce the study rebate issued to the vendors who supported those projects to reflect the reduced savings achieved.

Program Marketing and Outreach

IPL and Heapy primarily conducted direct outreach via phone calls, emails, and in-person meetings to recruit customers into this program in 2020. When conducting outreach to customers, they targeted a business energy manager or facility manager. They also conducted some public outreach via online marketing materials and through IPL representatives, who contacted customers in their region. In 2021, IPL and Heapy plan to continue using public outreach methods to recruit customers for the Custom Incentives and Prescriptive Rebates programs who are not currently taking advantage of a whole-building–focused effort.

Program Application Process

Retro-Commissioning customers can access all informational documentation about the Retro-Commissioning component, along with the application for participation, from the IPL website. Customers can complete their application and send it via email. Heapy and IPL staff review all applications to determine eligibility and the resources needed. The preferred building types have a direct digital control system with remaining opportunities for energy improvement, and IPL designed the application process to assess these criteria quickly. If the customer does not already have a preferred vendor selected, Heapy assists them to identify an appropriate vendor for the project.

The customer and vendor must prepare a Retro-Commissioning study report within four weeks of the study start. The report must identify the intended efficiency measures and estimated savings values from implementing those measures. Savings estimates should be derived from utility or metered data, or by industry standard calculations. Once the study is complete, the customer, vendor, Heapy, and IPL discuss each efficiency measure in detail to determine which measures to implement (based on payback, total energy savings, and total implementation costs) and through which program to process the rebates.

The customer is required to implement all agreed-upon measures within three months of the study report meeting. Once implementation is completed, Heapy conducts four weeks of M&V supported by utility data, sub-metered data, trend data, and industry standard calculations to determine the verified savings of each measure.

Impact of COVID-19 on Participation and Program Operations

IPL and Heapy reported that the Retro-Commissioning component of the program was not significantly impacted by the COVID-19 pandemic. The increased incentive levels likely provided enough assistance to overcome any reduction in customer financial ability to participate.

It is difficult to draw comparisons in number of participating projects or *ex ante* saving between the 2019 and 2020 program years due to the newness of the program and the unique customer projects. The 2020 program year likely represents a more typical collection of projects and total *ex ante* savings and does not appear to have been impacted significantly by the pandemic. COVID-19 effected Heapy's ability to quantify standard operations and occupancy through normal methods.

Projects fell into one of three categories: (1) those where the study and M&V were conducted prior to the pandemic, (2) those where the study was conducted pre-pandemic and the M&V was conducted during the pandemic, and (3) those where the study and M&V were both conducted after the pandemic started. The four projects in the second category posed some quantification challenges, as the assumptions made during the study about the standard operation and occupancy of the building shifted during the pandemic and were reflected differently in the M&V.

The pandemic impacted how Heapy conducted post-installation inspections: due to having limited access to facilities, Heapy performed all inspections occurring after March virtually. For one project that started and concluded prior to the pandemic, Heapy conducted an on-site M&V inspection.

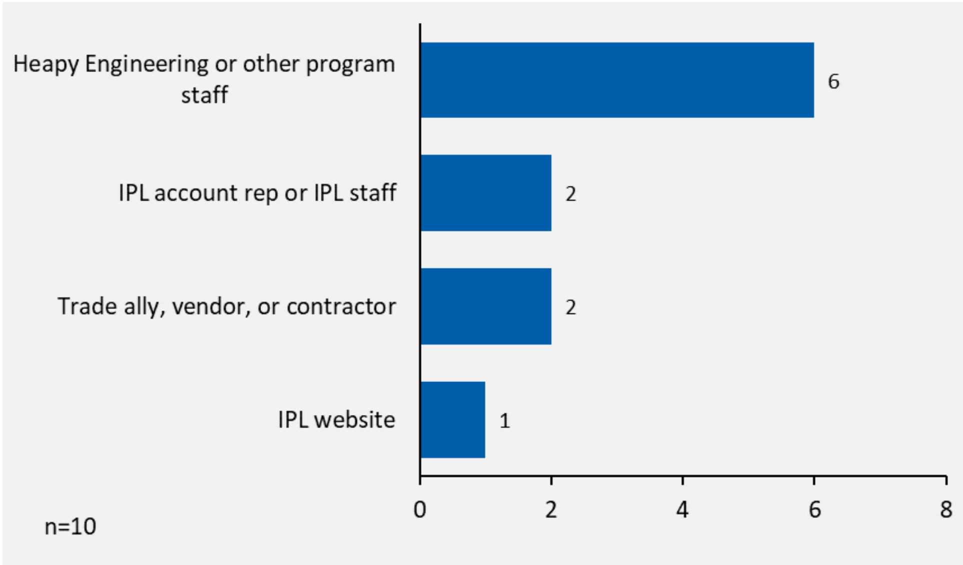
Participant Feedback

The evaluation team conducted phone interviews with key contacts for the 10 unique customers who participated in the Retro-Commissioning component of the Custom Incentives program in 2020. The team specifically pursued phone interviews along with the virtual site visit activities with the goal of achieving a 100% response rate. These 10 customers represent all 17 buildings in the 2020 Retro-Commissioning component and 100% of the component *ex ante* savings.

Energy Efficiency Awareness and Marketing

As shown in Figure 81, six survey respondents in 2020 learned of the Retro-Commissioning component directly through Heapy Engineering, while two learned from IPL staff. Most respondents viewed these two parties as part of the same entity, which aligns with the program's organizational intent. Two of the respondents learned of the program directly through their vendor, with whom they have a long-term working relationship. These results were expected since the program is in the first year of operation, and IPL had pursued direct marketing to targeted businesses to boost participation in the 2020 program, while Heapy recruited several vendors to reach out to their own network and recruit projects.

Figure 81. 2020 Retro-Commissioning Source of Awareness



Source: 2020 IPL Retro-Commissioning Participant Survey Question B1. "How did you first learn about IPL's Retro-Commissioning program?" Multiple responses allowed.

All respondents said they received enough information about the program to successfully participate, and they all indicated that information on how to receive the full program rebate was the most helpful element provided. Respondents also provided details about additional information they did not receive that would have been helpful in their decision to pursue the program:

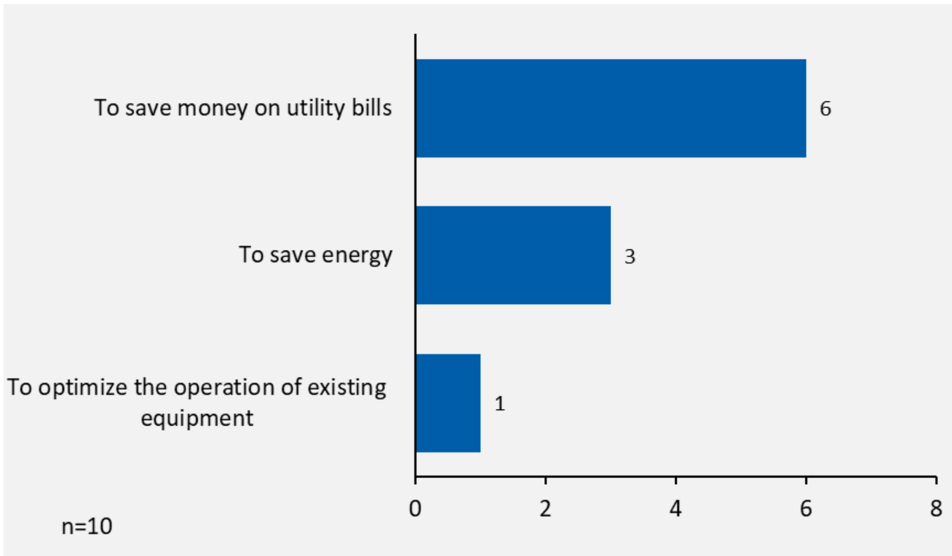
- How to complete additional efficiency projects (four respondents)
- How to receive rebates for implementing energy efficiency projects (one respondent, who has some buildings that are within a different utility territory, and who receives regular information from their account representative at that other utility regarding what rebates are applicable to them—but does not currently receive the same direct feedback from their IPL utility or program representative)
- Additional IPL rebates and ways to save (three respondents)
- Local providers who could assist with identifying or implementing energy efficiency projects (one respondent, who said their vendor was selected by their corporate office, but they would have liked to select a local vendor if more information had been provided upfront)

When asked how IPL could best keep organizations informed about energy-saving opportunities in the future, all 2020 respondents said they prefer to be kept informed through their IPL representative (indicating email, phone, or in person), and all respondents said they would also like their vendor to be kept informed about program offerings. This response was not unexpected since most 2020 participants were approached directly to participate in the program, demonstrating that they already have good communication established with an IPL representative(s).

Participation Drivers

As shown in Figure 82, six Retro-Commissioning participants identified that saving money on utility bills was the most important factor in their decision to participate in the program and implement the efficiency measures.

Figure 82. 2020 Retro-Commissioning Participation Drivers

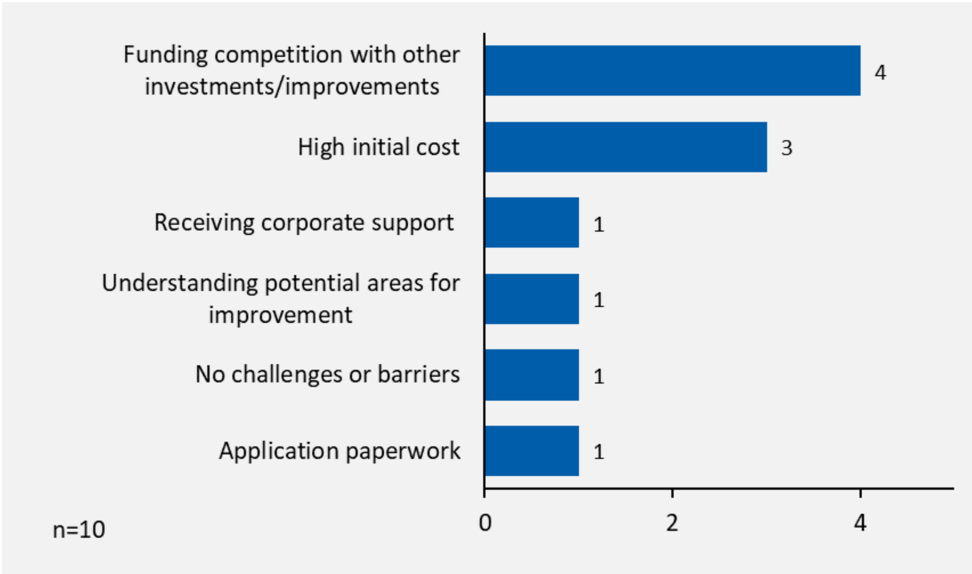


Source: 2020 IPL Retro-Commissioning Participant Survey Question C1. "What factor was most important in your decision to make energy-saving improvements through this program?"

Participation Barriers

Businesses face many challenges when pursuing energy efficiency projects in their facilities. The 2020 participants identified several challenges they typically face when considering this type of project. As shown in Figure 83, most respondents indicated that funding competition and the high cost of pursuing projects were the main barriers to participation.

Figure 83. 2020 Retro-Commissioning Barriers to Participation



Source: 2020 IPL Retro-Commissioning Participant Survey Question D1. "What are the most significant challenges for your organization in becoming more energy efficient?" Multiple responses allowed.

Respondents also shared whether they had experienced any challenges with the Retro-Commissioning implementation. One respondent experienced slight challenges with program participation, specifically saying that the timeline for implementation was somewhat difficult to meet, mainly due to the availability of their out-of-state vendor (and not due to program rigidity).

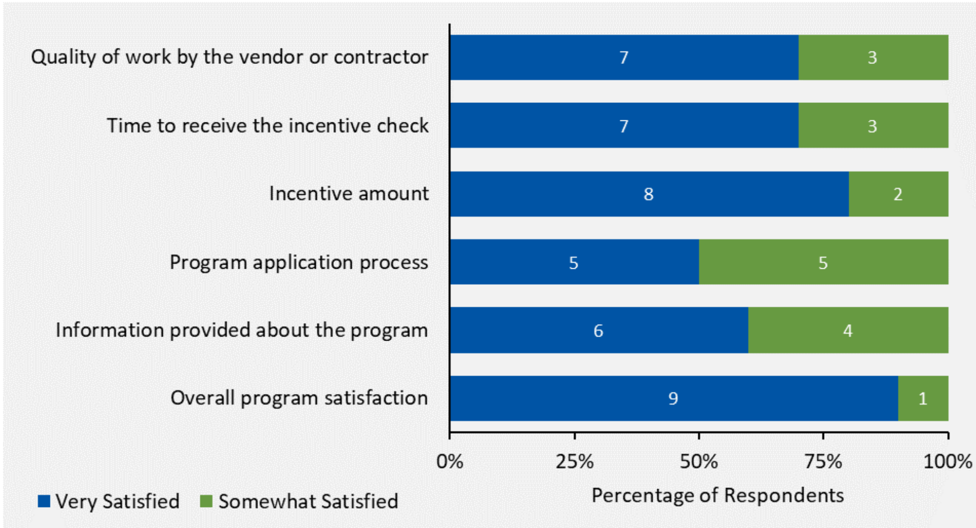
Retro-Commissioning participants shared what IPL could do, other than providing incentives, to help companies overcome challenges in making improvements. One respondent had no suggestions, while nine respondents provided a recommendation:

- Provide more technical and engineering support in the recommended measure discussion process and in the validation of energy savings, both before and after implementation (six respondents)
- Provide more technical and engineering support in the measure implementation or verification process (one respondent)
- Provide more support in identifying and selecting a qualified, local study vendor (one respondent)
- Provide more standardization of the application and submittal process to reduce the amount of paperwork participants need to complete (one respondent, who acknowledged that this may be difficult to accomplish with a custom program)

Satisfaction with Program Processes

Retro-Commissioning respondents rated their satisfaction with the program components and the program as a whole. As shown in Figure 84, all respondents were either *very satisfied* or *somewhat satisfied* with all program component aspects and with the program overall.

Figure 84. Participant Satisfaction with Aspects of 2020 Retro-Commissioning Component



Source: 2020 IPL Retro-Commissioning Participant Survey Question H1. "How would you rate your level of satisfaction with each of these components of the program?"

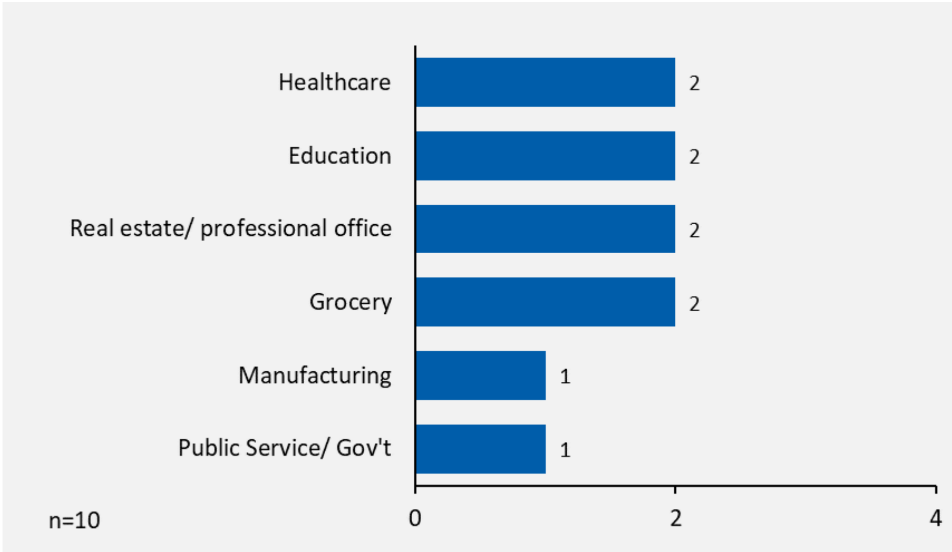
All respondents indicated that, as a result of the program, they benefited by saving money on utility bills, saving energy, obtaining an incentive, reducing maintenance costs, and protecting the environment. Two respondents additionally provided a recommendation for program improvement:

- Provide assistance and guidance with tracking energy performance in order to validate the program, receive buy-in from stakeholders for the measures implemented, and track ongoing performance over time. Report performance back to the customer to close the feedback loop.
- Provide assistance in identifying more measures to implement, other peer groups to learn from, and best practice strategies for efficient operation.

Participant Firmographics

The evaluation team asked survey respondents about various aspects of their business and the facility in which they operate. The 10 Retro-Commissioning respondents represent a variety of sectors, as shown in Figure 85.

Figure 85. 2020 Retro-Commissioning Respondents by Business Sector



Source: 2020 IPL Retro-Commissioning Participant Survey Question A2. "What industry is your organization in?"

Nine of the ten 2020 Retro-Commissioning respondents own their facility, while one respondent leases the property. All participants have previously and are currently making active improvements to their facility, including projects around LED lighting, domestic hot water (DHW) improvements, HVAC programming and sequencing improvements, and variable-speed drives.

Follow-Up on 2019 Evaluation Recommendations

The evaluation team followed up with IPL and implementer staff regarding the status of the recommendations made during the 2019 evaluation, shown in Table 227.

Table 227. 2019 Custom Incentives Program Recommendation Status

2019 Recommendation	Status
Increase trade ally program engagement, as trade allies have historically been a source of custom measure awareness. Send trade allies updates on program changes, provide trainings on program offerings, and send reminders to complete their projects and submit rebate applications.	***Completed***. CLEAResult ran a series of trade ally workshops on custom program improvement and marketing. Trade allies indicated that simpler program requirements would make it easier to market the program.
Interview trade allies to assess the kind of support they would like to receive from IPL and CLEAResult in terms of marketing, training, and delivering the program to customers, as well as barriers to customer program participation.	
If continued, make the Retro-Commissioning self-study path fully published and available to any eligible customer. Define the eligibility requirements to pursue that path, outline the required program documentation, and specify the elements that are necessary to report in a study.	***Completed***. IPL published the Retro-Commissioning self-study path as an available option, which four buildings pursued in 2020.

2019 Recommendation	Status
Enforce the Retro-Commissioning study as a required deliverable. The study report and all early project documentation serve as the primary details to determine a building's eligibility for the program, a realistic energy-savings goal for the project, individual energy conservation measures and their energy and cost impacts, and the means of quantifying and verifying energy savings that result from measure implementation. Without the study report or measure-level documentation in place, the energy savings that result from measure implementation cannot be confidently determined during M&V.	***Partially completed***. The four self-study projects submitted in 2020 did not have very robust study documentation. However, three of these projects were started in 2019, before this recommendation was issued. Heapy incorporated much of the building documentation within the M&V report to compensate for the lack of building documentation. Heapy also quantified measure-level savings at each self-study project, including those started in 2019.
To reduce the barrier of entry for Retro-Commissioning customers, pursue methods to reduce the level of effort needed from the customer instead of reducing the amount of energy-savings documentation. Continue to allow for self-studies, but with aid from IPL or Heapy to identify measures with robust savings. Consider ways to reduce the financial burden of engaging an external vendor for customers who might require more assistance to participate in the program.	***Partially completed***. IPL increased the rebate incentive from 20% to 50%, and the majority of 2020 projects elected to pursue a vendor-supported study. Heapy clearly took a larger role in repackaging and quantifying the measures pursued by self-study participants in 2020. However, it is notable that the self-study projects had among the lowest savings identified and realized. It is likely that a vendor-supported study would aid to increase viable measures at these sites.
Prior to conducting a Retro-Commissioning study, talk to the customer about the methods to quantify each proposed measure. The evaluation team will use the agreed-upon strategy to confirm actual energy savings from implementing each individual measure.	***Completed***. The quantification methods Heapy used in 2020 generally aligned well between the study reports and the M&V reports.
Do not use utility bill analysis as the primary method of verification for Retro-Commissioning self-study projects, which is unreliable when cumulative savings are less than 10% of baseline, does not provide measure-level savings calculations, and it is unable to differentiate savings from implemented Retro-Commissioning versus non-retro-commissioning measures. Instead, follow the verification methods used for the vendor path, which will provide more accurate measure-level energy-saving calculations. Use utility bill analysis as a secondary means of verification only.	***Completed***. Heapy used a utility bill analysis as a secondary means of verification in three projects (started in 2019), but not as the final or only means of measure quantification. Heapy developed measure-level savings calculations for all measures in 2020.
Determine what types of Retro-Commissioning measures to recommend, ensuring that they are quantifiable and result in meaningful energy savings. Publish these recommended measures as guidance literature for the program or discuss them with potential customers as part of the application phase.	***Not completed.*** IPL published guidance for general eligibility, but not detailed guidance of specific measures (which may be available once a project is initiated).
Encourage behavior modification as part of a larger conservation strategy, but do not provide rebates for these as individual, stand-alone project measures.	***Completed.*** Projects in 2020 did not include any quantified behavior modification–based measures.

2019 Recommendation	Status
Identify preventive maintenance measures during the Retro-Commissioning study, but do not provide rebates for implementing these actions. These measures are in the best interest of the customer to ensure equipment health and longevity, and to ensure that the customer's operational parameters are being met. There is a great deal of grey area between preventive maintenance and retro-commissioning, and the evaluation of eligibility would need to be made on a case-by-case basis as part of early Retro-Commissioning study discussions between IPL, Heapy, and the customer to ensure that the proposed measures are appropriate for the specific project. Consider preventive maintenance measures as those that fit within the following definition: • Measures where the fundamental design or nature of the equipment remains unaltered after implementation • Measures where the associated equipment would be damaged if the measure were not implemented, or actions that are recommended by the equipment manufacturer as maintenance • Measures where the facility could not operate properly without the measure being implemented (or actions that are required to allow the facility or equipment to operate as designed) • Actions that are performed periodically at the facility or on equipment under an established maintenance protocol. • Measures that return equipment to the facility's required operational parameters (where the measure is not be an eligible Retro-Commissioning measure if it proposed an operating condition that violated the set operational parameters of the building)	***Completed.*** Measures in 2020 did not include any preventative maintenance activities as stand-alone, quantified measures.
Encourage the strategic energy management energy champions within sectors to work collaboratively. As facilities tend to be similar within a sector, the potential areas for improvements are often consistent. Energy champions within sectors can learn from each other's successes.	***Not completed.*** IPL did not offer the strategic energy management portion of the Custom Incentives program in 2020.
Account for all rebated measures installed during the baseline in the final strategic energy management regression model.	
For all facilities participating in strategic energy management, test major holidays when selecting the baseline model.	

Conclusions and Recommendations

CONCLUSION 1: The Custom component operated smoothly in 2020, with contractors resuming their large role in program awareness and project initiation.

Despite the COVID-19 pandemic, the program operated smoothly in 2020. the number of Custom projects remained steady from 2019 to 2020. Customer satisfaction also remained high in 2020: all Custom component survey respondents were *very satisfied* or *somewhat satisfied* with the program overall, and most respondents were satisfied with the various program aspects. CLEAResult resumed its pre-2019 strategy of primarily marketing the program through contractors and held a trade ally seminar in February 2020. Though still lower than 2018 and 2017 levels (which were 54% and 56%, respectively), contractors and vendors were a source of program awareness for 42% of respondents in 2020, increasing from 18% of respondents in 2019. The number of contractors participating in the Custom component also increased by 4% in 2020 compared to 2019 levels.

CONCLUSION 2: Most Custom component participants would consider a retro-commissioning offering, and even smaller Custom component participants often have BASs. Most Custom component participants will need additional information about Retro-Commissioning to pursue this offering.

Most Custom respondents' buildings contain at least one type of control that is a good candidate for an in-person Retro-Commissioning offering (a BAS for HVAC or an automated scheduled lighting system), including respondents with smaller facilities (10,000 to 50,000 square feet). Survey results indicate that participants from these smaller facilities may be more interested in the virtual offering than in the in-person study, while participants with facilities sized over 100,000 square feet may be more interested in an in-person study; however, the small sample size of 13 meant that the evaluation team could not test these results for statistical significance.

Most Custom survey respondents said they would need more information before deciding to participate, with respondents most often requesting information about the ROI and program processes and requirements. Respondents also said they would need information about the program timeline, required time commitment, and the cost to implement program measures. A common barrier respondents saw to program participation included the cost to implement the study recommendations, and some also saw lack of staff time to participate or implement measures as a barrier. The evaluation team identified the following a potential helpful estimates to include in program marketing materials:

- Typical upfront cost to implement study recommendations
- Typical savings that can be expected from implementing study recommendations
- Typical payback period (for example, a facility sized between 5,000 and 10,000 square feet will typically spend between $X and $Y on Retro-Commissioning improvements, with a payback period between X and Y years)
- Hours per week that their facility staff will need to spend on the Retro-Commissioning study and implementation and what exactly will be required of those staff

RECOMMENDATIONS

As BASs for HVAC have the highest savings potential among the various types of building controls, consider directing any Custom customer with a BAS to the in-person Retro-Commissioning program offering to maximize the savings. Direct facilities that contain programmable or smart thermostats only to the virtual Retro-Commissioning offering. Add screening criteria to the virtual Retro-Commissioning study that alerts the customer when they would be better off financially with the in-person study.

To reduce the barrier of lack of staff time, increase the eligible implementation timeframe so that customers have more than three months to implement recommended measures. Facilities often need to request formal approval for this type of spending, which can take time. Do not require the study and measure implementation to take place within the same calendar year.

CONCLUSION 3: The 2020 Retro-Commissioning component eligibility guidance indicates that buildings with programmable thermostats are not eligible, but these buildings were still allowed into the program.

The program application contains terms and conditions of participation in the Retro-Commissioning component of the Custom Incentives program, which indicate that preferred eligible buildings are those with sophisticated control systems rather than programmable thermostats. The primary reason for this guideline is that facilities with BAS control have more advanced scheduling and sequencing parameters, allowing building managers to employ greater potential energy-saving strategies. A second reason is that buildings with a sophisticated control system tend to have larger, more complex HVAC systems, which provide greater potential for adjustments and improvements. Buildings controlled by a programmable thermostat have very limited improvement potential. In the 2020 program, at least one building was fully controlled by programmable thermostats. A second building was potentially controlled by thermostats, but the study was self-generated, and therefore the evaluation team did not have sufficient details about the control system to confirm this detail. This participant was only able to pursue limited measures, resulting in low *ex ante* savings and a high cost-to-savings ratio.

RECOMMENDATIONS

Uphold the application eligibility language to restrict the Retro-Commissioning component to buildings with BAS control.

Consider offering a unique program or path designed with scaled-down incentives and minimized documentation requirements to match the savings potential for facilities without BAS controls.

CONCLUSION 4: Occupied temperature setpoint adjustments are not typically considered viable Retro-Commissioning component measures in the long term.

It is problematic to include modifications to occupied temperature conditions as a viable Retro-Commissioning measure because gains in efficiency are typically very limited, result in negative savings as frequently as they result in positive savings, and have to potential for a very low measure life. Occupied temperatures are ultimately under the control of the building occupants, who typically adjust this frequently. It is therefore difficult to ensure that first-year savings will be sustained. Incentivizing modifications to the occupied temperature setpoints potentially creates the incentive to adjust the occupied temperature setpoints outside of the ASHRAE 55 comfort zone, or at least outside the comfort zone established by the occupants or function of the building.

RECOMMENDATIONS

Define and review the types of Retro-Commissioning measures that IPL recommends, ensuring they are quantifiable and result in meaningful energy savings. Publish these recommended eligible Retro-Commissioning measures as guidance literature for the program or discuss them with potential customers as part of the application phase.

Encourage occupied temperature setpoint adjustments as part of a larger conservation strategy, but do not provide rebates for this action as an individual, stand-alone measure. Verify the occupied setpoints with the customer to ensure that the HVAC system is operating to meet the customer expectations and occupant comfort criteria, and to ensure that zones are properly balanced.

Adjust any systems with occupied temperature setpoints outside of ASHRAE 55 comfort zone thresholds to fall within the comfort zone. In these cases, claim the adjustments to the occupied temperature setpoints as a viable Retro-Commissioning measure.

CONCLUSION 5: Heapy is increasingly using the small business retro-commissioning calculator for measure documentation, and this tool may require additional vetting.

Heapy has developed a suite of M&V tools to document measure savings, one of which was designed for small-packaged HVAC systems and primarily allows entries related to the occupied and unoccupied temperature setpoints and the scheduling of the HVAC unit. Within the measures that used this tool, there were several instances where the estimated natural gas savings were overestimated. In one instance, the expected natural gas savings for the measure was nearly equal to the total natural gas consumption at the facility. Since IPL is not a natural gas utility, this error is inconsequential to the evaluation scope. However, this error might indicate that the small business retro-commissioning calculator in particular needs additional quality control verification to produce accurate savings, particularly if Heapy will continue using this tool for Retro-Commissioning projects in subsequent years.

RECOMMENDATION

As the Retro-Commissioning component continues to grow, and as the virtual Retro-Commissioning component starts up, the accuracy of the standardized savings quantification tools will become increasingly important. Conduct thorough quality control checks of any savings quantification tools to ensure that the savings being calculated are reasonably accurate for the wide range of affected buildings.

CONCLUSION 6: All Retro-Commissioning participants reported receiving measurable energy and cost savings from participation in the Retro-Commissioning component and several expressed a desire for additional feedback on continuous improvement.

Participation satisfaction with the Retro-Commissioning component remains very high, with all participants expressing that they were pleased with the energy and cost savings they achieved. A couple participants expressed interest in continuing to improve upon their positive results but were unsure of the next steps to take. Without the help of a vendor, they felt unable to identify additional viable measures to pursue. They saw a decrease in their overall utility bills, but were unsure which individual measures were successful given a lack of continuous monitoring and measurement to confirm actual savings. Some participants have unique building types and lack a network of peer building owners with whom to brainstorm energy efficiency measures and share lessons learned. IPL and Heapy are well-positioned to help participants form these networks and can provide additional recommendations and feedback on performance after the Retro-Commissioning project concludes. Retro-Commissioning participants are primed to participate in other IPL offerings given their positive experience with the program component.

RECOMMENDATIONS

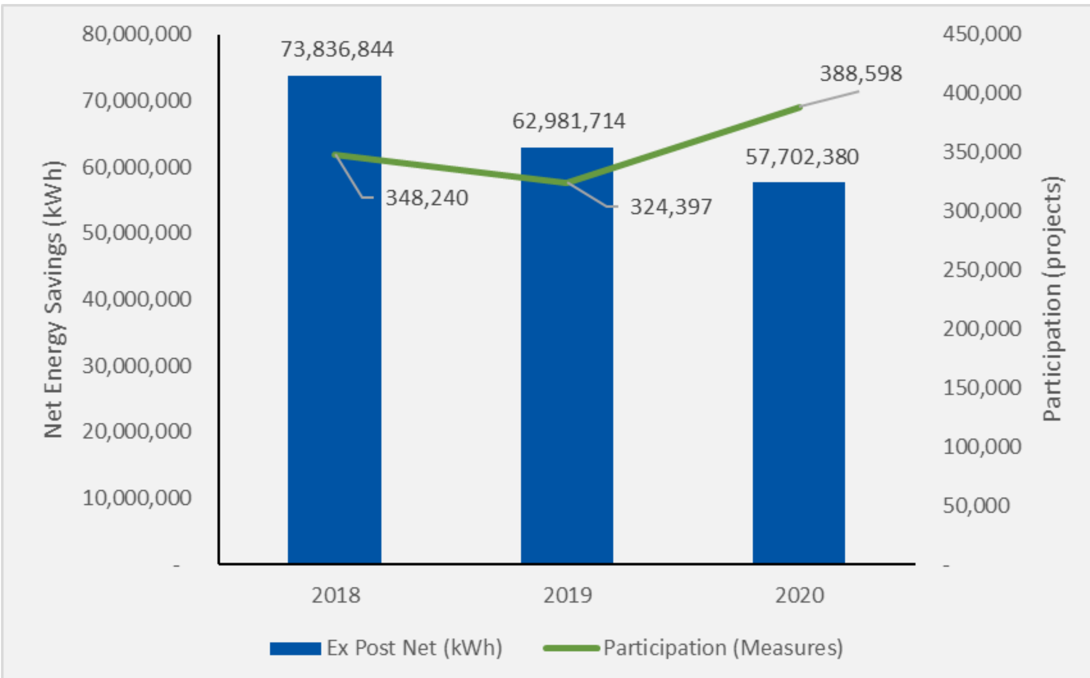
Provide participants with assistance and guidance to track their building energy performance in order to validate the program, receive buy-in from stakeholders for the measures implemented, and track ongoing performance over time. Report building-level performance back to the customer to close the feedback loop.

Assist Retro-Commissioning participants with identifying more measures to implement, other peer groups to learn from, and best practice strategies for efficient operation and continuous improvement.

Prescriptive Rebates Program

Through the Prescriptive Rebates program, IPL offers incentives for C&I customers who install energy efficiency measures (primarily high-efficiency lighting such as LEDs). In 2020, the program exceeded its energy-savings and demand reduction goals (reaching 109% and 115%, respectively). As indicated in Figure 86, participation in the Prescriptive Rebates program increased from 2019 to 2020, but net energy savings decreased, evidenced by fewer large rebated projects when compared to 2019.

Figure 86. Prescriptive Rebates Program Savings and Participation, 2018–2020



Sources: Indianapolis Power & Light Company. Year-end DSM scorecards for 2018, 2019, and 2020.; Cadmus. Demand-side management evaluation reports for 2018 and 2019.

Program Description

The program implementer, CLEAResult, oversees program management, direct program marketing to customers, and program delivery. CLEAResult relies on trade allies to promote and deliver the program to customers, supplemented by outreach support from IPL and direct program marketing from CLEAResult. IPL delivers a portion of the Prescriptive Rebates program's lighting incentives through local lighting distributors via the Midstream delivery channel. Through this delivery channel, lighting distributors offer point-of-sale incentives to nonresidential IPL customers for the purchase of energy-efficient lighting products. The Prescriptive Rebates program still achieves a majority of its savings through the traditional, Non-Midstream delivery channel, through which participants or contractors apply for rebates for installed energy efficiency measures.

Research Objectives

For the 2020 program year, the evaluation team addressed several research objectives:

- Determine whether the program is meeting its goals and objectives
- Assess customer satisfaction with various program aspects
- Assess contractor satisfaction with the program and barriers to participation
- Assess customer interest in virtual and in-person retro-commissioning offerings
- Identify whether the program has influenced customers' decisions and behaviors to purchase energy-efficient equipment
- Estimate a program NTG value
- Determine program energy savings and demand reduction

Research Approach

To answer the research objectives outlined above, the evaluation team conducted several activities:

- Interviewed IPL and CLEAResult staff
- Surveyed 2020 participants
- Interviewed non-lighting contractors
- Assessed savings reported in VisionDSM extracts (CLEAResult's program tracking database) against project documentation
- Examined whether claimed savings algorithms aligned with the Indiana TRM (v2.2) or other appropriate secondary sources
- Determined any reduction in verified savings using ISRs calculated from on-site EM&V
- Assessed the accuracy of prescriptive savings assumptions in describing the building types and operating schedules of installed equipment through site visits and desk reviews

Program Performance

The 2020 Prescriptive Rebates program achieved 109% of its net energy-savings goal and surpassed its peak demand reduction goal, achieving 115% of planned savings. Table 228 shows the net goal, *ex post* actuals, and percentage of goal, along with the budget and expenditures for the Prescriptive Rebates program. The program exceeded its *ex ante* goals and on budget.

Table 228. 2020 Prescriptive Rebates Program Expenditures, Participation, and Savings

Metric	Net Goal [a]	*Ex Post Net*	Percentage of Goal
Energy Savings (kWh)	53,078,008	57,702,380	109%
Demand Reduction (kW)	8,601	9,877	115%
Participation (Units) [b]	N/A	388,598	N/A
Budget	$10,197,060	$10,045,203	99%

Note: Values rounded for reporting purposes.

[a] Goals per IPL's Settlement in DSM Cause #44945.

[b] Units are defined as a single fixture or installed item (such as a 2x2 LED fixture) or, for some equipment, units are a measure of capacity, such as controlled wattage for lighting controls. This report defines measures as the smallest granular tracking record for a program, which is generally a unit or collection of units installed in a given project and grouped at the measure category level (such as three 2x2 LED fixtures installed at Site A).

Table 229 presents 2020 savings for the Prescriptive Rebates program. *Ex post* gross energy savings and demand reduction yielded lower savings compared with *ex ante* savings for both delivery channels. Similar to previous years, the lower savings for the Midstream delivery channel was primarily driven by a lower ISR for Midstream measures while lower savings for the Non-Midstream delivery channel were driven by differences in annual hours of operation.[58] This issue, as well as other EM&V findings, drove the realization rates, as discussed in the *Ex Post Gross Savings* section.

Table 229. 2020 Prescriptive Rebates Program Savings Summary

Metric	*Ex Ante* Gross [a]	Audited	Verified	*Ex Post* Gross	*Ex Post* Net
Non-Midstream					
Energy Savings (kWh)	50,746,371	50,032,426	50,012,945	45,212,036	37,978,110
Demand Reduction (kW)	7,496	7,298	7,295	7,178	6,029
Midstream					
Energy Savings (kWh)	22,524,501	25,222,570	24,388,970	19,777,025	18,788,174
Demand Reduction (kW)	4,206	4,356	4,212	3,875	3,682
2016-2019 Midstream Carryover Savings					
Energy Savings (kWh)	N/A	N/A	N/A	1,101,289	936,096
Demand Reduction (kW)	N/A	N/A	N/A	195	166
Total Program					
Energy Savings (kWh)	73,270,872	75,254,996	74,401,915	66,090,350	57,702,380
Demand Reduction (kW)	11,702	11,654	11,507	11,248	9,877

Note: Values rounded for reporting purposes.

[a] The 2020 IPL scorecards report the aggregated savings for the Prescriptive Rebates program Non-Midstream and Midstream delivery channels combined. The team sourced *ex ante* savings in this table from data extracts in VisionDSM to illustrate the savings share of each delivery channel. The team verified that, when combined, the VisionDSM savings match the scorecards.

Table 230 presents the *ex post* gross and net energy adjustment factors resulting from the evaluation, with realization rates for energy savings and demand reduction. The Non-Midstream delivery channel measures had a NTG of 84% and the Midstream delivery channel measures had a NTG of 95%. The NTG for the program as a whole, including Midstream carryover savings, was 87%.

Table 230. 2020 Prescriptive Rebates Program Realization Rates and Net-to-Gross Summary

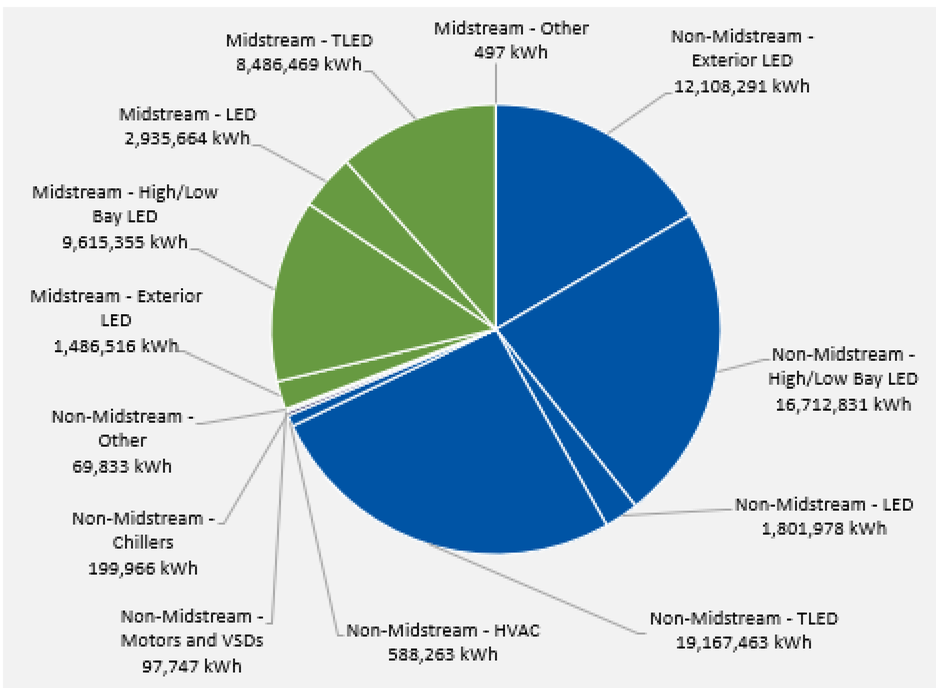
Realization Rate		Program Component	Freeridership	Spillover	NTG
Energy Savings (kWh)	Demand Reduction (kW)				
89.1%	95.8%	Non-Midstream	16%	0%	84%
87.8%	92.1%	Midstream	5%	0%	95%
N/A	N/A	2016-2020 Midstream Carryover Savings	15%	0%	85%
90.2%	**96.1%**	**Total Program**	**13%**	**0%**	**87%**

58 As in previous years, the 2020 Midstream delivery channel ISR was largely driven by stored bulbs, so a portion of the unachieved savings in 2020 will be evaluated as carryover savings in future program evaluations.

Impact Evaluation

In 2020, the Prescriptive Rebates program accounted for 73.3 million kilowatt-hours in *ex ante* savings through its delivery channels: Non-Midstream and Midstream. The Non-Midstream delivery channel measures accounted for 69.3% of the total rebated measures and 69.7% of total program *ex ante* savings in 2020 (where lighting measures accounted for 99% of the rebated Non-Midstream measures). The Midstream delivery channel measures accounted for 30.7% of the total Prescriptive Rebates program measures and 30.3% of total *ex ante* savings. Because the Midstream and Non-Midstream delivery channels are administered differently, the team evaluated the two populations of measures separately, calculating distinct ISRs and realization rates for each delivery channel. Figure 87 illustrates the Prescriptive Rebates program population (including Non-Midstream and Midstream delivery channels) by energy savings and measure type.

Figure 87. 2020 Prescriptive Rebates Program *Ex Ante* Savings Distribution by Measure Category



Note: The evaluation team grouped and defined measure categories in this figure based on the "Equipment Name" field in the tracking database.

LED lamps and fixtures dominated 2020 savings for the Midstream delivery channel, accounting for over 99% of claimed savings. For the Non-Midstream delivery channel, the most common measures in 2020 were linear LED fixtures (38.5% of lighting savings), followed by high/low bay LED fixtures (33.6% of lighting savings), exterior LED fixtures (24.3% of lighting savings), and general LED fixtures. Non-lighting measures contributed only 1.3% of the energy savings in the 2020 Prescriptive Rebates program. This is lower than in previous years, when non-lighting measures represented between 2% and 5% of energy savings. Within the non-lighting measures, 93% of savings came from heating and cooling equipment, chillers, and motors and variable frequency drives (VFDs).

The evaluation team's impact approach was consistent with prior years. In 2018, 2019, and 2020, the team confirmed that CLEAResult used the same methodology to determine savings for the Midstream and Non-Midstream delivery channel measures (based on evaluation recommendations), using site-specific inputs based on building type and installed fixture wattage. CLEAResult supplied documentation for each sampled project measure to support the data tracked in the VisionDSM database.

To analyze the impact of the Prescriptive Rebates program in 2020, the team selected a sample of measures for each delivery channel and extrapolated findings to the larger population. The team assigned each delivery channel a unique ISR and realization rate, then determined the evaluation sample for each delivery channel using a PPS sampling approach. Table 231 shows the unit and measure populations, actual and target measures in the sample, and the sample's share of energy savings for the Prescriptive Rebates program.[59]

Table 231. 2020 Prescriptive Rebates Program Impact Sample Characteristics

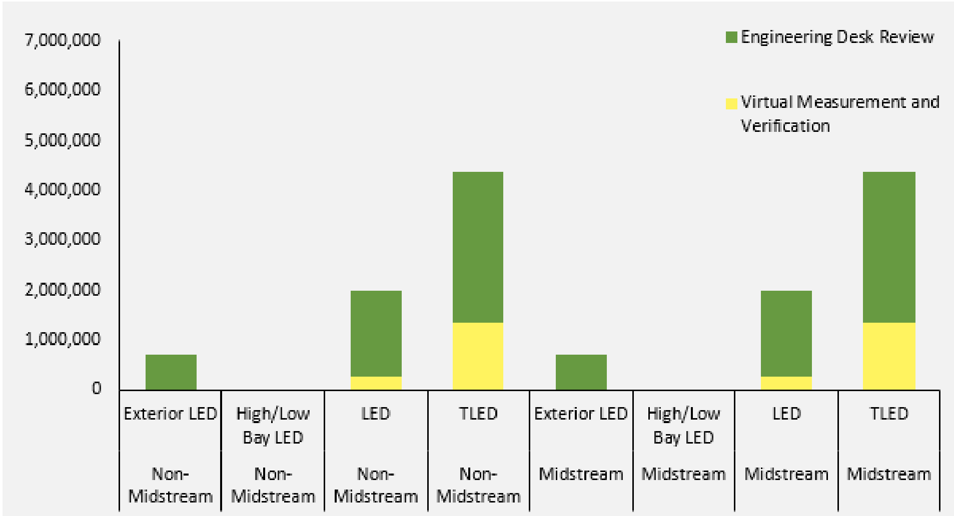
Gross Population Count		Virtual Site Visit Sample Measure Count		Total Sample Measure Count		Evaluation Sample Share of Program Energy Savings
Unit	Measure	Actual	Target	Actual	Target	
Non-Midstream	322,631	7	9	41	42	14%
Midstream	65,967	11	18	35	44	14%
Total	**388,598**	**18**	**27**	**76**	**86**	**14%**

To inform sampling targets for the Non-Midstream delivery channel in 2020, the team used findings from the 2015 through 2019 evaluations. By understanding the savings variability (error ratio) for these measures, the team could more efficiently target the sample. The 2020 sample predicted that 42 Non-Midstream measures and 44 Midstream measures would need to be evaluated to achieve 90% confidence at ±10% precision for the realization rates. The final sample for the Non-Midstream delivery channel achieved an energy realization rate of 89% (at 90% confidence with ±9.03% relative precision), while the Midstream delivery channel achieved an energy realization rate of 87.8% (at 90% confidence with ±13.49% relative precision). A higher-than-typical refusal rate from participants and delays in project data delivery limited the target sample count.

The 2020 evaluation sample for Midstream and Non-Midstream represented 14% of the total Prescriptive Rebates program energy savings. Figure 88 shows the breakdown of on-site EM&V analysis and engineering desk reviews for various measure categories in the sample.

[59] This report defines a unit as a single fixture or installed item and defines a measure as the smallest granular tracking record for a program, which is generally a unit or collection of units installed at a given project and grouped at the measure category level (such as three 2x4 LED fixtures installed at Site A).

Figure 88. 2020 Prescriptive Rebates Program Evaluation Sample *Ex Ante* Distribution by Measure Category



Ex ante energy savings in the sample closely correlated to the distribution of measure types in the total Prescriptive Rebates program population. The team conducted virtual site visits to verify the installation of 11 Midstream measures and seven Non-Midstream measures and calculated a separate ISR for each delivery channel.[60] The team performed an engineering review of virtual site visit measures using the EM&V data, supplemented with additional engineering desk reviews of other projects to increase the sample to 35 Midstream and 41 Non-Midstream measures.

Audited Savings

The evaluation team calculated audited savings based on CLEAResult's savings calculation methodology and using the quantity of installed units, building type, baseline equipment efficiency, and installed equipment efficiency. Audited savings are essentially a comparison of reported savings from the tracking data to details shown in the project files. Similar to prior years, audited savings generally aligned well with *ex ante* savings. Most adjustments to *ex ante* savings were small and resulted from minor discrepancies in lamp wattage reported in the database versus the project files, such as an efficient 9.5-watt lamp being listed in the tracking data and used for calculations, while the project files indicated a 9-watt lamp. The evaluation team's recalculations resulted in 75,254,996 kWh of savings per year (103% of the program *ex ante* value) and 11,654 kW of peak demand reduction (100% of the *ex ante* value).

Table 232 summarizes the audited and *ex ante* savings for each delivery channel and for the program overall in 2020.

[60] The evaluation plan includes conducting site visits each year to validate measure ISRs over the three-year evaluation cycle (2018 to 2020), where the ISRs combined over the three years achieve ±10% precision at the 90% confidence level.

Table 232. Audited Savings Summary by 2020 Prescriptive Rebates Program Delivery Channel

Metric	*Ex Ante* [a]	Audited
Non-Midstream		
Energy Savings (kWh)	50,746,371	50,032,426
Demand Reduction (kW)	7,496	7,298
Midstream		
Energy Savings (kWh)	22,524,501	25,222,570
Demand Reduction (kW)	4,206	4,356
Total Program		
Energy Savings (kWh)	73,270,872	75,254,996
Demand Reduction (kW)	11,702	11,654

[a] The 2020 IPL scorecards reported the aggregated savings for the Prescriptive Rebates program Non-Midstream and Midstream delivery channels combined. The team sourced *ex ante* savings in this table from data extracts in VisionDSM to illustrate the savings share of each delivery channel. The team verified that, when combined, the VisionDSM savings matched the scorecards.

Verified Savings

The evaluation team determined verified savings based on CLEAResult's energy-savings calculation methodology and supplemented with data collected through virtual site visits (which the team used to determine the ISR). Ultimately, the verified savings are equal to the audited savings multiplied by the ISR. The evaluation team conducted virtual site visits to verify the installation of seven sampled measures from the Non-Midstream delivery channel and 11 sampled measures from the Midstream delivery channel. Table 233 lists the sampled measures where differences existed between the *ex ante* and *ex post* quantities in the midstream channel, along with details related to those discrepancies.

Table 233. 2020 Prescriptive Rebates Program In-Service Rate Adjustments

Site	Channel	Technology	*Ex Ante* Quantity	*Ex Post* Quantity	Discrepancy Notes
1	Midstream	LED	432	100	A virtual site visit revealed that the majority of bulbs were in storage.
2	Midstream	High Bay/Low Bay LED	28	22	A virtual site visit revealed that six bulbs that were kept in storage.

The team found no discrepancy within the Non-Midstream delivery channel and calculated a verified ISR of 100.0% with a relative precision of ±0.2% at 90% confidence, and verified ISR of 96.7% with a precision of ±16.0% at 90% confidence for the Midstream channel. The team applied these verified ISRs to the audited savings to calculate the verified savings for both delivery channels (shown in Table 202).

Table 234. Verified Savings Summary by 2020 Prescriptive Rebates Program Delivery Channel

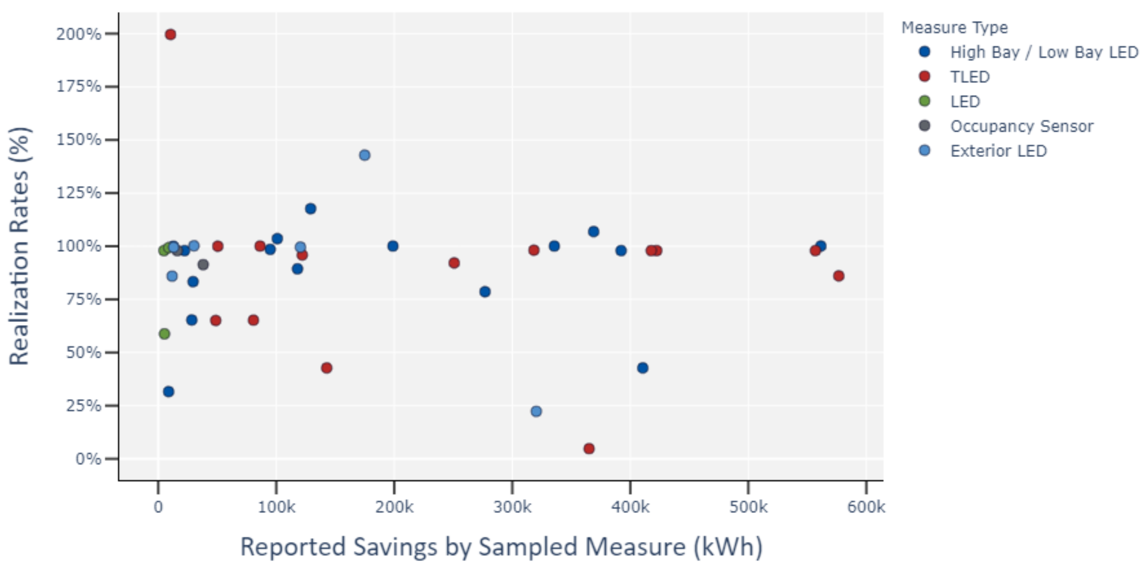
Metric	Audited	ISR	Verified
Non-Midstream			
Energy Savings (kWh)	50,032,426	100.0%	50,012,945
Demand Reduction (kW)	7,298		7,295
Midstream			
Energy Savings (kWh)	25,222,570	96.7%	24,388,970
Demand Reduction (kW)	4,356		4,212
Total Program			
Energy Savings (kWh)	75,254,996	98.9%	74,401,915
Demand Reduction (kW)	11,654		11,507

Note: Values rounded for reporting purposes.

Ex Post Gross Savings

The evaluation team determined *ex post* savings by using the savings calculation methodologies outlined in the Indiana TRM v2.2, the UMP's Commercial and Industrial Lighting Evaluation Protocol,[61] and lumen equivalency values from the UMP's Residential Lighting Evaluation Protocol.[62] The team used data we collected through virtual site visits or engineering desk reviews to supplement the evaluated energy-savings calculations. Figure 89 and Figure 90 illustrate the reported energy savings and demand reduction, respectively, along with associated realization rates by measure type for Non-Midstream sampled measures.

Figure 89. 2020 Prescriptive Rebates Program Non-Midstream Energy Savings Sample Results



61 "Chapter 2:Commercial and Industrial Lighting Evaluation Protocol." https://www.nrel.gov/docs/fy17osti/68558.pdf

62 "Chapter 21: Residential Lighting Evaluation Protocol." https://www.nrel.gov/docs/fy17osti/68562.pdf

Figure 90. 2020 Prescriptive Rebates Program Non-Midstream Demand Reduction Sample Results

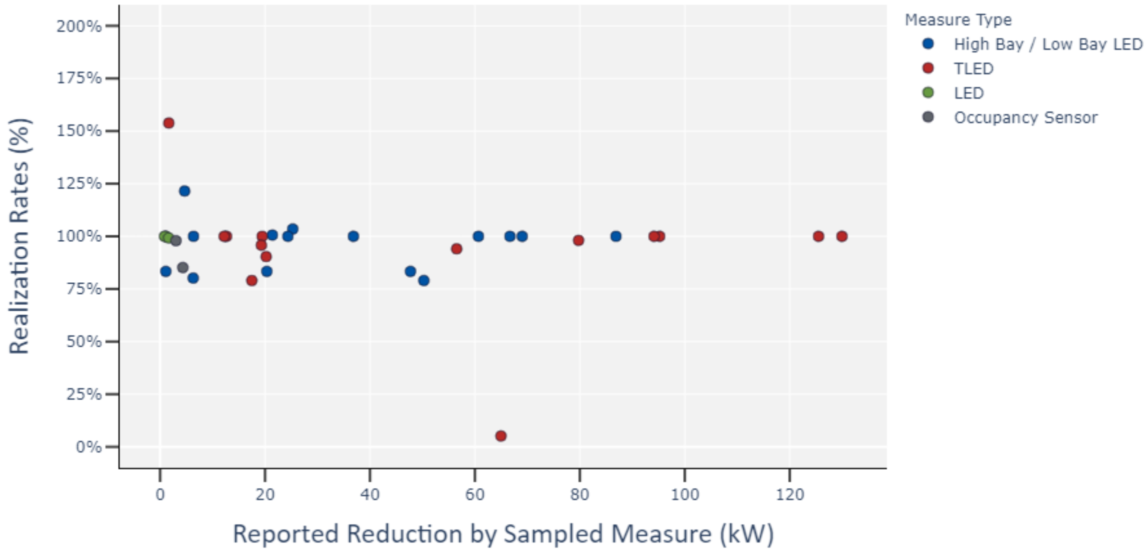


Figure 91 and Figure 92 illustrate the reported energy savings and demand reduction, respectively, along with associated realization rates by measure type for Midstream sampled measures.

Figure 91. 2020 Prescriptive Rebates Program Midstream Energy Savings Sample Results

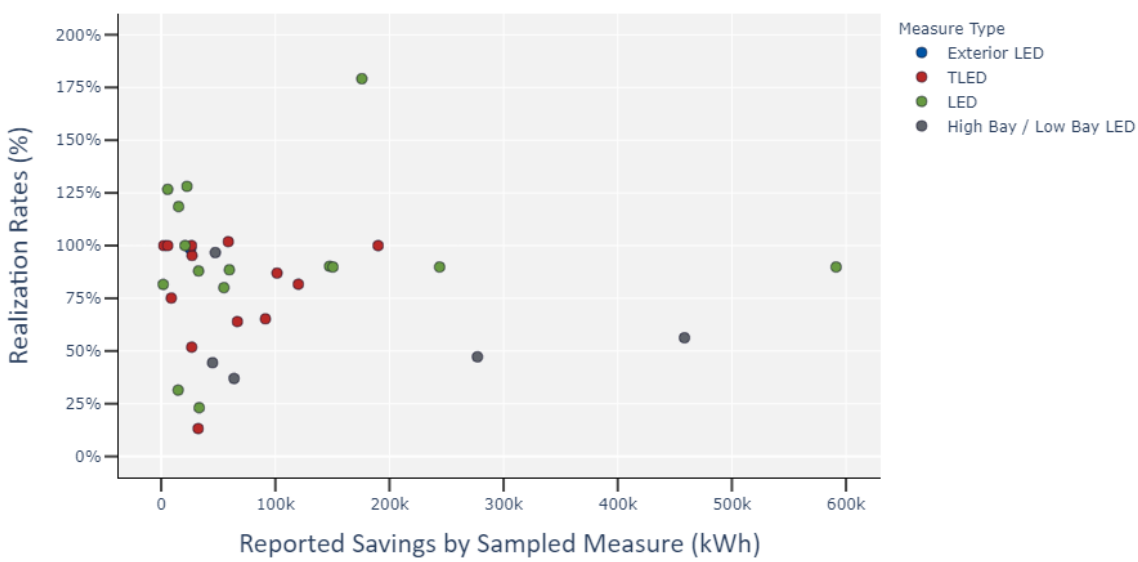
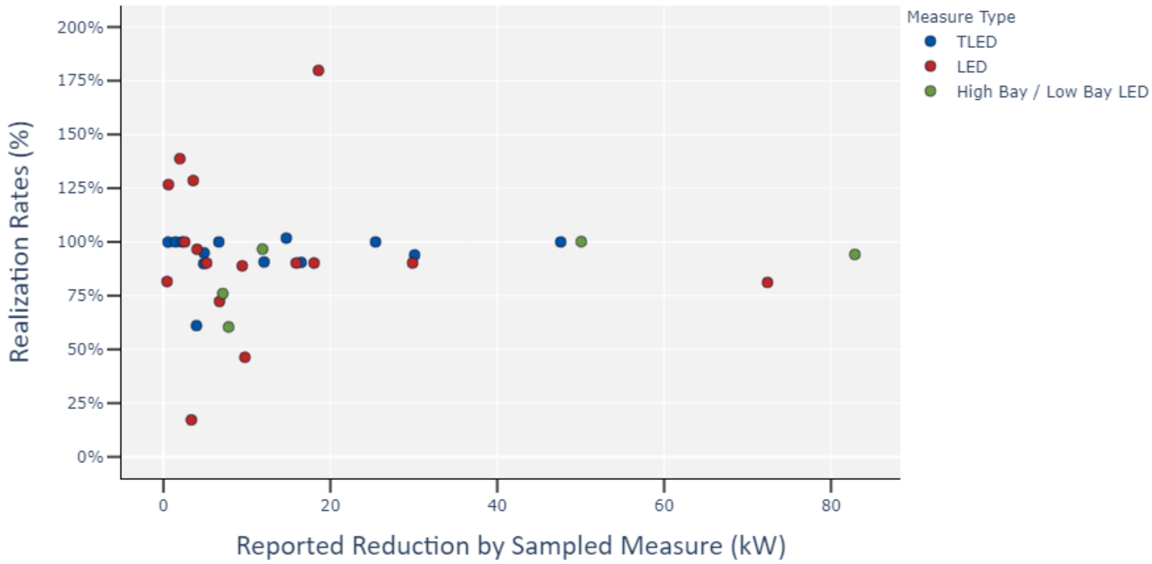


Figure 92. 2020 Prescriptive Rebates Program Midstream Demand Reduction Sample Results

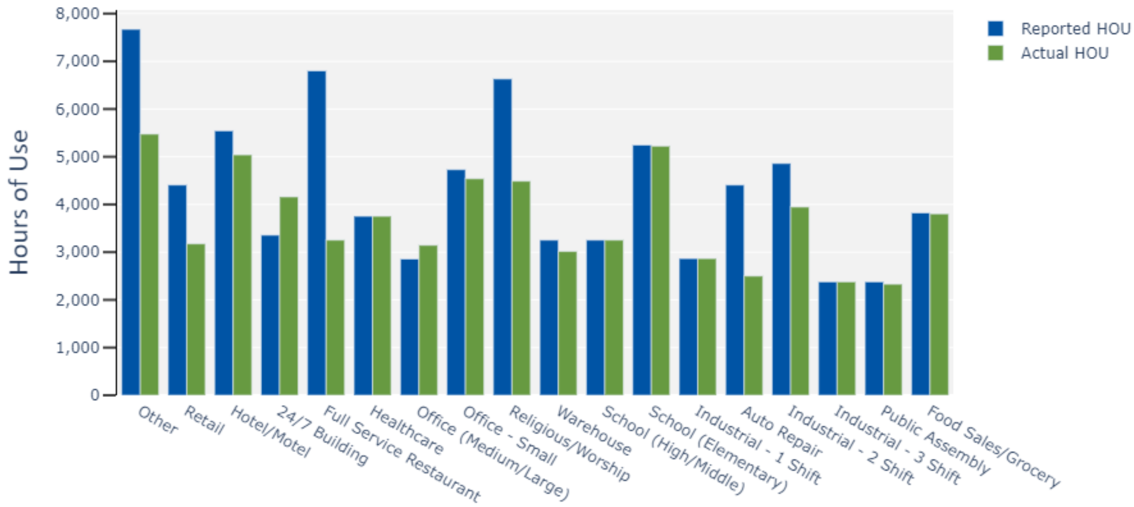


All measure types exhibited realization rates above and below 100%; that is, a portion of sampled measures for all measure types exhibited one or more discrepancies:

- AOH reported by facility managers that was lower or higher than the actual AOH. Evaluated savings based on more accurate AOH result in lower or higher realized energy savings.
- Facility type selected by CLEAResult that did not closely match the actual facility type. When using the defined AOH by facility type from the Indiana TRM (v2.2), the evaluated savings may be lower or higher than reported.
- Rebated measures that had been put into storage. Uninstalled measures impacted the ISR and ultimately resulted in reduced realized energy savings.
- Installed measure energy use did not match reported energy savings. In some cases, a rebated bulb or fixture may use more or less energy than the value reported, leading to lower or higher evaluated energy savings when based on the actual bulb wattage.
- Clerical errors resulted in some discrepancies between reported and realized energy savings.

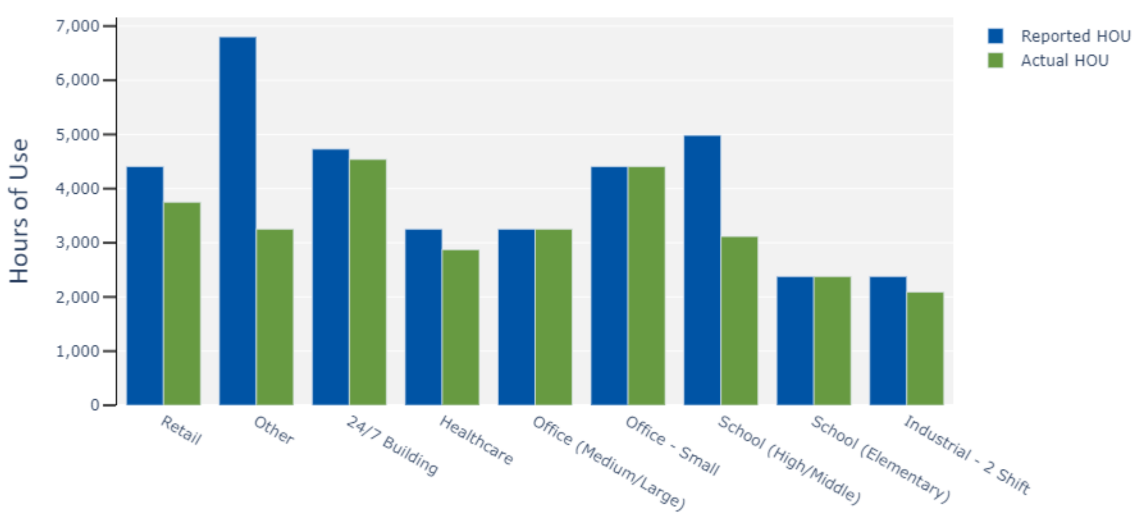
Similar to the 2019 evaluation, 2020 evaluation adjustments to AOH had the largest impact on the energy-savings realization rates for both delivery channels. The team adjusted AOH for 17 Non-Midstream and 15 Midstream sampled measures. Among the adjusted measures, the average reported AOH was 5,100 hours and the average adjusted AOH was 3,461 hours. For these measures, evaluated energy savings were lower than reported by 46% due to the reduced AOH. As shown in Figure 93, the Healthcare, Industrial, Religious/Worship, and 24/7 Building facility types exhibited the greatest deviations between average reported and average actual AOH.

Figure 93. 2020 Prescriptive Rebates Program Average Reported and Actual Hours of Use by Building Type



The evaluation team conducted virtual site visits and facility staff interviews for 10 of the 32 sampled measures that had lower evaluated AOH than reported. The largest differences in AOH from virtual site visits and facility staff interviews were found in the 24/7, Retail, and School facility types, as shown in Figure 94. Among all Midstream and Non-Midstream prescriptive customers contacted by the evaluation team, the average actual AOH was 22% lower than the reported AOH, with a corresponding average energy savings realization rate of 83.3%.

Figure 94. 2020 Prescriptive Rebates Program Average Hours of Use by Facility Type for Virtual Site Visits



The team adjusted AOH based on the facilities' posted operation hours, which resulted in higher AOH for seven sites and lower AOH for 15 sites.

- For the seven sites where the actual AOH was higher than reported, the AOH adjustments did not consistently match to a specific measure type. These sites had an average reported AOH of 3,952 and an actual AOH of 5,294 (for an average increase of 34%).
- For the 15 sites with lower actual AOH than reported, the most common facility type was a 24/7 Building. Based on the posted operating hours for these facilities, the average actual AOH was 3,336 hours. Building types varied for the remaining sites, with an average reduction in AOH from 4,588 to 2,957 (36%).

The evaluation team then determined ISR. Two customers installed fewer measures than were incentivized (as was detailed in Table 233). The overall ISR has improved from 91.5% in 2019 to 96.7% in 2020 for the Midstream channel. The Non-Midstream channel exhibited a 100.0% ISR.

For Midstream delivery channel measures, where the wattage of the replaced lamp or fixture is often unknown at the time of sale and is not reflected in the measure definition, the team made *ex post* adjustments on a case-by-case basis to align baseline wattage and efficiencies with the UMP and current federal minimum requirements.[63] CLEAResult sourced its baseline wattage lookup tables from a memo it had prepared for the 2016 evaluation,[64] which described baseline wattage assumptions from a 2010 U.S. Department of Energy *Market Lighting Characterization* study. For this evaluation, the team determined baseline wattages for Midstream measures using the lumen equivalence method described in the UMP: This is best practice for estimating the wattage of replaced equipment to determine program savings and is a more current approach than the details outlined in the 2010 *Market Lighting Characterization* study.

The lumen equivalence method assumes that customers purchase bulbs with similar lighting characteristics to those already installed and relies on maximum wattage requirements for bulbs, by lumens range, based on EISA 2007. The team used this method to determine baseline bulb wattages based on the lumen output of purchased bulbs (as provided in specification sheets for the installed fixtures or lamps), and sometimes found higher or lower lumens than that used by CLEAResult.

Clerical errors occasionally occur when documenting savings. One sampled project misreported savings for linear LED measures. The project documentation indicated that 4-foot linear LEDs were installed at a grocery

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63 Government Publishing Office. Last modified April 1, 2020. "Electronic Code of Federal Regulations: Energy Conservation Program for Consumer Products." https://www.ecfr.gov/cgi-bin/text-idx?SID=2fed8aa79758a538d0878801f58a3312&mc=true&node=se10.3.430_132&rgn=div8; Government Publishing Office. Last modified April 1, 2020. "Electronic Code of Federal Regulations: Part 431—Energy Efficiency Program for Certain Commercial and Industrial Equipment." https://www.ecfr.gov/cgi-bin/text-idx?SID=d4564d0dc7aca6e97a8b4c1dcc774eb0&mc=true&node=pt10.3.431&rgn=div5

64 Core Engineering and CLEAResult. January 2017. *Savings Methodology for Midstream Commercial Lighting Measures.*

store, while the database indicated that 8-foot linear LEDs were installed. Because of the corresponding change to the baseline and installed energy use, lower savings were realized for these measures.

Midstream Carryover Savings

In 2016, the evaluation team calculated the first-year ISR for the Midstream delivery channel as 79.1%, finding that program participants, on average, stored 20.9% of lighting units they received through the program. To account for the portion of these bulbs that participants would install in year two (2017), the team followed the installation schedule described in the UMP. This schedule assumes that 24% of stored bulbs will be installed in year two (and in each subsequent year). The evaluation team has used this method to carry savings over from stored bulbs each year since 2016.

The 2020 *ex post* analysis includes year five carryover from 2016, year four carryover savings from 2017, year three carryover savings from 2018, and year two carryover savings from 2019 (with full carryover savings shown in Table 235). The team incorporated these carryover savings into the *ex post* gross and net savings for the Prescriptive Rebates program.

Table 235. 2020 Prescriptive Rebates Program Savings Summary (Carryover)

Metric	Year Five Carryover Savings (from 2016)	Year Four Carryover Savings (from 2017)	Year Three Carryover Savings (from 2018)	Year Two Carryover Savings (from 2019)	Total Carryover Savings in 2020
***Ex Post* Gross**					
Energy Savings (kWh)	871,068	387,285	420,047	190,533	**1,868,933**
Demand Reduction (kW)	154.5	68.1	66.6	27.8	**317.0**
***Ex Post* Net**					
Energy Savings (kWh)	792,672	360,175	365,440	177,196	**1,695,484**
Demand Reduction (kW)	140.6	63.3	57.9	25.9	**287.7**

Realization Rates

Table 236 shows the program realization rates and ISRs. The Non-Midstream delivery channel achieved a realization rate of 89.1% for energy savings and 95.8% for demand reduction. The Midstream delivery channel had lower realization rates of 87.5% for energy savings and 92.1% for demand reduction.

Table 236. 2020 Prescriptive Rebates Program Realization Rates

Delivery Channel	Realization Rate (*Ex Post* Gross/*Ex Ante*)		ISR	ISR Precision at 90% Confidence
	Electric Energy (kWh)	Peak Demand (kW)		
Non-Midstream	89.1%	95.8%	100.0%	±0.2%
Midstream	87.8%	92.1%	96.7%	±16.0%

To calculate the *ex post* gross impacts, the team applied each sample's energy and demand realization rates to the *ex ante* energy savings and demand reduction of the corresponding delivery channel, as shown in Table 237. The team calculated realization rates based on the sample and applied the results to the population *ex ante* impacts for each delivery channel.

Table 237. 2020 Prescriptive Rebates Program Realization Rates and *Ex Post* Gross Savings

Metric	*Ex Ante*	Realization Rate	*Ex Post* Gross
Non-Midstream			
Electric Energy Savings (kWh)	50,746,371	89.1%	45,212,036
Peak Demand Reduction (kW)	7,496	95.8%	7,178
Midstream			
Electric Energy Savings (kWh)	22,524,501	87.8%	19,777,025
Peak Demand Reduction (kW)	4,356	92.1%	4,013

Note: Values rounded for reporting purposes.

Ex Post Net Savings

The evaluation team calculated freeridership and spillover using the methods described in *Appendix B* and the survey data collected from 2020 participants. As shown in Table 238, we estimated an 87% NTG for the Prescriptive Rebates program.

Table 238. 2020 Prescriptive Rebates Program Net-to-Gross Summary

Delivery Channel	Freeridership [a]	Spillover	NTG
Non-Midstream	16%	0%	84%
Midstream	5%	0%	95%
Overall	**13%**	**0%**	**87%**

[a] The team weighted Non-Midstream and Midstream freeridership by survey sample *ex post* gross energy savings, while we weighted overall freeridership by program population *ex post* gross energy savings.

The overall freeridership, spillover, and NTG for the 2020 Prescriptive Rebates program are heavily weighted toward the Non-Midstream delivery channel estimates, since the channel represents 70% of the total *ex post* gross population program kilowatt-hour savings. The overall *ex post* gross population NTG of 87% for the 2020 Prescriptive Rebates program is consistent with savings-weighted NTG averages of 88% and 90% for the 2018 and 2019 Prescriptive Rebates program evaluations, respectively.

Freeridership

The overall 13% freeridership for the Prescriptive Rebates program is the population savings-weighted average of the delivery channel–specific freeridership estimates based on survey feedback (shown in Table 239). Each delivery channel freeridership estimate is an average of the savings-weighted *intention* and *influence* freeridership scores from respondents. Refer to *Appendix B* and the subsections below for further details on the *intention* and *influence* questions and scoring methodologies.

Table 239. 2020 Prescriptive Rebates Program Freeridership Results

Delivery Channel	Responses (n)	Freeridership [a]	*Ex Post* Gross Population Savings (kWh)
Non-Midstream	40	16%	45,212,036
Midstream	26	5%	19,777,025
Overall	**66**	**13%**	**64,989,061**

[a] The team weighted Non-Midstream and Midstream freeridership by survey sample *ex post* gross kilowatt-hour savings, while we weighted overall freeridership by program population *ex post* gross energy savings.

The overall *ex post* gross population savings-weighted freeridership of 13% for the 2020 Prescriptive Rebates program is higher than the freeridership average of 10% for the 2019 program, primarily due to an increase in Non-Midstream delivery channel freeridership from 11% in 2019 to 16% in 2020.

Intention Freeridership

The evaluation team estimated *intention* freeridership scores for all participants based on their responses to the *intention*-focused freeridership questions. The team translated their responses into a matrix value and applied a consistent, rules-based calculation to obtain the final score. As shown in Table 240, the overall *intention* freeridership score for the Prescriptive Rebates program is 21%, higher than the 2019 *intention* freeridership evaluation result of 16%.

Table 240. 2020 Prescriptive Rebates Program *Intention* Freeridership Results

Delivery Channel	Responses (n)	*Intention* Freeridership [a]
Non-Midstream	40	26%
Midstream	26	9%
Overall	**66**	**21%**

[a] The team weighted the Non-Midstream and Midstream intention freeridership scores by the survey sample *ex post* gross program energy savings, while we weighted the overall freeridership by the *ex post* gross population program energy savings.

Table 241 shows the unique Non-Midstream delivery channel participant response combinations resulting from the *intention* freeridership questions, along with the *intention* freeridership score assigned to each combination and the number of responses for each combination. An “x” indicates that a question was skipped because of the participant’s response to a previous question. The “Yes,” “Partial,” and “No” values in the table represent whether the respondent’s answer to a given question was indicative of freeridership. Table 242 shows these same details for the Midstream delivery channel.

Table 241. 2020 Prescriptive Rebates Program Non-Midstream Delivery Channel Frequency of *Intention* Freeridership Scoring Combinations

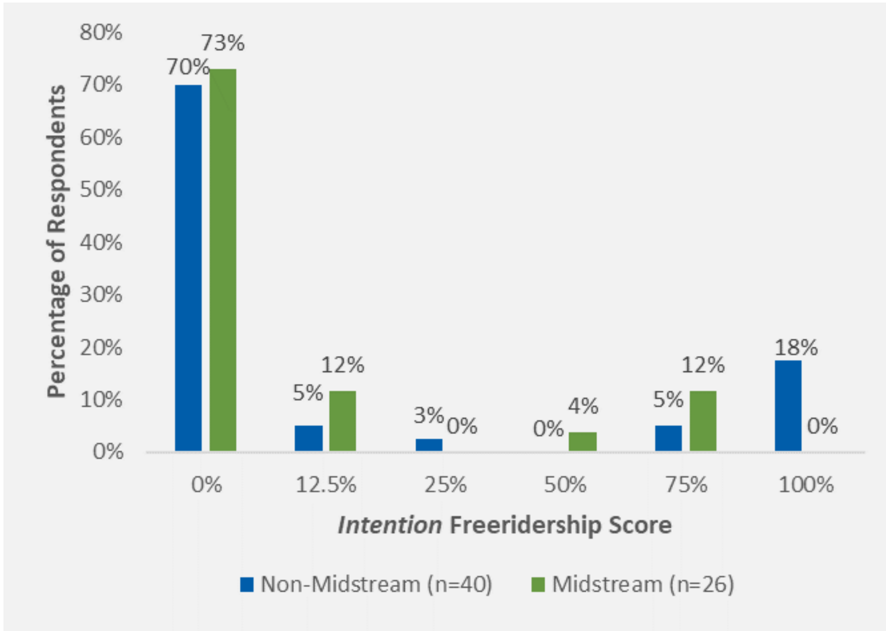
1. Installed same measure without incentive ?	2. Already ordered or installed?	3 Already planning to purchase ?	4. In capital budget ?	[Ask if 1=No] 5. Confirm, would not have installed any measure?	6. Installed same quantity?	7. Installed same efficiency?	8. Installed at the same time?	9. Organization has ROI goal?	[Ask if 9=Yes] 10. Program incentive was key to meeting goal?	Freeridership score	Response frequency
Yes	Yes	x	x	x	x	x	x	x	x	100%	5
Partial	Yes	x	x	x	x	x	x	x	x	100%	1
Yes	No	Yes	Yes	x	Yes	Yes	Yes	Yes	x	100%	1
Yes	No	Yes	Yes	x	Yes	Yes	Partial	Yes	x	75%	1
Yes	No	Yes	Partial	x	Yes	Yes	Yes	Yes	x	75%	1
Yes	No	Yes	No	x	Yes	Yes	No	x	x	0%	1
Yes	No	No	x	x	Yes	No	x	x	x	0%	1
Yes	No	No	x	x	Partial	Partial	Partial	Yes	x	0%	1
Yes	No	No	x	x	No	x	x	x	x	0%	1
Partial	No	Partial	x	x	Yes	Yes	Partial	Yes	x	25%	1
Partial	No	Partial	x	x	Yes	Partial	Partial	Yes	x	12.5%	1
Partial	No	Partial	x	x	Partial	Yes	Partial	Yes	x	12.5%	1
Partial	No	No	x	x	Yes	Yes	Partial	No	No	0%	1
Partial	No	No	x	x	Partial	Yes	Partial	No	No	0%	2
Partial	No	No	x	x	Partial	Yes	Partial	Yes	x	0%	1
Partial	No	No	x	x	Partial	Yes	No	x	x	0%	1
Partial	No	No	x	x	Partial	Partial	Partial	Yes	x	0%	2
Partial	No	No	x	x	No	x	x	x	x	0%	1
No	x	x	x	Yes	Partial	No	x	x	x	0%	1
No	x	x	x	Partial	Partial	Yes	No	x	x	0%	1
No	x	x	x	No	x	x	x	x	x	0%	14

Table 242. 2020 Prescriptive Rebates Program Midstream Delivery Channel Frequency of *Intention* Freeridership Scoring Combinations

1. Installed same measure without incentive?	2 Already planning to purchase?	[Ask if 1=No] 3. Confirm, would not have installed any measure?	4. Installed same quantity?	5. Installed same efficiency?	6. Installed at the same time?	7. Organization has ROI goal?	[Ask if 7=Yes] 8. Program incentive was key to meeting goal?	Freeridership score	Response frequency
Yes	Yes	x	Yes	Yes	Yes	No	No	50%	1
Yes	Yes	x	Yes	Yes	Partial	Yes	x	75%	3
Yes	No	x	Partial	Partial	Partial	Yes	x	0%	1
Partial	Yes	x	Partial	Yes	Partial	No	No	0%	1
Partial	No	x	Yes	Yes	Partial	Yes	x	12.5%	2
Partial	No	x	Yes	Partial	No	x	x	0%	1
Partial	No	x	Partial	Yes	Partial	Yes	x	0%	2
No	x	Yes	Partial	Yes	Partial	Yes	x	12.5%	1
No	x	Yes	x	No	x	x	x	0%	1
No	x	No	x	x	x	x	x	0%	13

Figure 95 shows the distribution of *intention* freeridership scores by delivery channel.

Figure 95. Distribution of *Intention* Freeridership Scores by 2020 Prescriptive Rebates Program Delivery Channel



Influence Freeridership

The evaluation team assessed *influence* freeridership by asking participants how important various program elements were in their purchase decision. Table 243 shows program elements participants rated for importance, along with a count and average rating for each factor.

Table 243. 2020 Prescriptive Rebates Program *Influence* Freeridership Responses

Influence Rating	*Influence* Score	IPL Incentive/ Discount		Energy-Saving Opportunities Information from IPL		Recommendation from Contractor or Vendor		Previous IPL Energy Efficiency Program Participant	
		Non-Midstream	Midstream	Non-Midstream	Midstream	Non-Midstream	Midstream	Non-Midstream	Midstream
1 - Not at all important	100%	0	0	0	0	1	0	2	0
2	75%	1	0	6	4	4	4	7	5
3	25%	13	6	21	10	15	5	6	4
4 - Very important	0%	25	19	8	11	18	17	7	8
Not applicable	50%	1	0	5	1	2	0	18	9
Average Rating		**3.6**	**3.8**	**3.1**	**3.3**	**3.3**	**3.5**	**2.8**	**3.2**

We determined each respondent's *influence* freeridership rate by using the maximum rating provided for any factor in Table 243. As shown in Table 244, the respondents' maximum *influence* ratings ranged from 1 (*not at all important*) to 4 (*very important*). A maximum score of 1 means the customer ranked all factors from the table as *not at all important*, while a maximum score of 4 means the customer ranked at least one factor as *very important*. Counts refer to the number of "maximum *influence*" responses for each factor/*influence* score response option. The team weighted the average *influence* scores for both delivery channels by *ex post* kilowatt-hour program savings. The overall *intention* freeridership score for the Prescriptive Rebates program is 4% after weighting the delivery channel–specific *influence* freeridership scores by delivery channel *ex post* gross population program kilowatt-hour savings.

Table 244. 2020 Prescriptive Rebates Program *Influence* Freeridership Score

Maximum *Influence* Rating	*Influence* Score	Non-Midstream			Midstream		
		Count	Total Survey Sample *Ex Post* Savings (kWh)	*Influence* Score Savings (kWh)	Count	Total Survey Sample *Ex Post* Savings (kWh)	*Influence* Score Savings (kWh)
1 - Not at all important	100%	0	0	0	0	0	0
2	75%	0	0	0	0	0	0
3	25%	8	3,294,719	823,680	2	101,833	25,458
4 - Very important	0%	32	9,814,157	0	24	1,881,007	0
Not applicable/Don't know	50%	0	0	0	0	0	0
Average Maximum *Influence* Rating (Simple Average)		**Non-Midstream: 3.8**			**Midstream: 3.9**		
Average *Influence* Score (Weighted by *Ex Post* Savings)		**Non-Midstream: 6%**			**Midstream: 1%**		

Final Freeridership

Next, we calculated the mean of the *intention* and *influence* freeridership components to estimate final freeridership for each program delivery channel.

$$Final\ Freeridership = \frac{Intention\ FR\ Score\ + Influence\ FR\ Score}{2}$$

The higher the freeridership score, the more savings are deducted from the gross savings estimates. Table 245 shows the *intention*, *influence*, and final freeridership scores by delivery channel.

Table 245. 2020 Prescriptive Rebates Program Freeridership Score

Delivery Channel	Responses (n)	*Intention* Score [a]	*Influence* Score [a]	Freeridership Score
Non-Midstream	40	26%	6%	16%
Midstream	26	9%	1%	5%
Overall	**66**	**21%**	**4%**	**13%**

[a] The team weighted the Non-Midstream and Midstream *intention* and *influence* freeridership scores by the survey sample *ex post* gross program energy savings, while we weighted the overall *intention* and *influence* freeridership scores by the *ex post* gross population program energy savings.

Spillover

The evaluation team estimated spillover measure savings using specific information about participants determined through the evaluation and relying on the Indiana TRM (v2.2) as a baseline reference.

One Non-Midstream delivery channel participant and one Midstream delivery channel participant rated the overall Prescriptive Rebates program as *very important* in their decision to install additional high-efficiency measures for which they did not receive a rebate from IPL. Table 246 shows the additional spillover measures and the total resulting energy savings.

Table 246. 2020 Prescriptive Rebates Program Spillover Measures, Quantity, and Savings

Delivery Channel	Spillover Measures	Quantity	Total Energy Savings (kWh)
Non-Midstream	LED Exit Signs	4	81
Midstream	Refrigeration Equipment	4	1,159

We estimated the percentage of program spillover by dividing the sum of additional spillover savings (as reported by survey respondents) by the total gross savings achieved by all program respondents. The spillover estimates by delivery channel are shown in Table 247.

Table 247. 2020 Prescriptive Rebates Program Spillover

Delivery Channel	Spillover Savings (kWh)	Participant Program Savings (kWh)	Spillover
Non-Midstream	81	13,108,877	0%
Midstream	1,159	1,982,840	0%

Table 248 summarizes the percentage of freeridership, spillover, and NTG by delivery channel and for the Prescriptive Rebates program overall.

Table 248. 2020 Prescriptive Rebates Program Net-to-Gross Summary

Delivery Channel	Freeridership [a]	Spillover	NTG
Non-Midstream	16%	0%	84%
Midstream	5%	0%	95%
Overall	**13%**	**0%**	**87%**

[a] The team weighted Non-Midstream and Midstream freeridership by survey sample *ex post* gross energy savings, while we weighted overall freeridership by program population *ex post* gross energy savings.

Evaluated Net Savings Adjustments

Table 249 shows the energy savings, realization rate, and NTG for the Prescriptive Rebates program.

Table 249. 2020 Prescriptive Rebates Program *Ex Post* Net and Gross Energy Savings and Demand Reduction

Program Category	*Ex Post* Gross Savings		NTG		*Ex Post* Net Savings	
	kWh	kW	kWh	kW	kWh	kW
Prescriptive Non-Midstream	45,212,036	7,178	84%	84%	37,978,110	6,029
Midstream	19,777,025	4,013	95%	95%	18,788,174	3,682
Subtotal	**64,989,061**	**11,053**	**87%**	**88%**	**56,766,284**	**9,711**
2016-2020 Midstream Carryover	1,101,289	195	85%	85%	936,096	166
Program Total	**66,090,350**	**11,248**	**87%**	**88%**	**57,702,380**	**9,877**

Process Evaluation

To determine process findings for the Prescriptive Rebates program, the evaluation team conducted a database review, participant survey, stakeholder interviews, and non-lighting contractor interviews.

Program Delivery

As in 2018 and 2019, the program exceeded its 2020 *ex ante* energy-savings and demand reduction goals while staying on target with the program budget. CLEAResult distributed 20% more program measures in 2020 than in 2019, achieving this success despite the COVID-19 pandemic.

Through the program, IPL offers prescriptive incentives to customers who implement eligible energy-saving measures, such as efficient lighting, heating and cooling, refrigeration, pumps and drives, and commercial kitchen equipment. A subset of the Prescriptive Rebates program lighting rebates are delivered by distributors through a Midstream lighting delivery channel, where the distributor deducts the incentive amount from the product price and gets reimbursed from IPL.

In 2020, the Midstream delivery channel measures accounted for 31% of the total Prescriptive Rebates program's *ex ante* kilowatt-hour savings (compared to 15% in 2019) and 36% of the total *ex ante* demand reduction (compared to 15% in 2019). Midstream delivery channel measures used 32% of the total 2020 Prescriptive Rebates program incentives budget, compared with 14% in 2019.

Impact of COVID-19 on Program Participation and Operations

While the program did not shut down at any time in 2020 due to the COVID-19 pandemic, there was a downturn in Prescriptive Rebates program applications once stay-at-home orders were issued for Indiana in March 2020. To boost program participation, IPL introduced a successful bonus offering for several measures if the customer submitted their program application between August 1 and December 1, 2020:

- Lighting measures: 25% bonus
- VFDs: 25% bonus
- HVAC measures: 50% bonus

The bonus offering appeared to have stimulated participation, especially for non-lighting measures. Overall *ex ante* savings declined by 26% from January 1 to July 31, 2020 (compared to that same time period in 2019) and non-lighting *ex ante* savings declined by 75%. During the bonus offering, overall 2020 *ex ante* savings were just 2% lower than that same time period in 2019, and 2020 non-lighting *ex ante* savings were 4% lower.

IPL also offered a trade ally bonus rebate based on the dollar amount of the customer's incentive application: $75 for incentives of $250 to $1,999 and $150 for incentives for $2,000 or above. To receive the incentive, a trade ally needed to attend a training and submit a program agreement to CLEAResult. While IPL and CLEAResult hoped that this incentive would deepen contractor engagement with the program, neither thought the strategy ended up being very effective.

The pandemic impacted how CLEAResult implemented post-installation inspections: due to limited facility access, CLEAResult offered program participants the option for in-person or virtual inspections.

Program Marketing and Outreach

CLEAResult relies on different marketing strategies for the Non-Midstream and Midstream channels.

- For the Midstream program, CLEAResult primarily relies on participating distributors to market the program to contractors.
- For the Non-Midstream channel, while CLEAResult does periodically send marketing emails to customers, it primarily markets the program to contractors and relies on those contractors to market the program to customers. CLEAResult explained that the program does not have a formal recruitment approach for contractors and has not needed to formally develop a lighting trade ally network due to the already high program participation by lighting contractors in the Indianapolis area. However, CLEAResult said low program awareness exists among area mechanical and HVAC contractors and that most of those who are aware of IPL's programs have not yet figured yet how to incorporate the program incentives into their sales process. Both IPL and CLEAResult said that it will be important to increase program participation from non-lighting contractors in future years as savings opportunities from lighting measures decline.

CLEAResult held an in-person trade ally seminar in February 2020 that was attended by approximately 80 contractors. CLEAResult focused on educating contractors about new technologies and how they could market the program to customers. CLEAResult also marketed its bonus incentives (available from August 1 to December 1) via email campaigns to customers and contractors and through a bonus incentive webinar attended by both contractors and customers. CLEAResult also sent reminder "last call" emails to contractors and customers in December 2020 to encourage them to submit their rebate applications prior to December 31. The contractor reminder email had an open rate of 33% and the customer reminder email had an opening rate of 26%. While CLEAResult does not maintain a newsletter for customers or contractors, it agreed that such a newsletter would be a good addition to this program.

Program Application Process

Non-Midstream delivery channel customers can complete their application via email or an online application portal that is available for Prescriptive Rebates, Custom Incentives, and SBDI program incentives. The online application portal allows customers to verify that their equipment meets the program requirements and to track their application status. However, the IPL program manager and CLEAResult reported that most customers completed program applications via email rather than the online application portal. CLEAResult offers to help contractors and customers to complete rebate applications, and reminded contractors of this application assistance opportunity during the February contractor seminar and August bonus incentive webinar.

Midstream delivery channel distributors apply for reimbursement via email and do not have access to an online application portal; CLEAResult said the Midstream delivery channel application process works smoothly.

Program Key Performance Indicators

In addition to its energy savings and participation goals, CLEAResult tracked key performance indicators related to program delivery, shown in Table 250. CLEAResult achieved all but two of its program goals, except to increase the trade ally network by 5% annually (no growth achieved) and, on average, to cut incentive checks within 20 business days of receiving an application (which they did not achieve in the fourth quarter).

Table 250. 2020 Prescriptive Rebates Program Service-Level Key Performance Indicators

Service Level	Key Performance Indicator	2020 Result
Quality Assurance and Quality Control Site Verification	100% site verification for self-installed projects with rebate payments ≥$1,000, all projects with rebate payments ≥$20,000, and 5% of a random selection of all other projects	Achieved
Trade Ally Network	Increase number of participating trade allies [a] by 5% annually (from 198 participating trade allies in 2019)	Did not reach goal (achieved 157 participating contractors)
Incomplete Notice	Send an incomplete notice within five business days of receiving application	Achieved
Rebate Payment	On average, cut check incentive checks within 20 business days of receiving application	Achieved in the first, second, and third quarters

Source: December 2020 CLEAResult scorecards and program tracking data.

[a] CLEAResult defined trade allies as the number of contractors who participated in the Prescriptive Rebates program.

Future Program Changes

The IPL program manager and CLEAResult mentioned three planned changes for future program years:

- IPL will launch a midstream HVAC program in 2021 and will try to increase the share of program savings for non-lighting measures. IPL hopes a non-lighting midstream incentive will reduce the administrative burden faced by customers and contractors
- IPL and CLEAResult received feedback from contractors in 2020 that HVAC and mechanical incentives may be too low, so IPL will examine the appropriateness of such incentive levels in 2021.
- IPL anticipates that CLEAResult will cross-promote a virtual retro-commissioning offering to Prescriptive Rebates program customers in 2021. Uplight will implement the virtual retro-commissioning offering, with CLEAResult acting as a subcontractor. This study will be free to

customers, and IPL will provide incentives to customers who complete the study recommendations within three months of their study. The evaluation team tested 2020 survey respondent interest in both a virtual and in-person retro-commissioning program offering (see the *Interest in Retro-Commissioning Offerings* section below). For in-person retro-commissioning, IPL will partially offset the cost of the study.

Follow-Up on 2019 Evaluation Recommendations

The evaluation team discussed program status with IPL and CLEAResult to follow up on the recommendations made during the 2019 evaluation; the status of each is shown in Table 251.

Table 251. Prescriptive Rebates Program 2019 Recommendation Status

2019 Recommendation	Status
Assess contractors' opinion of the application process in future program evaluations.	***Completed***. The team interviewed contractors as part of the 2020 evaluation.
Consider encouraging contractors to complete the rebate application for Non-Midstream measures on behalf of the customer. Explain to contractors that this practice increase customer satisfaction.	***Completed.*** CLEAResult regularly works with contractors to provide instruction and to answer questions about the application process, specifically suggesting that contractors fill out applications for their customers.
For Non-Midstream measures, where contractors have the ability to determine AOH, consider requiring an AOH input for each measure installed at each site. This will support more accurate savings estimates for the Non-Midstream measures in general and will allow for separate, more accurate savings estimates for lighting that operates on different schedules within a facility.	***Not Completed***. Neither the application nor the processing database currently use specific AOH on a calculated basis. CLEAResult uses Indiana TRM (v2.2) assumptions for AOH by building type in the Prescriptive Rebates program.
Use the Indiana TRM (v2.2) "Public Assembly" and "Assembly" facility types to assign AOH, coincidence factor, and WHF values for Religious/Worship buildings, to avoid overstating energy savings.	***Partially completed.*** IPL incorporated the Public Assembly building type into 2020 program tracking details.
Align lighting and HVAC algorithms to reflect the proper baseline efficacy/efficiency standards based on current federal regulations and the UMP Chapter 6. The affected lighting measures include general-service screw-base and linear LED fixtures.	***Not completed.*** IPL and CLEAResult reviewed baseline assumptions and began making updates for the 2021 through 2023 program cycle.
To support the assignment of baseline values through the lumen equivalence method, consider providing a lookup table with lumens and wattage values for each fixture and lamp in the *Qualified Products List*.	***Rejected.*** IPL and CLEAResult use this process for Custom Incentives projects, not Prescriptive Rebates projects. Moving to this model would require a data capture and processing system overhaul, creating additional administrative costs but providing no certainty that applicants submit accurate baseline data. IPL avoids baseline uncertainty for Custom Incentives projects by requiring program review and pre-approval prior to the project start.
For each lighting measure in the Non-Midstream delivery channel, collect and report the actual wattage of removed lamps or fixtures in the tracking data. This would allow for calculating first-year savings based on the replaced wattage for early replacement measures.	
For lighting control measures, provide the number of installed controls in the Number of Units field. Values in the gross kilowatt per-unit and gross kilowatt-hour per-unit fields should provide savings per installed lighting control, not per controlled watt.	***Partially completed.*** CLEAResult provided the evaluation team with additional information to clarify the measure units captured in the system.

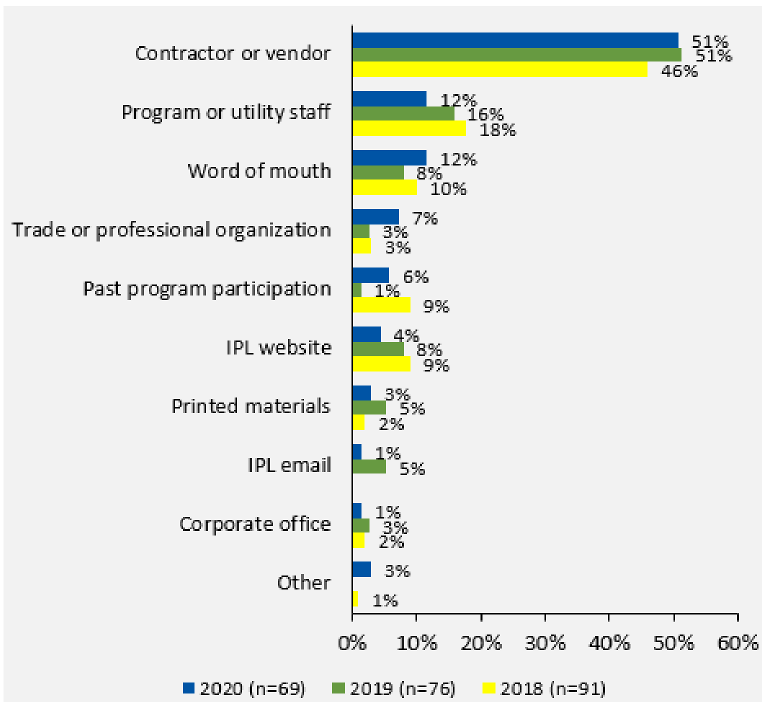
Customer Participant Feedback

In January 2020, after removing duplicate emails, the evaluation team sent survey invitations to 668 businesses that participated in the Prescriptive Rebates program through either the Non-Midstream (n=394) or Midstream (n=274) delivery channel. Email was sufficient to achieve responses from 42 Non-Midstream delivery channel participants (an 11% response rate) and from 27 Midstream delivery channel participants (a 10% response rate).

Energy Efficiency Awareness

In 2020, respondents most commonly heard about the Prescriptive Rebates program through their contractor or vendor (51%), followed by program or utility staff (12%) and word of mouth (12%). As shown in Figure 96, those avenues were also the most common sources of awareness in 2018 and 2019. Despite CLEAResult's email outreach to customers about the program, just 1% of customers learned about the program from email, similar to the 5% of customers in 2019. No differences in awareness sources between program years were statistically significant.

Figure 96. Prescriptive Rebates Program Source of Awareness (2018-2020)

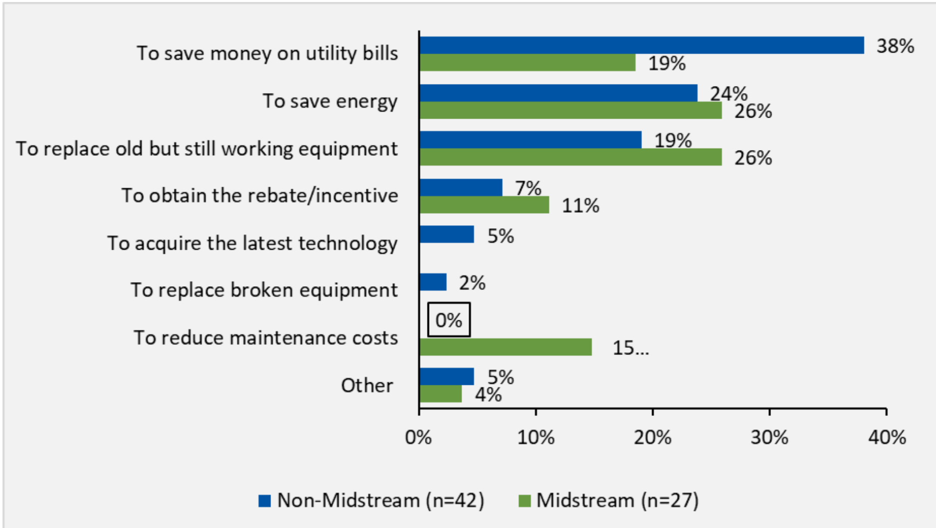


Source: 2018, 2019, and 2020 IPL Prescriptive Rebates Program Participant Survey Question B1. "How did you first learn about IPL's Prescriptive Rebates program?"

Participation Drivers

Figure 97 shows the 2020 participation motivations for each delivery channel. Overall, the most common driver of participation across delivery channels in 2020 was saving money on utility bills (30%, n=69), followed by saving energy (25%) and to replace old but working equipment (22%). Significantly more Midstream than Non-Midstream customers were motivated to reduce their maintenance costs.

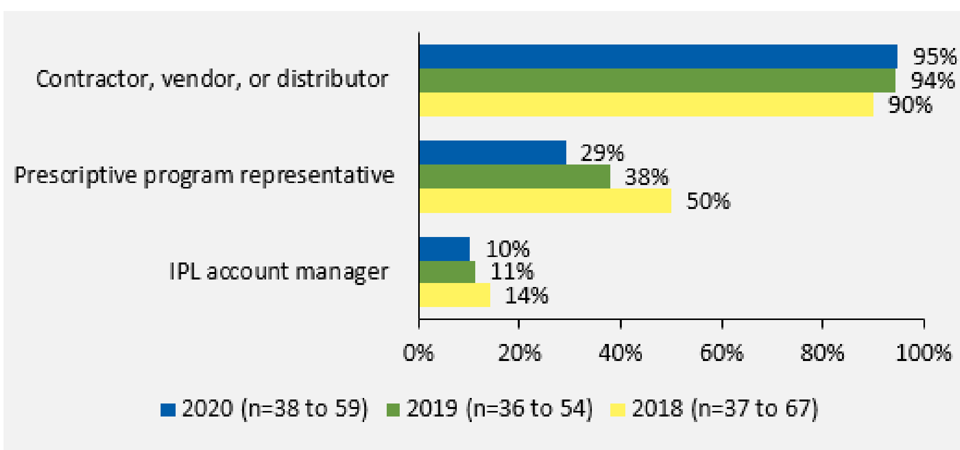
Figure 97. 2020 Prescriptive Rebates Program Participation Drivers by Delivery Channel



Source: 2020 IPL Prescriptive Rebates Program Participant Survey Question B3. "What factor was most important in your decision to make energy-saving improvements through this program?"
☐ The response with a boxed rating significantly differed from the Midstream results at the 95% level (p<0.05).

Prescriptive Rebates program respondents identified contractors, vendors, or distributors as the most common types of people who helped them plan or initiate their energy efficiency project (Figure 98). More respondents said they worked with a Prescriptive Rebates program representative than with an IPL account manager. These findings are similar to the 2019 results, when 94% were helped by a contractor, vendor, or distributor while 38% were helped by a program representative and 11% were assisted by an IPL account manager. The portion of respondents who said they worked with a Prescriptive Rebates program representative has decreased each year, from 50% in 2018 to 38% in 2019, then to 29% in 2020. No differences in results between years are statistically significant.

Figure 98. Sources of Prescriptive Rebates Program Project Initiation (2018-2020)

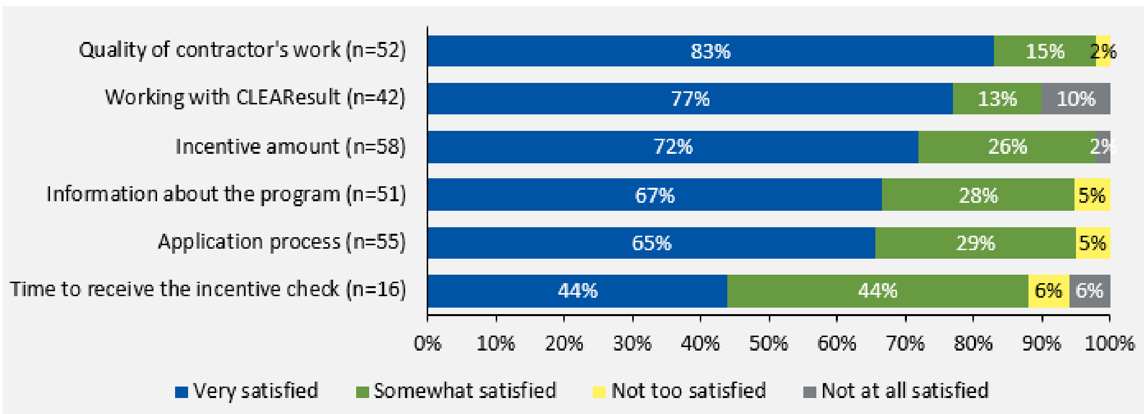


Source: 2020 IPL Prescriptive Rebates Program Participant Survey Question B2. "Who, if anyone, was involved in helping you plan or initiate your energy efficiency project?"

Satisfaction with Program Processes

Survey respondents rated their satisfaction with different program components. As shown in Figure 99, respondents gave high satisfaction ratings overall, with 88% to 98% being *very satisfied* or *somewhat satisfied* with all program components. The 2020 respondents were most satisfied with the quality of the contractors' work and were least satisfied with the time it took to receive the incentive check. The 2020 satisfaction ratings for all program components were statistically consistent with the 2019 satisfaction ratings. Though not statistically significant at the 95% confidence level, the share of respondents who were *very satisfied* with the application process increased from 2019 (52%; n=63) to 2020 (65%; n=55), while the share of respondents who were *very satisfied* with the time it to took receive their incentive check declined from 2019 (71%; n=28) to 2020 (44%; n=16)

Figure 99. Participant Satisfaction with 2020 Prescriptive Rebates Program Components

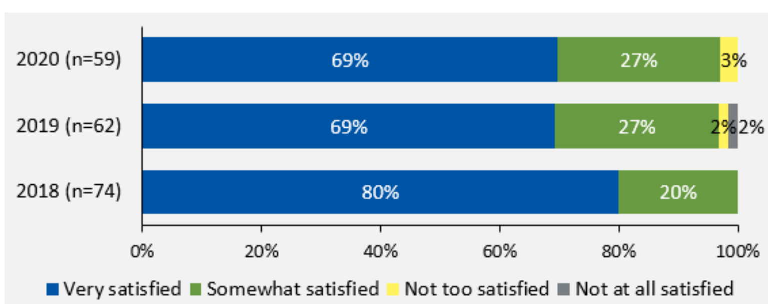


Source: 2020 IPL Prescriptive Rebates Program Participant Survey Question F1. "Please rate your level of satisfaction with each of these components."

Overall Satisfaction and Benefits of Program Participation

The 2020 participants expressed high levels of satisfaction with the program overall, with 96% being either *very satisfied* or *somewhat satisfied*, as shown in Figure 100. These 2020 results were nearly identical to 2019 results, and there was no notable difference in overall satisfaction between the 2020 Midstream (72% *very satisfied*) and Non-Midstream (68% *very satisfied*) respondent groups.

Figure 100. Overall 2018 through 2020 Prescriptive Rebates Program Satisfaction

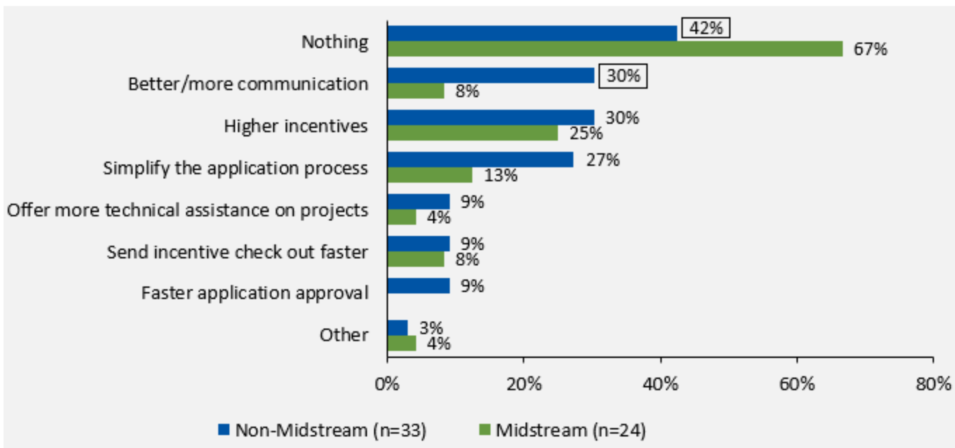


Source: 2020 IPL Prescriptive Rebates Program Participant Survey Question F1.7 and 2018 and 2019 Participant Survey Question H1.7. "How satisfied are you with the program overall?"

Suggestions for Improvement

Significantly more respondents across both delivery channels in 2020 (53%; n=57) than in 2019 (32%; n=62) had no suggestions for improvement. Top suggestions for improvement in 2020 were to offer higher incentives (28%), provide a simplified application process (21%), and offer better or more communication (21%). Despite higher incentives being the top suggestion in 2020, significantly fewer customers made this suggestion in 2020 than in 2019 (42%; n=62). Figure 101 shows responses by delivery channel, with significantly more Non-Midstream respondents suggesting that the program provide better or more communication.

Figure 101. 2020 Prescriptive Rebates Program Respondents' Suggestions for Improving Overall Prescriptive Rebates Program Experience



Source: 2020 IPL Prescriptive Rebates Program Participant Survey Question F3. "Is there anything IPL could have done to improve your overall experience with the program?" Multiple responses allowed.
☐ The responses with boxed ratings significantly differed from the Midstream results at the 95% level ($p<0.05$).

When asked why they were less than satisfied with the application process, two respondents gave feedback. One explained that the application requires a lot of documentation (such as W9 forms) and it is easy to make mistakes, which delays the application process. Another said "the application process is clunky" and that they thought the incentive check took a long time to arrive.

When asked, five respondents had suggestions for how IPL could improve communication:

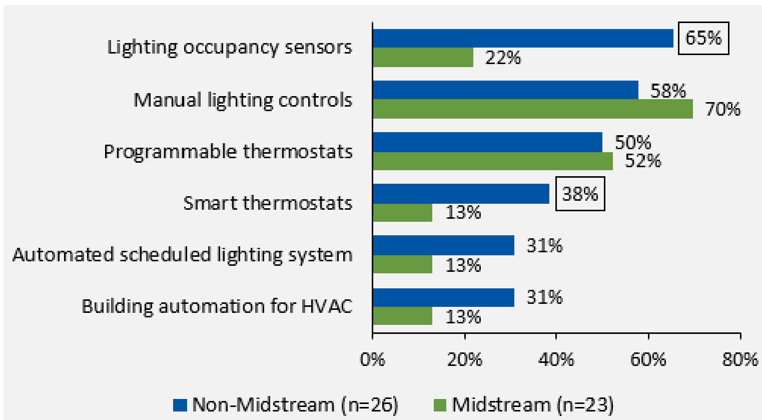
- Be more proactive in providing updates and returning calls (three respondents)
- Increase the availability of general program information (two respondents)

Interest in Retro-Commissioning Offerings

To assess the ability for IPL's Prescriptive Rebates program customers to participate in a virtual or in-person retro-commissioning program, the evaluation team asked 2020 participants which building controls are in their facilities. Of the response options provided to respondents, HVAC BAS and automated scheduled lighting systems are most applicable to a retro-commissioning program; however, it is possible to include programmable and smart thermostats in a retro-commissioning program. Though the evaluation team collected data on whether respondent buildings contain manual lighting controls and lighting occupancy sensors, those two control types are not normally included in retro-commissioning programs.

Overall, more Non-Midstream respondents than Midstream respondents said their facilities contain controls that could be optimized during a retro-commissioning offering (Figure 102). Half the Non-Midstream and Midstream respondents' buildings contain programmable thermostats, and less than half the respondents across both delivery channels said their building contains smart thermostats, automated scheduled lighting systems, or BAS for HVAC.

Figure 102. 2020 Prescriptive Rebates Program Facility Control Systems

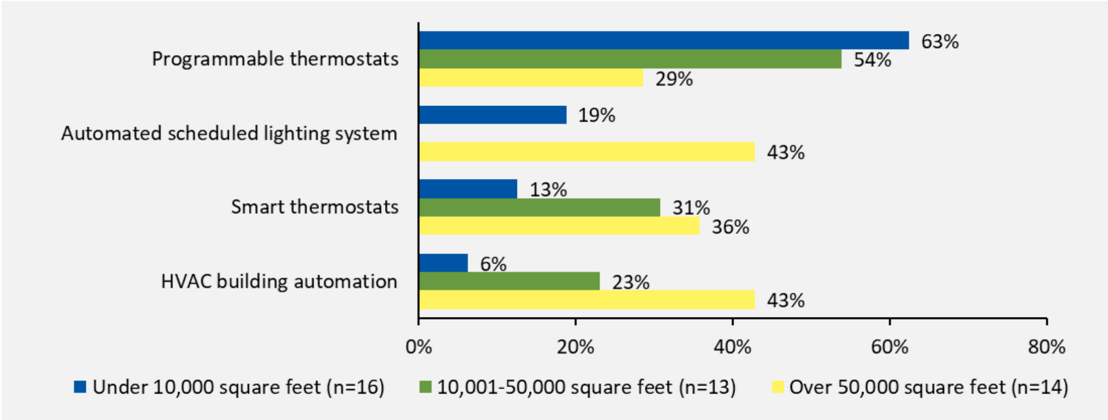


Source: 2020 IPL Prescriptive Rebates Program Participant Survey Question G1. "Which of the following control systems does your facility have?" Multiple responses allowed.

☐ The responses with boxed ratings significantly differed from the Midstream results at the 95% level (p<0.05).

A greater share of medium and large facilities than small facilities contain HVAC automation, automated scheduled lighting systems, and smart thermostats (Figure 103). Additionally, a greater share of facilities owned by respondents contain automated scheduled lighting systems (24%, n=37) and HVAC building automation (27%) compared to facilities that are leased by respondents (18% and 9%, respectively; n=11).

Figure 103. 2020 Prescriptive Rebates Program Facility Control Systems by Building Size



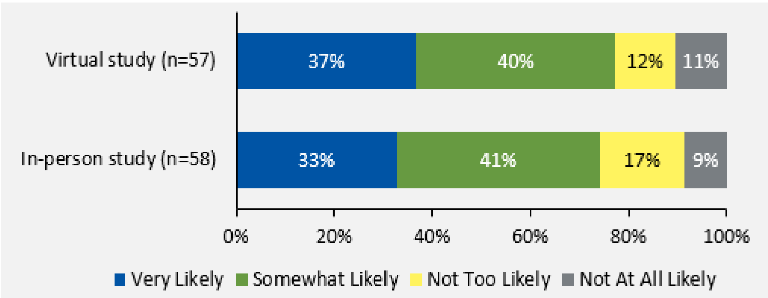
Source: 2020 IPL Prescriptive Rebates Program Participant Survey Questions G1 and H2. "Which of the following control systems does your facility have?" (multiple responses allowed) and "What is the approximate square footage of space in the facility where you made the efficiency improvements?"
Note: The evaluation team removed respondents who did not know their facility size.

In 2020, the evaluation team asked Prescriptive Rebates program respondents if they would consider participating in two retro-commissioning offerings, both of which would provide them with incentives for implementing recommendations within three months of the study:

- A free virtual study of their facility's energy usage and characteristics to recommend low- or no-cost facility improvements
- An in-person study partially funded by IPL to recommend low- or no-cost improvements to building systems

As shown in Figure 104, customer interest in both retro-commissioning offerings was high, with 77% of respondents being either *very likely* or *somewhat likely* to consider participating in a virtual study and 74% being *very likely* or *somewhat likely* to consider participating in an in-person study. Though the differences in responses were not statistically significant, a higher proportion of Midstream respondents (87%; n=23) than Non-Midstream respondents (71%; n=34) were *very likely* or *somewhat likely* to consider a virtual study.

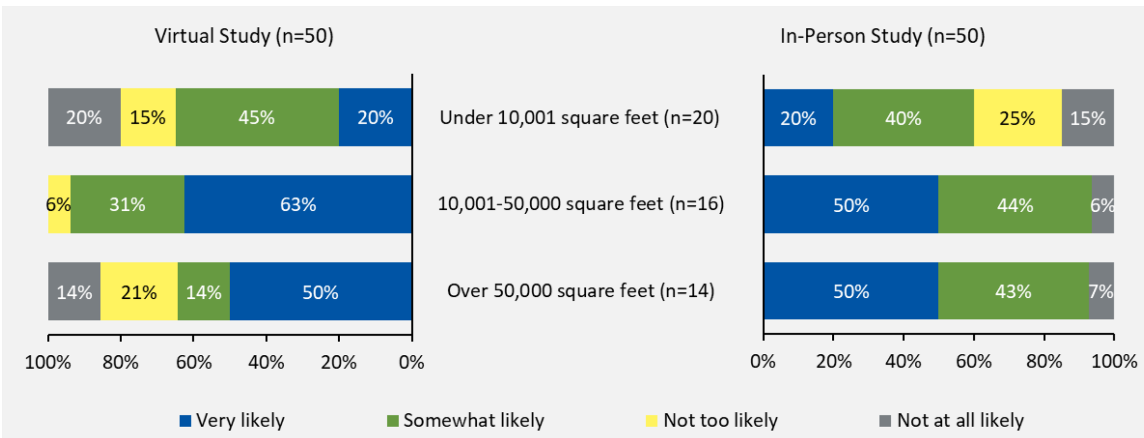
Figure 104. 2020 Prescriptive Rebates Program Respondents' Interest in Retro-Commissioning Offers



Source: 2020 IPL Prescriptive Rebates Program Participant Survey Questions G2 and G4. "How likely are you to participate in an in-person retro-commissioning study program?" and "How likely are you to participate in a virtual retro-commissioning study program?"

The evaluation team examined whether respondent firmographics correlated to interest in either retro-commissioning offering. As shown in Figure 105, a greater share of respondents whose facilities have at least 10,001 square feet are *very likely* to consider either retro-commissioning offer than those with smaller facilities. Respondents whose facility is over 50,000 square feet expressed more interest in an in-person study than a virtual study, while respondents whose facility is under 50,000 square feet expressed slightly more interest in a virtual study. Additionally, a greater share of those who lease their facilities are *very likely* or *somewhat likely* to consider in-person (92%; n=13) or virtual retro-commissioning (85%) than those who own their facilities (74% and 76%, respectively; n=42).

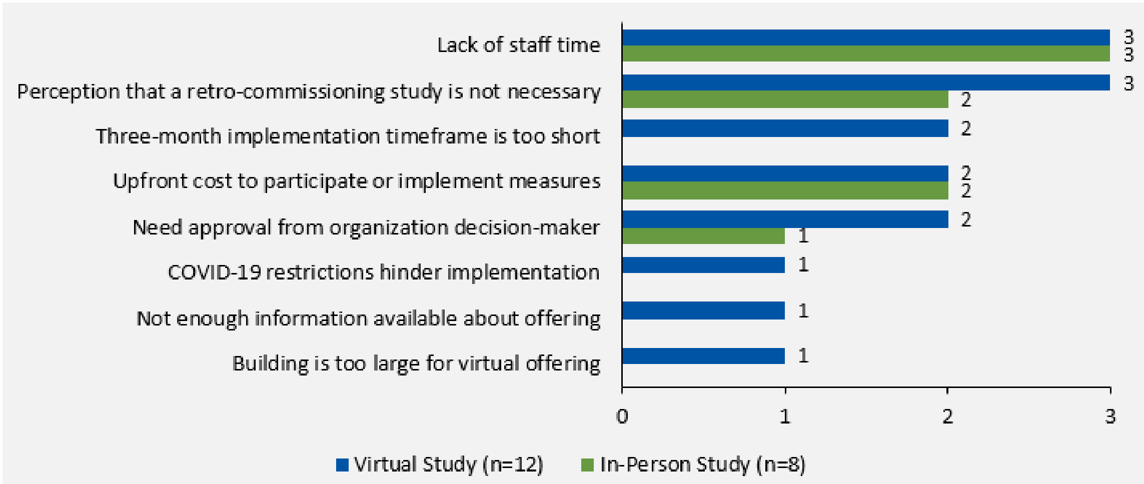
Figure 105. 2020 Prescriptive Rebates Program Respondents' Interest in Retro-Commissioning based on Facility Size



Source: 2020 IPL Prescriptive Rebates Program Participant Survey Questions G2 and G4. "How likely are you to participate in an in-person retro-commissioning study program?" and "How likely are you to participate in a virtual retro-commissioning study program?"
Note: The evaluation team removed respondents who did not know their facility size.

Common barriers mentioned by respondents to program participating in either retro-commissioning offering included the cost to implement the study recommendations (31%; n=35) and lack of staff time to participate in a study or implement measures (14%; Figure 106).

Figure 106.2020 Prescriptive Rebates Program Respondents' Reasons for Not Considering Retro-Commissioning Offerings



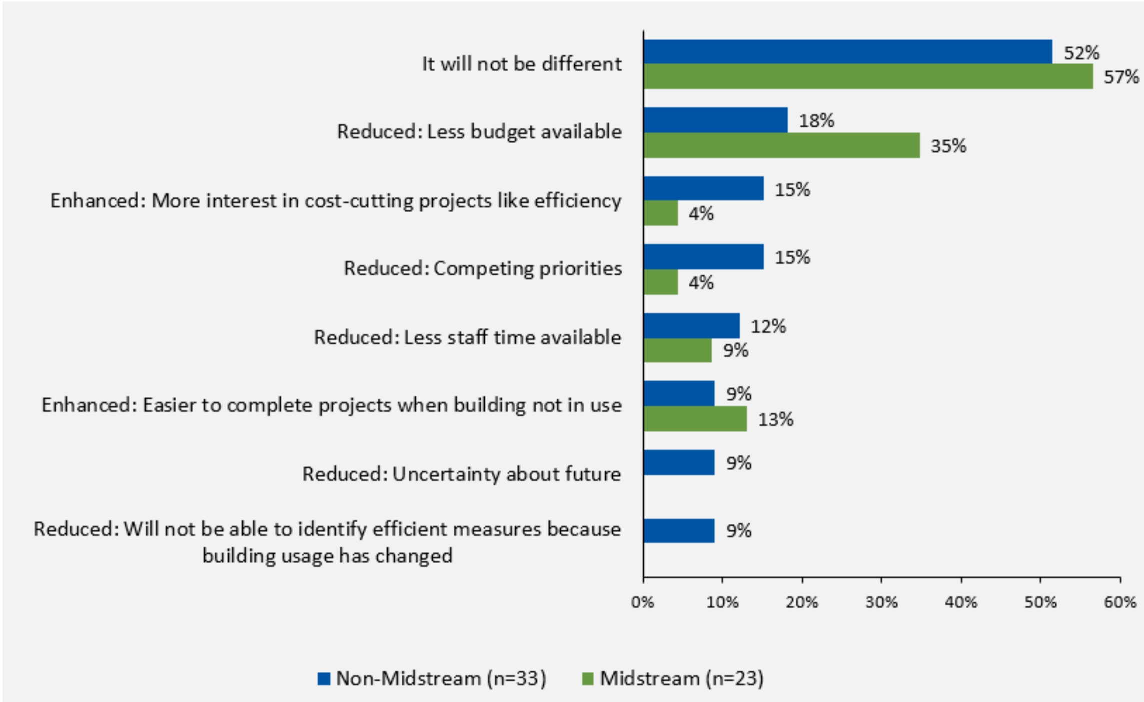
Source: 2020 Prescriptive Rebates Program Participant Survey Question G3 and G5. "Please tell me why you are unlikely to participate in this program." Multiple responses allowed.

When asked what information they would need before deciding to participate in either retro-commissioning offering, 26% of respondents (n=34) said they need information about the upfront cost of the study or measures and 24% said they need more information in general (such as details about program processes and requirements). Respondents also said they would need information about the program timeline (12%), an energy savings or ROI timeline (12%), and required staff time (9%).

Impact of COVID-19 on Plans for Future Energy Efficiency Projects

In 2020, 54% of Prescriptive Rebates program respondents did not foresee a difference in their organization's interest in or ability to complete energy efficiency projects as a result of COVID-19 (n=56). Of those who said COVID-19 reduced their interest in or ability to pursue energy efficiency projects, respondents most commonly said their organization has less budget available. As shown in Figure 107, 18% of Non-Midstream and 35% of Midstream respondents said COVID-19 reduced their budget for projects like energy efficiency. No differences in responses between delivery channels were statistically significant.

Figure 107. 2020 Prescriptive Rebates Program Impact of COVID-19 on Respondents' Plans for Future Energy Efficiency Projects

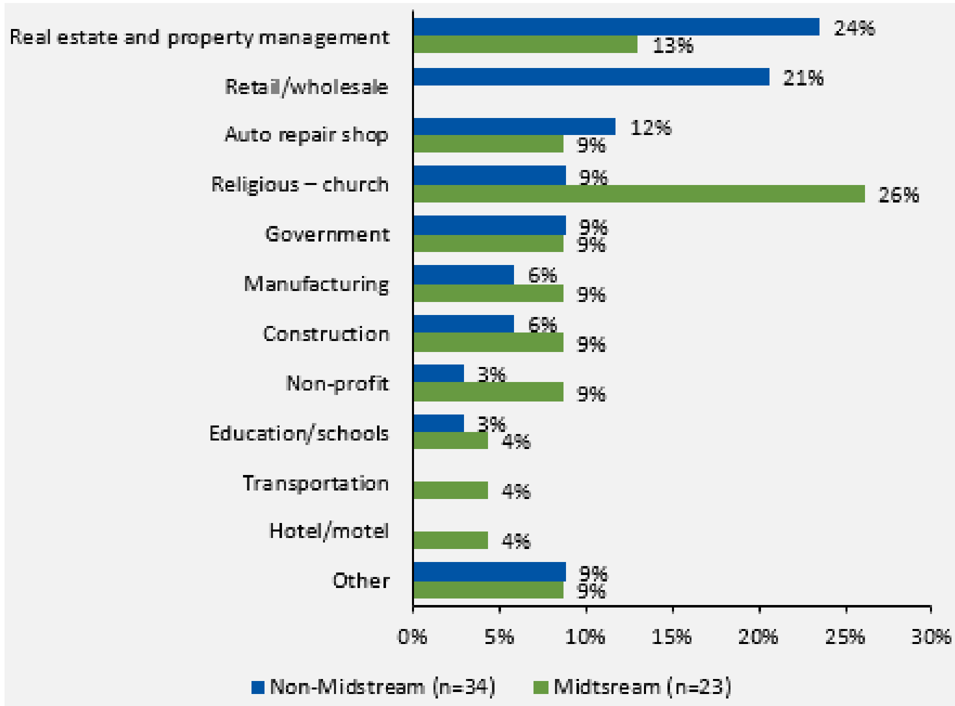


Source: 2020 Prescriptive Rebates Program Participant Survey Question F4. "In 2021, how will your organization's interest in or ability to complete energy efficiency projects like this one be different as a result of COVID-19? Please select all that apply." Multiple responses allowed.

Participant Firmographics

The evaluation team asked survey respondents about various aspects of their business and the facility in which they operate. As shown in Figure 108, Non-Midstream organizations were most commonly in real estate and property management (24%) and retail/wholesale (21%), while Midstream organizations were most commonly religious (26%) and real estate and property management (13%).

Figure 108. 2020 Prescriptive Rebates Program Respondents by Business Sector

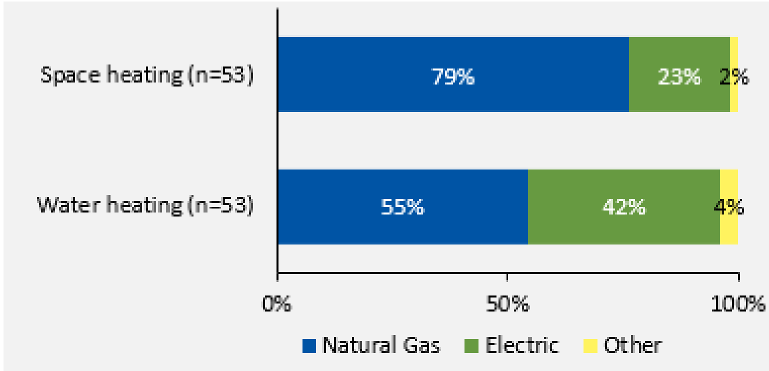


Source: 2020 IPL Prescriptive Rebates Program Participant Survey Question H1. "What industry is your organization in?"

The majority of respondents own their facility (76%; n=55) and 24% lease their facility. Prescriptive Rebates program respondents also reported their approximate facility square footage: 72% of facilities (n=50) are 50,000 square feet or less (40% are 10,000 square feet or less and 32% are between 10,001 and 50,000 square feet). Of the remaining facilities, 14% are over 100,000 square feet and 14% are between 50,001 and 100,000 square feet. Facility sizes does not vary significantly between the Midstream and Non-Midstream delivery channels.

As shown in Figure 109, most 2020 facilities use natural gas for general space heating (79%). The fuel type for water heating is split between natural gas (55%) and electric (42%). In 2019, water heating fuel type was split equally, with 50% using natural gas and 50% using electric.

Figure 109. 2020 Prescriptive Rebates Program Respondents' Main Fuel Type for Space and Water Heating



Source: 2020 IPL Prescriptive Rebates Program Participant Survey Questions H3 and H4. "What is the main fuel type used for heating the facility?" and "What is the main fuel type used for water heating at the facility?"

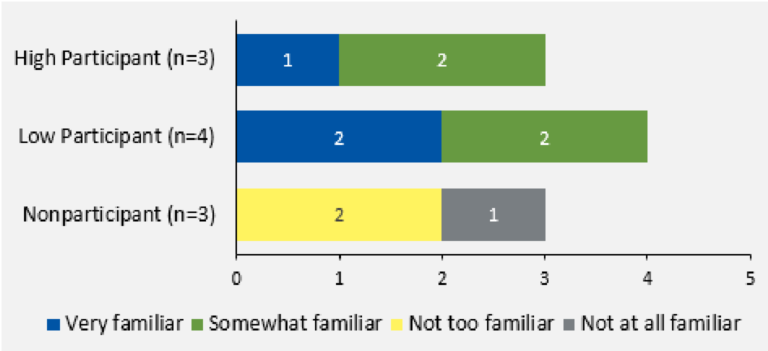
Contractor Feedback

The evaluation team completed in-depth interviews with 10 non-lighting commercial contractors to assess their familiarity and satisfaction with IPL's commercial programs, barriers to participation, and suggestions for program improvement. The team also asked each non-lighting contractor about their opinion of a midstream incentive program structure. The evaluation team used the 2018 to 2020 VisionDSM tracking data to identify the population of non-lighting contractors and divide them into "low participant" and "high participant" categories based on the number of projects they completed through IPL's Prescriptive Rebates and Custom Incentive programs. Of all contractors, 38 high participants completed at least five non-lighting projects (the evaluation team interviewed three, for a response rate of 8%) and 148 low participants completed one, two, three, or four non-lighting projects (the evaluation team interviewed four, for a response rate of 3%). The team also interviewed three nonparticipants, using a Google search to identify local non-lighting contractor companies that were not included in the 2018 to 2020 VisionDSM data.

Awareness and Frequency of Rebate Promotion

A contractor's familiarity with IPL's programs largely corresponded with their frequency of participating in those programs. Of seven participant contractors, three were *very familiar* with IPL's commercial energy efficiency incentive programs and four were *somewhat familiar* (Figure 110). Of the nonparticipant contractors, two were *not too familiar* and one was *not at all familiar.*

Figure 110. 2020 Prescriptive Rebates Program Contractor Familiarity with IPL's Commercial Incentive Programs



Source: 2020 IPL Prescriptive Rebates Program Contractor Interview Guide Question B1. "How familiar are you with IPL's commercial energy efficiency incentives programs?" and 2020 IPL Prescriptive Rebates Program Nonparticipating Commercial Contractor Interview Guide Question B1. "How familiar are you with IPL's commercial energy efficiency incentives programs for non-lighting equipment?"

For all the respondents who had some level of familiarity with IPL's commercial energy efficiency programs, the team asked how they first learned about the programs. Program awareness sources varied amongst these eight respondents:

- Fellow contractor (four respondents)
- CLEAResult employee (two respondents)
- Supplier (one respondent)
- Self-initiated search (one respondent)

The team asked participant contractors how often they promote IPL's rebates to their commercial customers. Three high participants and one low participant *always* promote IPL's commercial rebates for energy-efficient equipment, while three low participants *sometimes* promote the rebates. The two nonparticipants who were aware of the program said they *never* promote the rebates. Table 252 shows the drivers that contractors gave for why they *always*, *sometimes*, or *never* promote the program.

Table 252. 2020 Prescriptive Rebates Program Drivers of Contractor Program Promotion

Reasons for *Always* Promoting Program	Reasons *Sometimes* or *Never* Promoting Program
• Promoting the program is an easy way to bring down project costs (one high participant and one low participant) • Program promotion is a sales tactic (two high participants)	• Complicated rebate process (two low participants) • Difficulty finding projects that qualify (one low participant) • Perception that the effort to participate outweighs the value (one nonparticipant) • Has not yet looked into the program (one nonparticipant)

Source: 2020 IPL Prescriptive Rebates Program Contractor Interview Guide Questions C2 and C3. "How often do you promote IPL's rebates for energy-efficient equipment?" and "Why is that?"

When asked if they receive marketing materials from IPL to help them promote the programs to customers, four respondents said they have not received any marketing materials, two respondents download marketing materials from a website, and one respondent emails the CLEAResult representative to request marketing materials. There were no notable differences between low and high participants.

The evaluation team asked what additional marketing materials would help them to promote IPL to customers, and seven contractors provided suggestions. Most contractor suggestions centered around providing educational resources to customers that could aid in the customers' decision-making processes: whitepapers or brochures about the program or about energy-efficient equipment (three respondents), case studies (two contractors), and a benefit/cost analysis for different project types (one respondent). Two respondents also suggested that IPL create marketing emails the contractor could forward to their own customers. Though the online rebate application details eligibility requirements, IPL's public-facing website does not currently contain brochures, case studies, or whitepapers.

Overall Satisfaction and Program Effectiveness

Of seven participant contractors interviewed, four were *very satisfied* (one low participant and three high participants) and three were *somewhat satisfied* (three low participants) with the IPL Prescriptive Rebates program. Of the four respondents who were *very satisfied*:

- One appreciated the financial benefits,
- Two use the incentives as a sales tactic,
- One thought information was easily accessible, and
- One thought little effort was required for them to participate.

Among the three respondents who said they were *somewhat satisfied:*

- One thought the description of information needed in the application and the qualified equipment list could be clearer,
- One identified that long project approval timelines could be an issue if customers have a strict project deadline, and
- One did not cite a complaint but explained that not many of his customers have projects that qualify for incentives.

When asked if the program increases their sales of energy-efficient equipment, one high participant said his sales have increased by 10% to 15%. One high participant and one low participant said they saw an initial increase in sales that has since leveled off, while two low participants have not seen an increase in sales (and one high participant and one low participant did not know if the program affected their sales).

Program Staff Support

All seven respondents said they were *very satisfied* with the support they received from program staff. When asked to elaborate, five respondents said the staff were helpful, three said the staff could answer their questions, and two were pleased with the staff availability. Participant contractors communicate about the program with CLEAResult or IPL either monthly (four contractors) or quarterly (two contractors). Just one contractor said he does not often communicate with program staff.

Barriers to Customer Participation

When the team asked contractors what the biggest challenge is for customers to participate in the program, just one contractor (a high participant) said there are no barriers. The other nine contractors identified the following barriers:

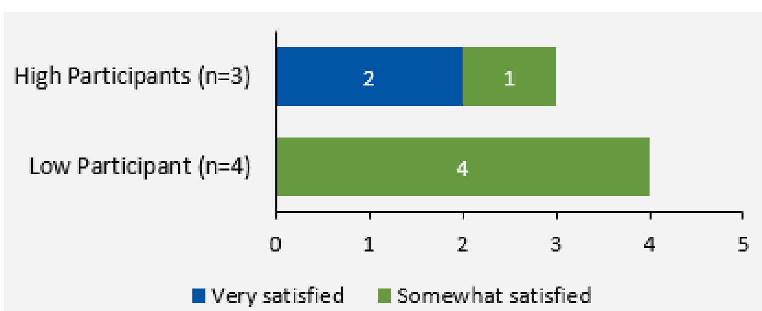
- ***Rebate application process*** (one high participant, two low participants, and two nonparticipants). One contractor elaborated that because the current guidelines do not apply to all projects, it is not always clear what needs to be submitted. Four contractors recommended simplifying the rebate process—two of these contractors offered a specific recommendation: (1) provide templates for easier submission of required materials and (2) state upfront what information is needed for the application. One contractor recommended offering a higher rebate to overcome this barrier.
- ***Time commitment associated with the program*** (one high participant and one low participant).
- ***Upfront cost*** (one high participant and one low participant). Both contractors recommended offering higher incentives to overcome this barrier.
- ***Customers' lack familiarity with energy-efficient options*** (one nonparticipant). This contractor recommended increasing the type of equipment available for rebates.
- ***Limited customer base in IPL's service territory*** (one low participant). This contractor installs direct-fired HVAC units and rack units.

Rebate Process

The evaluation team asked contractors about various aspects of the rebate application process. Of the seven participant contractors, three said they *always* reduce the equipment cost by the rebate amount then apply for the rebate on behalf of the customer (one high participant and two low participants), while three contractors *sometimes* do this (two high participants and one low participant) and one low participant *never* does this. Of those who *sometimes* or *never* complete the application on behalf of the customer, three said they will assist a customer with the application when asked.

Participant contractors rated their satisfaction with the program application process. As shown in Figure 111, two high participants were *very satisfied* and five contractors were *somewhat satisfied* (four low participants and one high participant).

Figure 111. Contractor Satisfaction with the Rebate Process



Source: 2020 IPL Contractor Interview Guide Question E5. "How would you rate your satisfaction…?"

One *very satisfied* high participant said the application process required little effort to complete. However, of the five participants who said they were *somewhat satisfied,* three said the application website is clunky or difficult to navigate (one high participant and two low participants) and two said they experienced long delays in receiving their incentives (one high participant and one low participant).

All three nonparticipant contractors said they would like IPL to reduce the program responsibility on contractors. One of these three nonparticipants elaborated, saying they would prefer for distributors to handle the application process in their place.

Midstream Offerings

In 2021, IPL will offer a commercial midstream HVAC program, through which they pay incentives to equipment distributors, who pass the savings down to the end user. This midstream model will allow customers to receive lower-priced equipment upfront instead of being requiring to submit a rebate application form.

The evaluation team asked contractors for their impressions of this upcoming change, and seven provided feedback (one high participant, three low participants, and three nonparticipants). All seven contractors were in favor of the midstream program design: Table 253 shows aspects of the program that contractors found more appealing and less appealing. When asked, five of the seven contractors also thought the program would cause a small increase in their HVAC equipment sales.

When asked what their company would need for the midstream HVAC program to work for them, six contractors iterated that program participation needs to be simple for contractors and customers and two specified that reporting requirements would need to be minimal.

Table 253. 2020 Prescriptive Rebates Program Contractor Feedback about Midstream HVAC Program Design

Positive Feedback	Negative Feedback
• A midstream concept will simplify the rebate process (one high participant, three low participants, and three nonparticipants) • The program design might lead distributors to stock more energy-efficient equipment (one low participant and one nonparticipant)	• The change might not work well for complex projects (two low participants)

Source: 2020 IPL Prescriptive Rebates Program Contractor Interview Guide Question H1 and 2020 IPL Prescriptive Rebates Program Nonparticipating Commercial Contractor Interview Guide Question E1. “What are your initial thoughts on this change?”

Conclusions and Recommendations

CONCLUSION 1: Customer satisfaction with the program remains high. However, the rebate application process remains a source of frustration to customers, and some non-lighting contractors view the rebate application as a barrier to their sales process. Shifting HVAC rebates to a midstream program concept will likely alleviate these customer and contractor concerns about the rebate application process and will diversify savings opportunities for future program years.

Survey respondents reported high overall program satisfaction ratings, with 96% rating themselves as *very satisfied* or *somewhat satisfied*, and the program exceeded its energy-savings and demand reduction goals. However, improving the incentive application process or paperwork remains a common suggestion despite CLEAResult's efforts to provide application assistance to customers and contractors. When asked to rate their satisfaction with various program aspects, respondents were least satisfied with the application process and the time to receive the incentive check. Three of seven participant contractors said the application website is clunky or difficult to navigate and two experienced long delays in receiving their incentives. Contractors offered specific recommendations for improving the rebate application process, including providing templates for easier submission of required materials and stating upfront what information is needed for the application.

All contractors reacted positively to a midstream HVAC program concept due to its potential to simplify the rebate application process. Most contractors thought a midstream concept would boost their sales, and two thought a midstream concept might cause distributors to stock more energy-efficient equipment. Given that less than 2% of the Non-Midstream delivery channel's savings came from non-lighting measures, reducing customer and contractor concerns with the HVAC rebate process is important for increasing their interest in non-lighting incentives.

RECOMMENDATIONS

Educate contractors and customers about the availability of midstream HVAC incentives so they can incorporate energy-efficient equipment into their facility improvement plans. Ensure that midstream reporting requirements are simple so that customers, contractors, and distributors will be willing to sell and purchase equipment through the midstream model.

Survey or interview distributors about their experience and satisfaction with the midstream HVAC channel and assess whether they have any recommendations for improvement.

CONCLUSION 2: Lighting contractors remain an important source of program awareness for both customers and non-lighting contractors, but additional marketing materials would help them to further increase program awareness.

Contractors are the most common source of program awareness, with half the customers and contractors having learned of the program from a contractor or vendor. However, contractors would benefit from receiving additional program marketing materials. Just three of the seven interviewed participant contractors said they received program marketing materials. Most contractors recommended that IPL provide educational resources to customers that could aid in the decision-making processes, such as whitepapers or brochures about the program or about energy-efficient equipment, case studies, or a benefit/cost analysis for different project types. Some contractors also recommended that IPL create program marketing materials that a contractor could easily email to their own customers.

RECOMMENDATION

Provide two types of educational resources to both contractors and customers via the public website, email, and a program updates newsletter:

- Downloadable and printable brochures about the program
- Case studies of various non-lighting measures that detail measures' costs, savings, and payback periods

CONCLUSION 3: Most Prescriptive Rebates program participants would consider a retro-commissioning offering, though facilities with at least 10,001 square feet are likely to generate deeper savings than smaller facilities. Prescriptive Rebate program participants will need additional information about retro-commissioning to pursue this offering.

Most survey respondents rated themselves as *very likely or somewhat likely* to considering participating in a virtual (77%) or in-person (74%) retro-commissioning program offering. Interest varied by facility size and delivery channel, with a smaller share of respondents with a facility under 10,001 square feet being *very interested* in the in-person (20%) or virtual study (20%). In contrast, more than half the respondents with a facility of 10,001 square feet or larger are *very interested* in the virtual or in-person study. Respondents with a facility under 50,001 square feet expressed slightly more interest in a virtual study, while respondents with a facility at least 50,001 square feet expressed more interest in an in-person study. Though differences in responses between Non-Midstream and Midstream respondents were not statistically significant, a higher proportion of Midstream respondents (87%) were *very likely* or *somewhat likely* to consider a virtual study than Non-Midstream respondents (71%).

More Non-Midstream than Midstream respondents reported having equipment that would qualify for retro-commissioning, and a greater share of facilities with at least 10,001 square feet contain HVAC building automation compared to smaller facilities.

Most Prescriptive Rebates program survey respondents said they would need more information before deciding to participate, most often requesting details about the upfront cost and program processes and requirements. Respondents also said they would need information about the program timeline, the cost to implement program measures, or details of the potential energy or cost savings. Common barriers to customer program participation included the cost to implement the study recommendations and a lack of staff time to participate in a study or implement study measures. Helpful estimates for potential participants included:

- Typical upfront cost to implement study recommendations
- Typical savings that can be expected from implementing study recommendations
- Typical payback period by facility size
- Hours per week that their facility staff will need to spend on the retro-commissioning study and implementation and what exactly will be required by those staff.

RECOMMENDATIONS

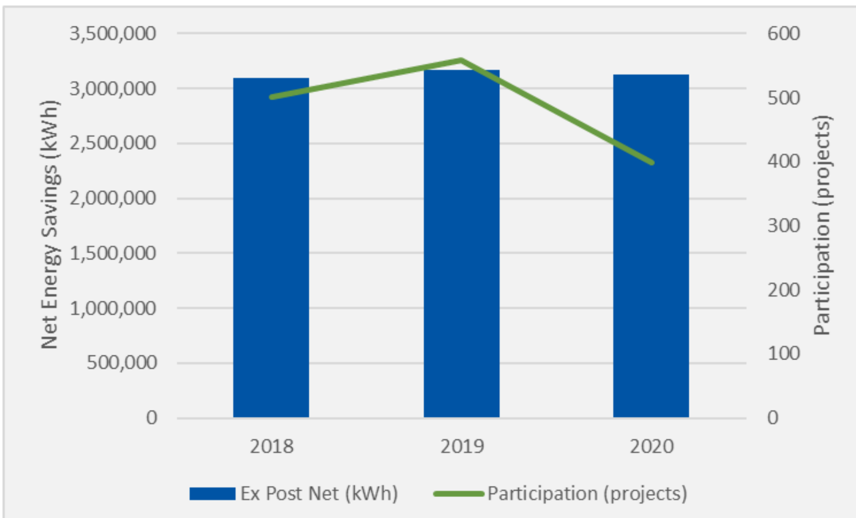
As BAS for HVAC have the highest savings potential among the various types of building controls, consider directing any Custom customer with a BAS to an in-person retro-commissioning program offering to maximize the savings. Direct facilities that contain programmable or smart thermostats only to the virtual retro-commissioning offering. Add screening criteria to the virtual retro-commissioning study that alerts the customer when they would be better off financially with the in-person study.

To reduce the barrier of lack of staff time, increase the eligible implementation timeframe so that customers have more than three months to implement recommended measures. Facilities often need to request formal approval for this type of spending, which can take time. Do not require the study and measure implementation to take place within the same calendar year.

Small Business Direct Install Program

IPL has offered the SBDI program since 2015 to provide small businesses with immediate energy savings and to help them identify other electric-saving opportunities. The program includes a free on-site audit of energy efficiency opportunities along with no-cost energy-saving measures. In 2020, the program met 85% and 97% of its energy-savings and demand reduction targets, respectively. IPL's reduced participation and net energy savings (kilowatt-hours) were due to a temporary shutdown of the program from mid-March 2020 through May 2020 in response to the COVID-19 pandemic, as well as reduced small business customer interest in energy efficiency projects as a result of competing priorities or reduced business operations in 2020. Figure 112 shows a comparison of SBDI program *ex post* net savings and participation over the last three years.

Figure 112. SBDI Program Savings and Participation, 2018 through 2020



Sources: IPL. Year-end DSM scorecards for 2018, 2019, and 2020;
Cadmus. Demand-side management evaluation reports for 2018 and 2019.

Program Description

Through the SBDI program, IPL offers a free facility energy audit and free direct install measures to business customers who have no more than 200 kW of peak demand. As the program implementer, CLEAResult, oversees program management and delivery, recruits customers, and administers program offerings directly to customers by performing audits and installing program-eligible measures, listed in Table 254. The program measures did not change from 2019 to 2020.

Table 254. 2020 SBDI Program Measures

Measure	
LED Lamp: A line, PAR38, BR30, linear LED replacing fluorescent T8 lamp	LED Exit Sign
Occupancy Sensors	Programmable Thermostat (electric heat)
Faucet Aerator	Low-Flow Showerhead
Salon Sprayer	Pre-Rinse Spray Valve
Water Heater Pipe Insulation	Water Heater Setback

In response to the COVID-19 pandemic, IPL shut the program down from mid-March 2020 until the end of May 2020, then resumed in-person audits and direct installations in June 2020.

Research Objectives

The evaluation team addressed several research objectives:

- Determine whether the 2020 program met its goals and objectives
- Assess customer satisfaction with various program aspects
- Assess customer interest in a virtual retro-commissioning program offering
- Identify whether the program influences customers' decisions and behavior
- Calculate program spillover and freeridership and estimate net program savings

Research Approach

To answer the research objectives outlined above, the evaluation team conducted several activities:

- Reviewed program materials
- Interviewed IPL and CLEAResult staff
- Surveyed 2020 participants
- Assessed savings reported in VisionDSM extracts against project documentation
- Examined whether claimed savings algorithms aligned with the Indiana TRM (v2.2) or other appropriate secondary sources
- Assessed the accuracy of *ex ante* savings assumptions and operating schedule of installed equipment through site visits and desk reviews, which the team conducted through a virtual platform due to the COVID-19 pandemic

Program Performance

IPL sought to achieve 3,662,753 kWh in net energy savings and 544 kW in net demand reduction. As shown in Table 255, the 2020 program spent 78% of its budget and achieved 85% of its net energy-savings goal and 97% of its demand reduction goal. The total 2020 savings were 3,122,696 kWh, or roughly 43,997 kWh less than in 2019. This reduced savings from 2019 to 2020 corresponds to the reduction in program activity due to the temporary program shutdown from mid-March 2020 through May 2020. Participation in the SBDI program declined by 19% from 2019 (491 sites) to 2020 (399 sites). .

Table 255. 2020 SBDI Program Expenditures, Participation, and Savings

Metric	Net Goal [a]	*Ex Post* Net	Percentage of Goal
Energy Savings (kWh)	3,662,753	3,122,696	85%
Demand Reduction (kW)	544	528	97%
Participation (Sites) [b]	N/A	399	N/A
Budget	$1,196,301	$937,976	78%

Note: Values rounded for reporting purposes.

[a] Goals per IPL's Settlement in DSM Cause #44945.

[b] Participation is defined as the number of distinct sites served in 2020. Multiple projects and measures may be associated with a single site.

As shown in Table 256, audited gross savings in 2020 aligned well with *ex ante* estimates. Based largely on the application of the ISR, verified savings experienced a general decrease compared to *ex ante* savings, and the team's review of supporting records and calculations uncovered lower savings than reported in the tracking database for some project measures. Due to the evaluation team's adjustments in AOH and other 2020 EM&V findings, the overall *ex post* savings were less than *ex ante* savings.

Table 256. 2020 SBDI Program Savings Summary

Metric	*Ex Ante* Gross	Audited	Verified	*Ex Post* Gross	*Ex Post* Net
Energy Savings (kWh)	3,724,318	3,724,318	3,652,197	3,206,685	3,122,696
Demand Reduction (kW)	574	573	562	542	528

Ex post gross savings represented a realization rate of 86% for energy savings and 95% for demand reduction (as shown in Table 257). A NTG value of 97% represented an improvement from the NTG value of 88% from 2019. However, the NTG still contributed to the reduction from *ex ante* to *ex post* gross and net savings.

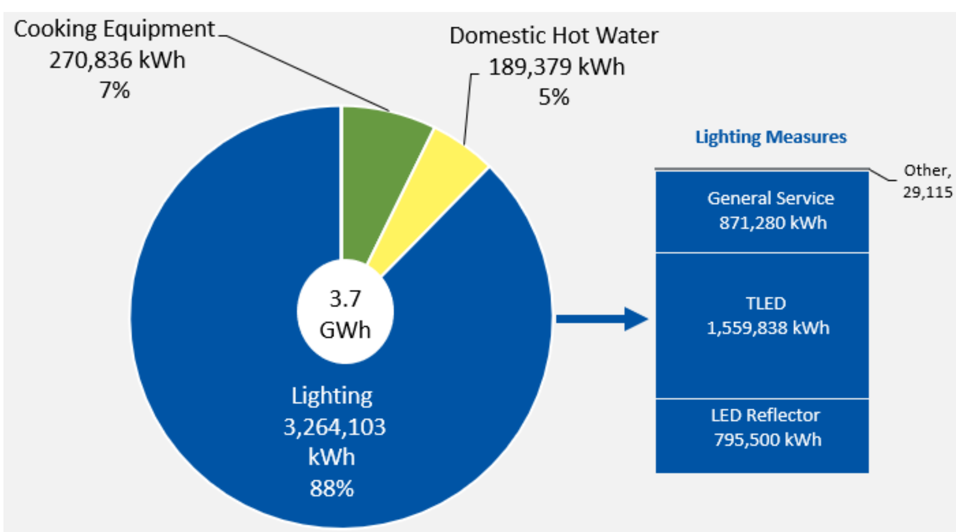
Table 257. 2020 SBDI Program Realization Rates and Net-to-Gross Summary

Realization Rate		Freeridership	Spillover	NTG
Energy Savings (kWh)	Demand Reduction (kW)			
86%	95%	13%	10%	97%

Impact Evaluation

The evaluation team assessed total program savings through a series of steps. In 2020, SBDI projects accounted for 3.7 million kilowatt-hours in *ex ante* savings. Figure 113 illustrates the SBDI project population by energy savings and measure types, as labeled in the tracking database.

Figure 113. 2020 SBDI Program *Ex Ante* Savings Distribution by Measure Category



Source: VisionDSM tracking database.

LED lighting measures accounted for 88% of *ex ante* population energy savings (similar to 89% in 2019 and 88% in 2018). In terms of *ex ante* kilowatt-hour savings, TLED retrofits represented the largest-saving lighting measure, with the remaining savings primarily attributable to LED general service and reflector-style screw-base fixtures. The 2020 distribution of lighting measures tracked fairly closely with 2019 results, with a few minor differences:

- TLED's share of savings increased slightly, from 42% in 2019 to 48% in 2020
- The percentage of LED reflector lamps decreased, from 26% in 2019 to 25% in 2020
- Though still well below their 60% share in 2017, LED general service lamps gained share, increasing from 26% in 2019 to 27% in 2020

For the 2020 SBDI program, the remaining *ex ante* savings derived primarily from direct install measures for electrically heated water conservation. DHW measures included faucet aerators, salon sprayers, showerheads, and water heater pipe insulation (with 2.2%, 2.6%, 0.3%, and 0.1% of *ex ante* kilowatt-hour savings, respectively). Cooking equipment consisted entirely of pre-rinse spray valves for dishwashing sinks and increased in share of total SBDI *ex ante* savings from 3% in 2019 to 7% in 2020.

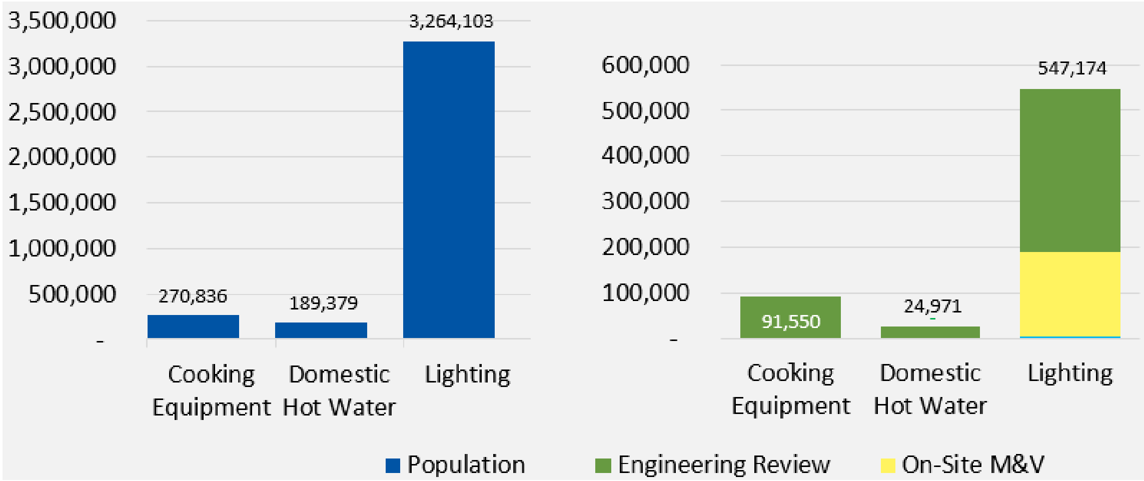
The evaluation team selected a representative sample of measures for the impact evaluation and extrapolated the findings from these measures to the larger program population. As with the 2018 and 2019 evaluations, the team used a PPS sampling approach in 2020. Table 258 shows the sample characteristics we used for the 2020 SBDI impact evaluation. Project measures represent each unique energy efficiency upgrade performed within the population. Units represent the quantity of each measure (such as the number of light fixtures, capacity of heating equipment in MBh, or feet of pipe insulation). Of 1,053 project measures installed through the SBDI program, the evaluation team completed an engineering review or an on-site EM&V analysis of 64 project measures, surpassing the 90% confidence at ±10% precision target for the energy-savings realization rate. The 2020 *ex post* gross energy savings achieved ±6.42% relative precision at 90% confidence.

Table 258. 2020 SBDI Program Impact Evaluation Sample Characteristics

Gross Population Count		Site Visit Sample Measure Count		Total Sample Measure Count		Evaluation Sample Energy-Savings Share of Program
Unit	Measure	Actual	Target	Actual	Target	
26,855	1,053	16	19	64	65	17.8%

Unlike the Custom Incentives and Prescriptive Rebates programs, where a small number of measures produce a large portion of program savings, the SBDI program tends to achieve the majority of its savings from small-savings measures. Therefore, the percentage of SBDI savings represented in the evaluation sample, of 17.8%, tends to be smaller than the percentage for other C&I programs. However, given that the SBDI program has historically exhibited smaller variations in realization rates, the sample realization rate and ISR both achieved the ±10% precision target. Figure 114 shows detail of the projects represented in the on-site EM&V analysis and engineering desk reviews.

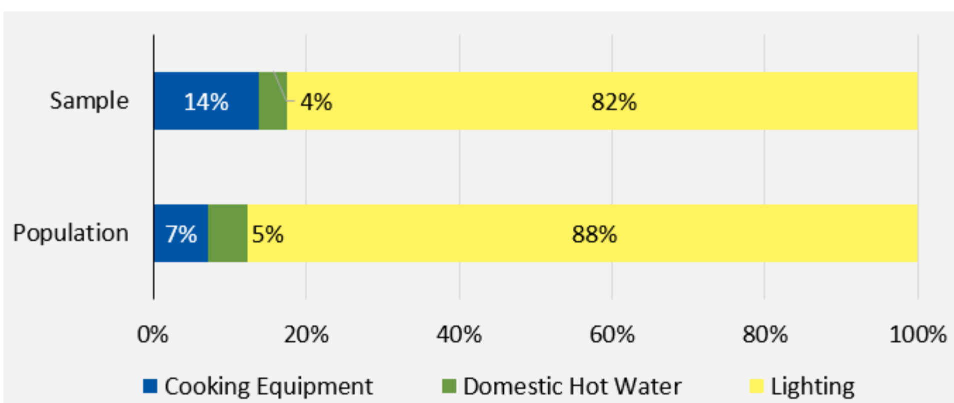
Figure 114. 2020 SBDI Program Sample Total *Ex Ante* Distribution by Measure Category Compared to Population



While the evaluated sample represented a relatively small portion of overall savings, the team's PPS sampling approach ensured that the distribution of *ex ante* energy savings in the sample closely correlated to the distribution of measure types in the total program population.

For 2020, the evaluation team reviewed 64 measures at 64 sites in the sample, via virtual site visits, to calculate the program ISR. The three-year evaluation cycle includes site visits each year to validate measure ISRs at 90% confidence and ±10% precision over the three years. The team performed an engineering review using on-site EM&V data for each virtual site visit measure, supplementing with additional engineering desk reviews to increase the evaluation sample to 64 project measures. Figure 115 shows the sample distribution by measure category, using data from the tracking database, compared with the 2020 population distribution.

Figure 115. 2020 SBDI Program Sample *Ex Ante* Percentage Distribution by Measure Compared to Population



Cooking equipment measures had somewhat higher representation in the sample than in the population due to the PPS sample weighting. On average, cooking equipment measures saved 283% more kilowatt-hours per project measure than lighting measures and 1,007% more than DHW measures, which increased their probability of selection.

Audited and Verified Savings

Audited savings generally aligned well with *ex ante* savings in 2020. The evaluation team found no discrepancies between incentivized and installed measures among the 64 sampled measures. The team performed virtual site visits to verify the installation of 16 sampled measures for the 2020 population. Only one virtual site visit revealed fewer bulbs installed than reported.

In 2020, the team calculated a 98.1% ISR with a precision of ±2.9% at 90% confidence. We applied the ISR to 2020's audited savings (3,724,318 kWh and 573 kW) to calculate verified savings for this program year (3,652,197 kWh and 562 kW).

Ex Post Gross Savings

The evaluation team adjusted *ex ante* measure savings in the *ex post* analysis based on several factors:

- Fixture quantity and wattage discrepancies discovered during virtual site visits or discussions with business owners
- AOH determined during site visits or provided by business owners
- AOH estimated by assigning hours based on a more representative facility type
- Adjustment of WHFs and a peak summer coincidence factor consistent with the Indiana TRM (v2.2)

In 2020, findings from the virtual site visits and engineering reviews were both key to the reduced *ex post* savings, especially energy savings (with a 13.5% reduction in realization rate). The biggest factor in this reduction was a downward adjustment in AOH for a majority of the sites, including sites with many measures that received only engineering review.

Adjustments to AOH typically have the largest effect on lighting measure savings. Reported and evaluated AOH were equal for 35 sampled measures and different for 29 sampled measures. Among all sampled measures, the average evaluated AOH was 17% lower than the average reported AOH (4,401 hours versus 5,332 hours). Table 259 indicates details related to sampled measures where the evaluated AOH differed from the reported AOH.

Table 259. 2020 SBDI Program Annual Operating Hour Findings

Facility or Business Type	Reported Annual Operating Hours	Evaluated Annual Operating Hours	Electric Energy Savings Realization Rate
Ambulance Service	6,802	8,760	128.31%
Apartment Complex	8,760	4,408	39.11%
Auto Repair	4,408	2,600	58.77%
Barber Shop	4,984	2,340	47.16%
Church	4,408	2,867	67.13%
	4,408	2,867	67.13%
	4,408	1,820	41.29%
Classrooms	4,408	1,352	22.64%
Clubhouse	8,760	2,867	33.78%
	8,760	4,300	43.86%
Exterior	8,760	4,300	43.86%
Exterior	8,760	4,300	43.86%
Fast Food Restaurant	4,408	5,278	118.66%
	4,408	5,850	131.52%
	4,408	5,460	122.75%
Hair Salon	4,984	2,600	52.40%
Healthcare	6,802	8,760	128.31%
Maintenance Shop	8,760	2,860	29.17%
Massage Therapy	4,408	2,340	53.09%
Music Theater	4,408	1,872	66.11%
	4,408	1,872	42.31%
Office	8,760	4,408	50.14%
	3,253	2,470	75.92%
	3,253	2,990	67.19%
Restaurant	4,408	4,368	98.20%
	3,357	3,224	95.09%
Retail	4,984	3,640	68.46%
	4,984	5,772	118.60%
	4,984	2,652	53.44%
Total	**5,332**	**4,401**	

Additional small variations between *ex ante* and *ex post* resulted from CLEAResult assuming the same energy WHF for all building types (0.119091), while the evaluation team used the Indiana TRM (v2.2) WHF lookup table for Indianapolis by each building type (where the WHF varies between 0.096 and 0.155 for an AC with natural gas heat).

Table 260 lists program realization rates and verification adjustments for the evaluation sample. The table also shows the 2020 ISR of 98.1%, as well as the gross energy savings and demand reduction program realization rates of 86% and 95%, respectively.

Table 260. 2020 SBDI Program Realization Rates

Program	Realization Rate (*Ex Post* Gross/*Ex Ante*)		ISR	ISR Precision at 90% Confidence
	Electric Energy (kWh)	Peak Demand (kW)		
SBDI	86%	95%	98.1%	±2.9

Realization rates by measure types in the sample varied with respect to on-site and engineering review findings. Table 261 shows aggregated *ex post* realization rates for each type of measure in the sample.

- The ***lighting*** measures account for most of the reduction in total *ex post* realization rates, with an energy realization rate of 84%; adjustments to AOH accounted for much of this decrease in *ex post* lighting savings (relative to claimed savings).
- For ***cooking equipment*** (pre-rinse spray valves) and ***DHW measures***, no discrepancies were found through desk reviews or virtual site visits.

Table 261. 2020 SBDI Program Evaluation Sample Results by Measure Type

Measure Type	Evaluation Sample Measure Count	Evaluation Sample Unit Count	Energy *Ex Post* Realization Rate	Demand *Ex Post* Realization Rate
Cooking Equipment	25	31	100%	N/A
Domestic Hot Water	176	510	100%	N/A
Lighting	852	26,314	84%	95%

Notably, the evaluation team did not apply the realization rates in Table 261 to each measure type in the population to determine *ex post* gross savings, which may have led to inaccurate results due to the relatively small sample sizes. Instead, the team calculated *ex post* gross savings by applying the realization rate for the sample as a whole to the population of *ex ante* energy savings and demand reduction. Table 262 provides an outline of findings within the evaluation sample.

Table 262. Application of 2020 SBDI Program Realization Rates

Metric	Population *Ex Ante*	Realization Rate (from Evaluation Sample)	Population *Ex Post* Gross
Electric Energy Savings (kWh/year)	3,724,318	86%	3,206,685
Peak Demand Reduction (kW)	574	95%	542

Note: Values rounded for reporting purposes.

Ex Post Net Savings

The evaluation team calculated freeridership and spillover using the survey data collected from 2020 participants. Table 263 shows an estimated NTG of 97% for the 2020 SBDI program.

Table 263. 2020 SBDI Program Net-to-Gross Summary

Measure Type	Freeridership [a]	Spillover	NTG	*Ex Post* Gross Population Savings (kWh)
LED Screw Base	18% [a]	10%	92%	1,488,522
LED Tube Replacement	8% [a]	10%	102%	1,289,637
DHW/Other	10% [a]	10%	100%	428,526
Overall	**13% [b]**	**10%**	**97%**	**3,206,685**

[a] The team weighted measure freeridership by the survey sample *ex post* gross program kilowatt-hour savings.
[b] The team weighted overall freeridership by the *ex post* gross program population kilowatt-hour savings.

Freeridership

To determine freeridership, the evaluation team asked 52 participants (representing 118 measure installations) whether they would have installed equipment to the same level of efficiency, at the same time, and in the same amount in absence of the program. Based on survey feedback, the evaluation team calculated overall freeridership for the program of 13% (Table 264).

Table 264. 2020 SBDI Program Freeridership Results

Measure Type	Responses (n)	Freeridership	*Ex Post* Gross Population Savings (kWh)
LED Screw Base	41	18% [a]	1,488,522
LED Tube Replacement	40	8% [a]	1,289,637
DHW/Other	37	10% [a]	428,526
Overall	**118**	**13% [b]**	**3,206,685**

Note: Values rounded for reporting purposes.
[a] The team weighted measure freeridership by the survey sample ex *post* gross program kilowatt-hour savings.
[b] The team weighted overall freeridership by the *ex post* gross program population kilowatt-hour savings.

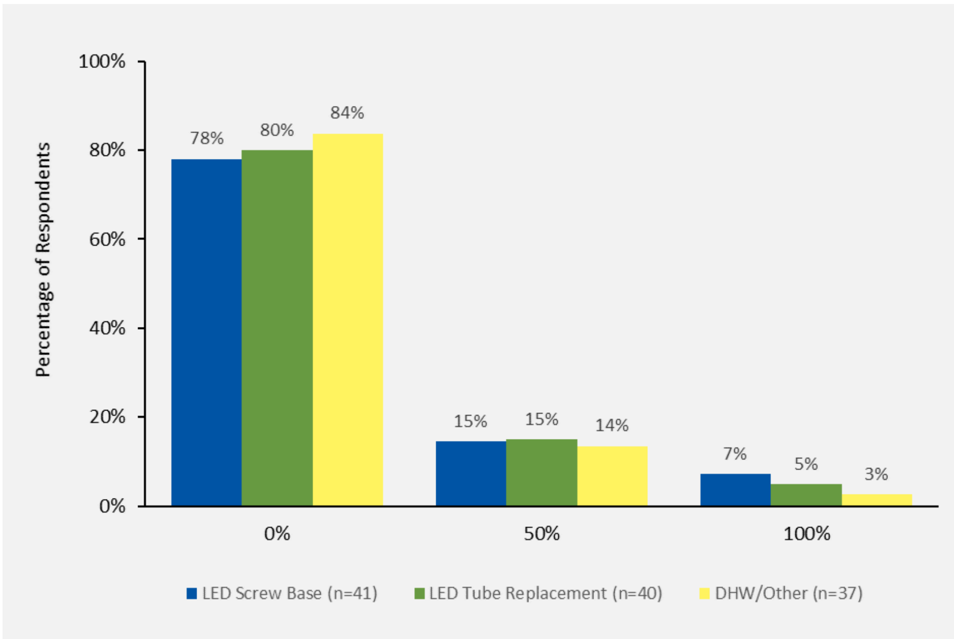
As in prior evaluations, the evaluation team estimated measure-level freeridership for each participant based on their response to the following question: "If the Small Business Direct Install program did not exist, in terms of timing, when would you most likely have purchased [MEASURE]s similar to those provided through the program?" The *intention* and *influence* freeridership components used in the Custom Incentives and Prescriptive Rebates programs' freeridership analyses do not apply well to a direct install program like SBDI, where customers do not purchase or install anything themselves. Table 265 shows the response options to the freeridership question, the freeridership score associated with each response, and the frequency of responses for each measure type.

Table 265. 2020 SBDI Program Freeridership Responses and Scoring

Response	Freeridership Score	Frequency of Responses		
		LED Screw Base	LED Tube Replacement	DWH/Other
At the same time	100%	3	2	1
Later, but within a year	50%	6	6	5
More than a year later	0%	16	20	5
Never	0%	16	12	26
Total	**N/A**	**41**	**40**	**37**

Figure 116 shows the distribution of assigned freeridership scores by program measure type.

Figure 116. 2020 SBDI Program Distribution of Freeridership Scores by Measure Type



Spillover

The evaluation team estimated spillover measure savings using specific information about participants determined through the evaluation and relying on the Indiana TRM (v2.2) as a baseline reference. We estimated the percentage of program spillover by dividing the sum of additional spillover savings (as reported by survey respondents) by the total gross savings achieved by all program respondents. The SBDI program had a 10% spillover estimate, rounded to the nearest whole percentage, as shown in Table 266.

Table 266. 2020 SBDI Program Spillover

Spillover Savings (kWh)	Participant Program Savings (kWh)	Spillover
53,509	515,461	10%

Four SBDI program participants said that overall the program was *very important* in their decision to install additional LEDs and occupancy sensors for which they did not receive a rebate from IPL. Table 267 shows these additional spillover measures and the total resulting energy savings.

Table 267. 2020 SBDI Program Spillover Measures, Quantity, and Savings

Spillover Measure	Quantity	Total Energy Savings (kWh)
LED Lighting - Parking Lot	40	50,576
LED Lighting	12	2,766
Occupancy Sensors	2	167
Total	**N/A**	**53,509**

Evaluated Net Savings Adjustments

Table 268 presents the *ex post* gross and net savings and NTG of 97% for the SBDI program.

Table 268. 2020 SBDI Program *Ex Post* Gross and Net Savings and Reduction

Savings Type	*Ex Post* Gross	NTG	*Ex Post* Net
Energy Savings (kWh)	3,206,685	97%	3,122,696
Demand Reduction (kW)	542	97%	528

Note: Values rounded for reporting purposes.

Process Evaluation

In 2020, the evaluation team conducted stakeholder interviews and participant phone surveys as part of the process evaluation activities.

Program Delivery

CLEAResult and IPL program staff reported that the program operated well in 2020 despite the COVID-19 pandemic. As in prior years, CLEAResult divided its staff into dedicated recruitment and installation roles. The outreach team performs recruitment and manages customer relationships until the installation team becomes involved, who performs installations and property energy assessments. Outreach staff schedule an on-site audit and an installation specialist visits the site to conduct the audit and perform the direct installations. CLEAResult subcontracts occupancy sensor installations to trade allies, who schedule and perform these installations separately from CLEAResult’s audit and installation.

During the walk-through audit, the installation specialist identifies energy-savings opportunities beyond the direct installations they make that day. To reach as many customers as possible, CLEAResult caps the number of measures that can be implemented at one site through the program (primarily limiting linear LEDs to 100). The installation specialist recommends applicable measures and incentives offered through IPL’s Prescriptive Rebates and Custom Incentives programs. After the audit, the customer receives an audit report with recommendations for further energy-efficient upgrades. Program staff provide contact information so the customer can reach out to pursue additional opportunities. When customers express an interest in pursuing other opportunities, staff refer them to a program specialist, who contacts the customer to help initiate the project.

Program Marketing and Outreach

CLEAResult's outreach team normally recruits eligible customers through direct mail and door-to-door canvassing, the program website, and limited telephone campaigns. CLEAResult sends letters to one geographic area every two weeks, following up face-to-face or over the phone. During the COVID-19 pandemic, CLEAResult switched from door-to-door canvassing to soliciting potential customers by phone. CLEAResult uses sector-specific language in its letters along with online case studies to persuade organizations to invest time in the direct install process.

COVID-19 Impacts on Program Operations

In response to the COVID-19 pandemic, IPL shut the program down from mid-March 2020 to the end of May 2020, though CLEAResult developed a waitlist of interested customers. Once IPL resumed program operations in June, CLEAResult deployed extra staff to conduct telephone outreach and offset lost program activity during the program shutdown. However, CLEAResult reported that after the program resumed, participation lagged compared to prior years, at 399 sites in 2020 (down from 491 sites in 2019). Due to the extra field staff manpower required in 2020, CLEAResult dropped its plans to implement a bonus rebate in 2020 for SBDI participants who installed certain measures through the Prescriptive Rebates program after completing an SBDI audit.

The pandemic also impacted how CLEAResult implemented post-installation inspections: due to limited facility access, CLEAResult offered program participants the option between in-person and virtual inspections.

Cross-Promotion of Other IPL Programs

IPL revised its customer engagement strategy in 2020 to educate customers about additional opportunities and resources offered through other IPL programs. After CLEAResult generates a report that captures additional savings opportunities for customers, it assigns an outreach representative to contact the customer and discuss savings opportunities available through IPL's other commercial programs. This discussion begins with a follow-up appointment by phone, then an in-person meeting. During the process of discussing the programs, CLEAResult asks the customer if they have a specific contractor with whom they currently conduct business. If not, CLEAResult provides a reference to three contractors with whom they have good relationships through working together in previous years of IPL's Prescriptive Rebates and Custom Incentives programs.

IPL's tracking data indicates that this post-audit customer engagement did not increase cross-program participation from 2019 to 2020: there was a 3% conversion rate of SBDI customers to the Prescriptive Rebates or Custom Incentives programs in both years. However, the evaluation team recognizes that a process change like this can take time to ramp up successfully and that this extra step may result in 2020 SBDI participants choosing to participate in the 2021 programs.

- Of 399 SBDI program participants in 2020, 11 also participated in Prescriptive Rebates and one also participated in Custom Incentives after the date of their SBDI program participation.
- Of 491 SBDI program participants in 2019, 13 also participated in Prescriptive Rebates and one also participated in Custom Incentives after the date of their SBDI program participation.

Changes to Future Program Design

IPL is considering adding a virtual retro-commissioning offering to its 2021–2023 portfolio, where SBDI participants would be eligible to participate if their facilities contain the correct types of control systems. IPL would use a web-based portal to allow customers to view interval energy usage data and receive free, personalized energy efficiency insights and recommendations meant to provide behavioral and process-driven savings. IPL would provide incentives to participants who implement recommendations within three months of complete the virtual study. The evaluation team used its 2020 SBDI participant survey to assess small business customer interest in a virtual retro-commissioning program offering and their ability to participate (see the *Interest in Virtual Retro-Commissioning* section below).

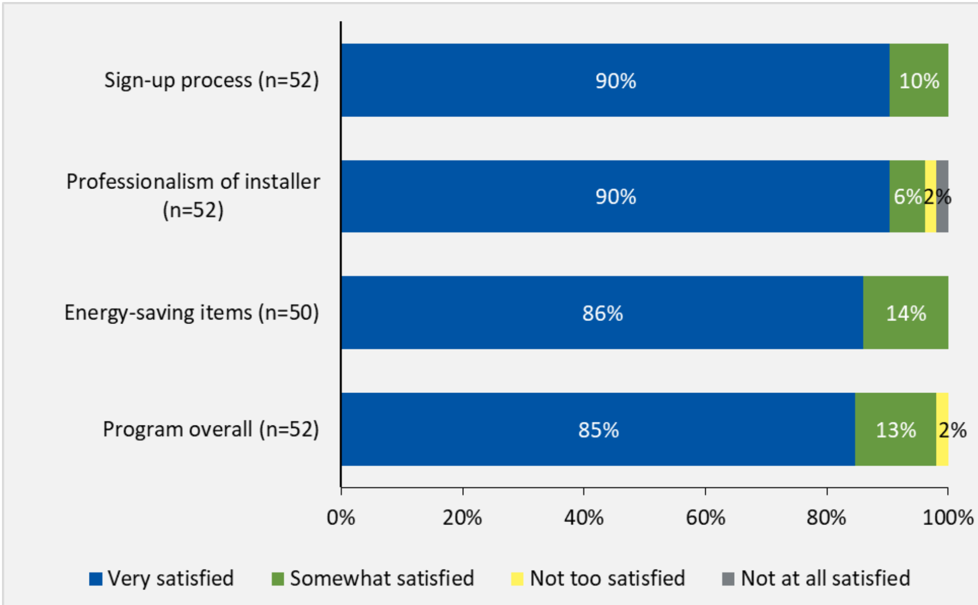
Participant Feedback

In February 2020, the evaluation team surveyed 52 SBDI program participants from a sample population of 205 unique participants to assess their program experiences, including participation drivers and barriers and satisfaction with the program and its components. While the team did not achieve the original target of reaching 70 participants, the 2020 phone survey achieved a 25% response rate (compared to 15% in 2019). The evaluation team tested for statistical significance across years, but due to the small 2019 and 2020 sample sizes, variations across program years may be overstated.

Satisfaction with Program Processes

In terms of individual program aspects, 2020 SBDI respondents were most satisfied with the sign-up process and the professionalism of the installer, with all respondents being either *somewhat satisfied* or *very satisfied* with the sign-up process (Figure 117). This represents a small increase from 2019 results, when 87% (n=54) were *very satisfied* with the sign-up process and 87% (n=55) were *very satisfied* with the professionalism of the installer. In 2020, 85% of respondents were *very satisfied* with their overall program experience, slightly lower than the 89% in 2019 (n=55). No differences between 2019 and 2020 responses were statistically significant.

Figure 117. 2020 SBDI Program Participant Satisfaction



Source: 2020 IPL SBDI Program Participant Survey Question F1. "Please rate your level of satisfaction with…"

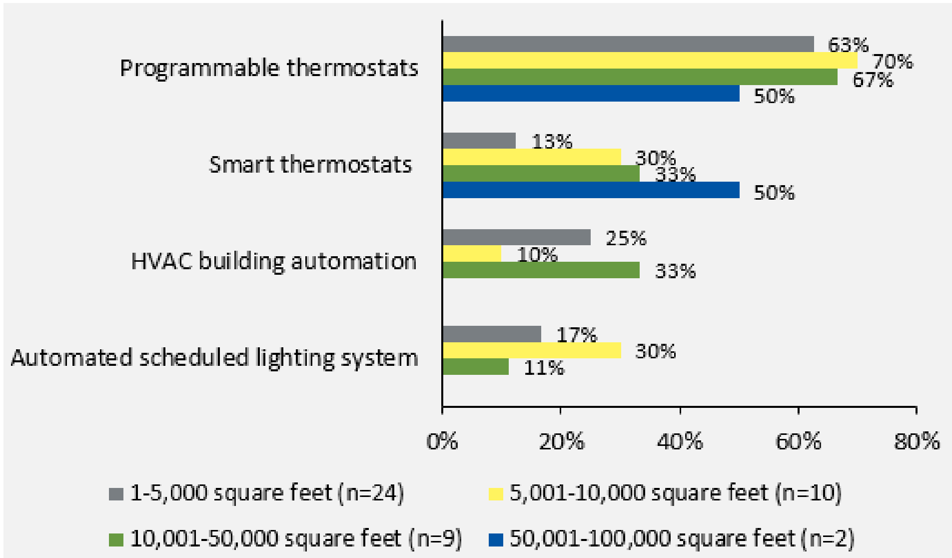
When asked for suggestions to improve the program, 77% of respondents (n=52) offered none. Of those providing comments (n=12, with one respondent offering two suggestions), seven requested that IPL provide more or different equipment offers, four suggested better or more communication with IPL or program staff throughout the process, and two suggested providing a better experience with the installer.

Interest in Virtual Retro-Commissioning

To assess the ability for IPL's small business customers to participate in a virtual retro-commissioning program, the evaluation team asked the 2020 SBDI participants which building controls are in their facilities. Of the response options, HVAC BAS and automated scheduled lighting systems are most applicable to a retro-commissioning program, but such a program may also include programmable and smart thermostats. Retro-commissioning programs do not normally include manual lighting controls or lighting occupancy sensors.

Overall, most SBDI respondents' facilities contain programmable thermostats (69%; n=49), while less than half of the facilities contain several other measures: building automation for HVAC (24%), smart thermostats (24%), and automated scheduled lighting systems (20%). Four respondents' facilities contain a building automation system for HVAC, an automated scheduled lighting system, and either a smart thermostat or programmable thermostat. Figure 118 shows the presence of controls that can be optimized through retro-commissioning by facility size.

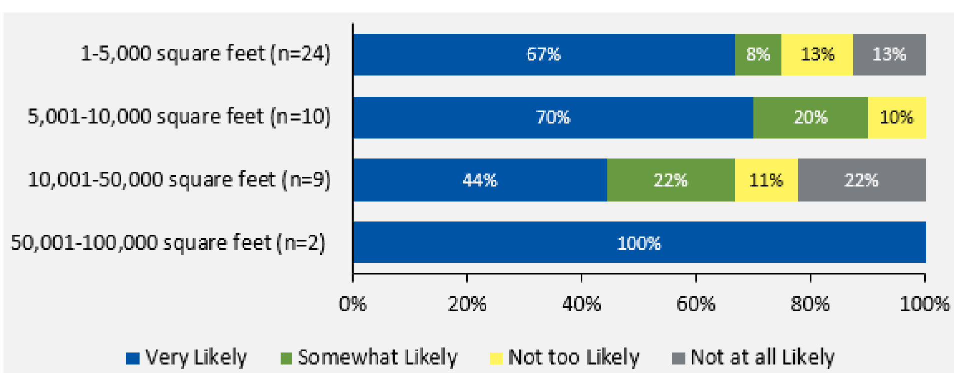
Figure 118. 2020 SBDI Facility Control Systems by Facility Size



Source: 2020 IPL SBDI Program Participant Survey Question G1. "Which of the following control systems does your facility have?" (Multiple responses allowed). The evaluation team removed respondents who did not know their facility size.

In 2020, the SBDI survey participants answered whether they would consider participating in a free virtual study of their facilities' energy usage and characteristics to hear recommended low- or no-cost facility improvements. Most respondents said they were *very likely* (60%) or *somewhat likely* (17%) to consider participating in the program offering (n=52). The evaluation team examined how interest in a virtual retro-commissioning offering varied by customer demographics. Slightly more respondents who own their building were *very interested* or *somewhat interested* in the offering (84%; n=25) compared to those who lease their buildings (70%; n=27). As shown in Figure 119, both large and small facilities are likely to consider participating.

Figure 119. 2020 SBDI Respondent Likelihood to Consider Virtual Retro-Commissioning by Facility Size



Source: 2020 IPL SBDI Program Participant Survey Question G2. "How likely are you to participate in a virtual retro-commissioning study program?" The evaluation team removed respondents who did not know their facility size.

Twelve participants were unlikely to consider participating in a virtual retro-commissioning offering due to various reasons:

- Sold business or changing business location (three respondents)
- Perception that no more energy efficiency opportunities exist (two respondents)
- Focused on other priorities (two respondents)
- Do not see the need to participate (two respondents)
- Need to ask owner for approval (one respondent)
- Equipment is too old to participate (one respondent)
- Cost of the upgrade (one respondent)

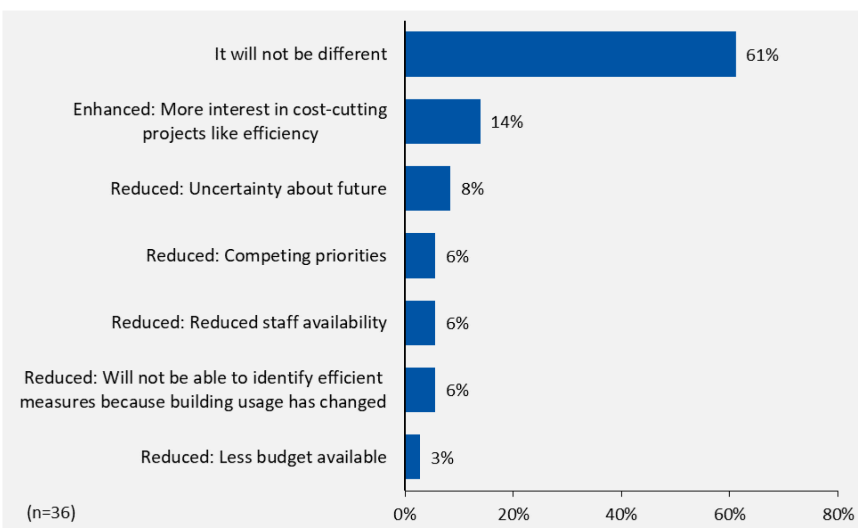
When asked what information they would need to know before deciding to participate, 55% of respondents (n=37) said they needed more information in general (such as details about the program processes and requirements). Respondents also said they would need information about the program timeline (21%), the cost to implement the recommended measures (16%), and potential energy or cost savings (13%).

Sixty-one percent of respondents did not foresee any barriers to participating in a virtual retro-commissioning program (n=51). Common barriers to program participation mentioned by others (n=20) included the cost to implement the study recommendations (nine respondents) and lack of staff time to participate in a study (five respondents).

Impact of COVID-19 on Plans for Future Energy Efficiency Projects

In 2020, 61% of SBDI respondents did not foresee a difference in their organization's interest in or ability to complete energy efficiency projects as a result of COVID-19 (n=36). As shown in Figure 120, 14% said COVID-19 increased their interest in cost-cutting projects like energy efficiency, but 29% said COVID-19 reduced their interest or ability to pursue energy efficiency projects.

Figure 120. Impact of COVID-19 on 2020 SBDI Program Participant Plans for Future Energy Efficiency Projects

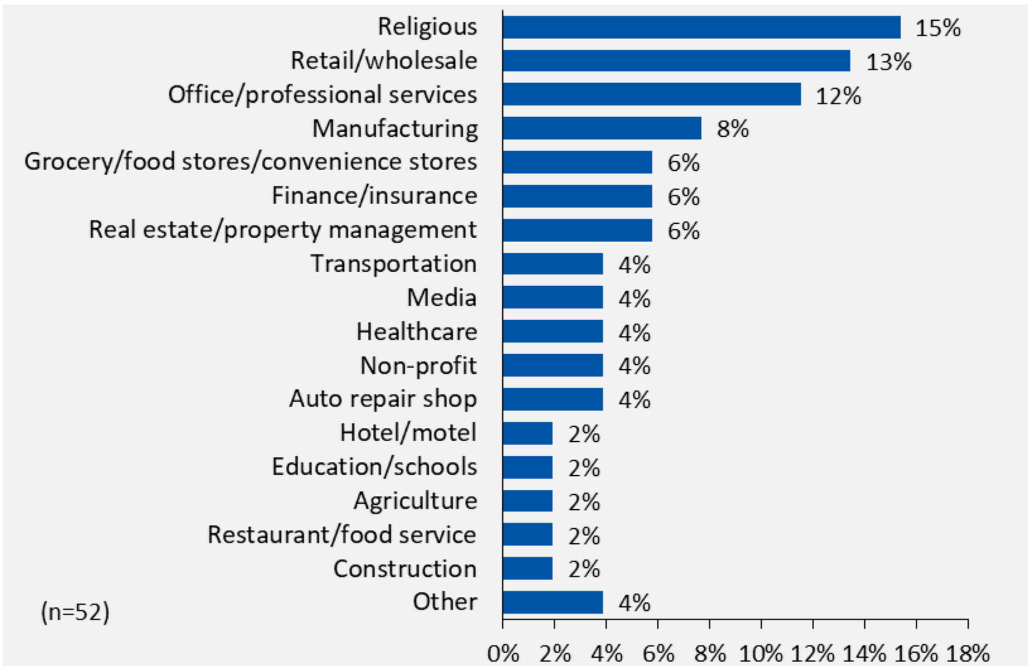


Source: 2020 IPL Program SBDI Participant Survey Question F4. "In 2021, how will your organization's interest in or ability to complete energy efficiency projects like this one be different as a result of COVID-19?" (Multiple responses allowed).

Participant Firmographics

In 2020, SBDI respondents most commonly worked in the religious sector (15%) or in retail or wholesale (13%). As shown in Figure 121, other common industries included office or professional services (12%), and manufacturing (8%).

Figure 121. 2020 SBDI Program Respondents by Business Sector

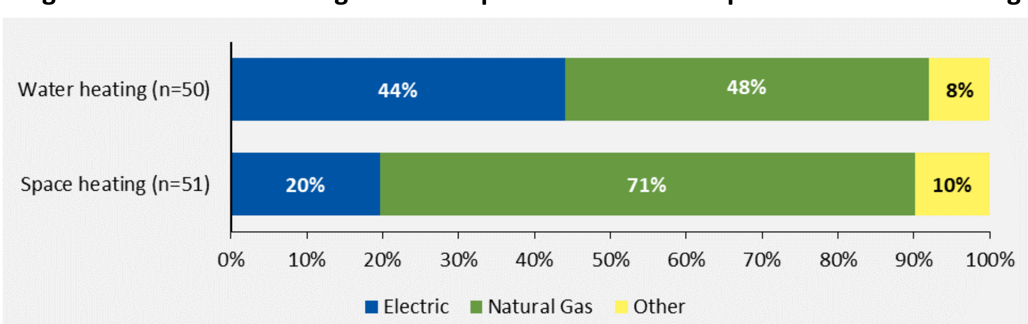


Source: 2020 IPL SBDI Program Participant Survey Question H1. "What industry is your organization in?"

Surveyed businesses were most commonly in facilities of 5,000 square feet or less (53%, n=45), with an additional 22% in facilities between 5,001 and 10,000 square feet. Forty-eight percent (n=52) of respondents owned the facilities receiving upgrades while the remaining leased their facilities.

As shown in Figure 122, 48% of facilities' use natural gas for water heating, while 71% use natural gas for general (space) heating.

Figure 122. 2020 SBDI Program Participant Main Fuel for Space and Water Heating



Source: 2020 IPL SBDI Program Participant Survey Questions H4 and H5. "What is the main fuel type used for general heating at your facility?" and "What is the main fuel type used for water heating at your facility?"

Follow-Up on 2019 Evaluation Recommendations

The evaluation team conducted stakeholder interviews and a program database review to follow up on the recommendations we made during the 2019 evaluation; the status of each is shown in Table 269.

Table 269. SBDI Program 2019 Recommendation Status

2019 Recommendation	Status
Formalize a process for providing written recommendations to each customer during the SBDI assessment by using a checklist of common energy-savings opportunities. Email the written recommendations to each customer within one week of the direct install process so the recommendations remain top-of-mind. In the email, include information about IPL's Prescriptive Rebates program bonus incentive for SBDI participants and a link to IPL's webpage for commercial customers.	***Completed***. CLEAResult revised their customer engagement to include an emphasis on additional measure opportunities and resources for follow-up projects. However, IPL did not offer a prescriptive bonus incentive for SBDI participants in 2020.
Prioritize SBDI participants to receive follow-up marketing either on general energy efficiency resources or on the Custom Incentives and Prescriptive Rebates programs for the two years after they complete the SBDI process. Some customers may not be ready to make additional upgrades the same year that they complete SBDI, but can use the materials to start planning for future energy efficiency upgrades.	***Completed***. CLEAResult revised their customer engagement to emphasize additional measure opportunities and resources for follow-up projects.
Use the Indiana TRM (v2.2) building descriptors for AOH and coincidence factor lookups that best identify specific locations within a building where lighting measures were installed, based on actual business operating hours and information provided by the site contact. While CLEAResult does assign AOH values based on Indiana TRM (v2.2) building descriptors, in most cases these assigned descriptors make sense superficially, often not reflecting the actual AOH. For example, barbershops and hair salons, which are typically open no more than 3,000 hours per year, are often assigned the Retail facility type, with 4,984 AOH. Similarly, small medical offices and dental offices may be assigned values for the Healthcare (6,802 AOH), Retail (4,984 AOH), or Other (4,408 AOH) facility type, but list much shorter business hours.	***Partially Completed.*** CLEAResult selects the building type most consistent with the participating facility. For facilities that match more than one description, CLEAResult selects the facility type with the closest AOH.
Use the Indiana TRM (v2.2) Public Assembly and Assembly facility types to assign AOH, coincidence factor, and WHF values for religious buildings, to avoid overstated energy savings. SBDI measures in facilities designated as Religious/Worship in the program tracking data accounted for 23% of SBDI *ex ante* energy savings, so this adjustment alone would have a strong positive effect on program realization rates.	***Partially Completed.*** CLEAResult added Public Assembly to the available building types.
Do not assign a facility type of 24/7 Building unless it is known that the installed lighting will operate 24 hours per day.	***Completed.*** CLEAResult will not use this building type unless it confirms that all measures installed at the site meet these AOH operating parameters.

Conclusions and Recommendations

CONCLUSION 1: Though COVID-19 hindered IPL's ability to meet the program 2020 energy-savings goals, the program continued to operate well in 2020 and customer program satisfaction remained high. COVID-19 may continue to suppress program participation in 2021 due to reduced interest in or ability to pursue energy efficiency among a subset of small businesses.

Program participation declined by 19% from 2019 (491 participants) to 2020 (399 participants), likely tied to IPL suspending the program operations from mid-March to the end of May in response to the COVID-19 pandemic, as well as to some businesses needing to shift priorities or close in 2020. Despite the pause in operations, participant satisfaction with the program overall and with various program components remained high. A similar share of 2019 and 2020 participants went on to participate in the Prescriptive Rebates or Custom Incentives program (3% in both years).

One-quarter of survey respondents indicated that the COVID-19 pandemic reduced their interest in or ability to pursue energy efficiency projects. Respondents' specific reasons were increased uncertainty about the future, competing priorities, reduced staff availability, reduced budgets, and inability to identify efficient measures because building usage has changed.

RECOMMENDATION

To help overcome SBDI customer challenges to pursuing additional energy efficiency projects during and after the COVID-19 pandemic, consider offering a bonus prescriptive incentive for customers who complete an SBDI audit.

CONCLUSION 2: A virtual retro-commissioning offering may be a good way to enhance the current SBDI program, either as a Phase II SBDI program offering or as a separate program offering that is cross-promoted to SBDI participants. SBDI participants will need additional information about virtual retro-commissioning to feel comfortable pursuing this offering.

Most respondents said they are *very likely* (60%) or *somewhat likely* (17%) to considering participating in a virtual retro-commissioning program offering, and most respondents' buildings contain at least one type of control that is a good candidate for a retro-commissioning offering (programmable or smart thermostats, a building automation system for HVAC, or an automated scheduled lighting system). However, some BAS for HVAC (reported by some SBDI respondents) may be candidates for an in-person offering rather than the virtual offering being considered.

Half the SBDI survey respondents said they would need more information in general about the offering (such as details about the program processes and requirements) in order to be interested. Respondents also said they would need information about the program timeline, the cost to implement program measures, or potential energy or cost savings. Though most survey respondents did not see barriers to participating in a virtual retro-commissioning offering, the cost to implement the study recommendations and the required staff time are both potential barriers for a minority of SBDI participants.

RECOMMENDATIONS

As BAS for HVAC have the highest savings potential among the various types of building controls, consider directing any small business customer with a building automation system for HVAC to an in-person retro-commissioning program offering to maximize the savings. Add screening criteria to the virtual retro-commissioning study that alerts the customer when it would be more cost-effective for them to engage in the in-person study.

To reduce the barrier of lack of staff time, increase the three-month eligible implementation timeframe. Do not require the study and measure implementation to take place within the same calendar year.

CONCLUSION 3: Reduced energy realization rates were primarily due to discrepancies between the AOH used for claimed savings and the AOH used for *ex post* savings.

Similar to the 2019 evaluation, in 2020 there were discrepancies between the reported lighting AOH and the actual hours the evaluation team determined through site interviews and observation. Reported and evaluated AOH were equal for 35 sampled measures and different for 29 sampled measures. Among all sampled measures, the average actual AOH was 17% lower than the reported AOH (4,401 hours versus 5,332 hours).

RECOMMENDATION

Update the AOH values used by CLEAResult in savings calculations to accurately reflect the actual AOH (as recommended in 2019). Use the Indiana TRM (v2.2) building descriptors for AOH and coincidence factor lookups based on actual business operating hours and information provided by the site contact.

Cost-Effectiveness

This chapter details the cost-effectiveness analysis results for measures installed through IPL's portfolio of electric programs (implemented in 2020). The evaluation team conducted several procedures, discussed below, to evaluate the cost-effectiveness of each electric program implemented within IPL's service area using the DSMore model. Throughout the EM&V process, the team collected information on the costs and impacts associated with each program, including indirect costs, which we used in our cost-effectiveness analysis for each customer sector and each program.

While numerous approaches adhere to the Evaluation Framework and California *Standard Practice Manual*, two are most relevant for studies of IPL programs:

- Evaluating the *ex ante* cost-effectiveness of proposed programs
- Evaluating the *ex post* cost-effectiveness of existing energy efficiency programs

The *ex ante* approach uses projected measure impacts, while the *ex post* approach uses actual load impact results from EM&V and actual program costs. For this cost-effectiveness analysis, the evaluation team used the *ex post* approach.

This report's benefit/cost assessments include IPL's program implementation costs (encompassing administrative, marketing, EM&V, and overhead costs). The results provide perspective on the cost-effectiveness of IPL's DSM portfolio performance, including oversight and management costs.

A form of economic analysis, cost-effectiveness compares an investment's relative costs and benefits. In the energy efficiency industry, this indicates the energy supply's relative performance (or the economic attractiveness of energy efficiency investments or practices) compared to the costs for energy produced and delivered in the absence of such investments (but without considering the value or costs of non-energy benefits or non-included externalities in the cost-effectiveness tests employed here). Typical cost-effectiveness formulas provide an economic comparison of costs and benefits.

This report provides benefit/cost test results for each program and for the full portfolio. Though not necessarily used to recover costs, IPL can use the information from these tests to make informed decisions about whether to adjust or continue a program, and ultimately to improve the performance of the overall energy efficiency portfolio. In addition, IPL may use these evaluation results to true-up previous estimates used in its cost-recovery mechanism.

The evaluation team based the analysis results on primary Evaluation Framework tests conducted at the program and portfolio levels, employing the benefits' NPVs versus costs for all tests. The team used the effective useful life (EUL) of installed measures and the utility's cost of capital, as though program funds were acquired via a utility loan from capital supply markets at a rate similar to those borrowed to construct a new generation plant.

The *Standard Practice Manual* identifies five cost-effectiveness tests typically used to evaluate energy efficiency programs: UCT, TRC, RIM, PCT, and SCT. For this EM&V analysis, the evaluation team did not use the SCT, as estimates of environmental and other non-energy costs and benefits[65] were not produced for this evaluation. However, the TRC test result provided the closest proxy to the SCT

Each cost-effectiveness test allows for examining measures from multiple perspectives:

- The TRC compares a program's total costs and benefits for the whole population of customers. These costs include total costs to the utility and incremental participation costs for customers, while the benefits include tax incentives and avoided supply costs. The TRC benefit/cost ratio is based on the present value of program benefits (primarily the avoided cost of capacity, generation, and transmission and distribution) relative to the total cost of program implementation and operation, as well as incremental customer costs.
- The UCT measures a program's net costs as a resource option based on costs incurred by the program administrator. Though the UCT offers the same benefits as the TRC (namely, avoided energy and capacity benefits), the more narrowly defined costs in the UCT do not include incremental costs to customers.
- The PCT assesses cost-effectiveness from participating customers' perspectives by calculating each customer's quantifiable benefits and costs for participating in the program. As many customers do not base their participation decisions entirely on quantifiable variables, this test does not necessarily provide a complete measure of all the benefits and costs perceived by a participant.
- The RIM measures a program's effect on consumer rates due to resulting changes in utility revenues and operating costs. This test indicates the direction and magnitude of expected impacts on rates.

The following test formulas use terminology from DSMore:

$$UCT = \frac{Avoided\ Costs}{Utility\ Costs}$$

$$TRC = \frac{Avoided\ Costs + Tax\ Saved}{Utility\ Costs\ Net\ of\ Incentives + Participant\ Incremental\ Costs}$$

$$RIM^{66} = \frac{Avoided\ Costs}{Utility\ Costs + Lost\ Revenue}$$

65 Such costs and benefits can include the value of displaced (or avoided) power plant emissions caused by the programs' direct energy impacts, the direct and indirect effects of the flow of dollars on Indiana's economy, and economic benefits from increased equipment life, improved productivity, lowered waste generation, increased sales, reduced injuries and illnesses, reduced repair and maintenance expenses, and increased property values.

66 DSMore produces RIM and RIM(Net Fuel) outputs. For this cost-effectiveness evaluation the team reported RIM.

$$RIM\ (Net\ Fuel) = \frac{Avoided\ Costs}{Utility\ Costs + Lose\ Revenue\ Net\ of\ Fuel}$$

$$PCT = \frac{Lost\ Revenue + Incentives + Tax\ Savings}{Participant\ Incremental\ Costs}$$

Inputs to Cost-Effectiveness Analysis

This section outlines the specific input data required by DSMore to evaluate energy efficiency measures or programs.

Hourly Prices and Energy Savings

Best practice cost-effectiveness modeling begins with hourly prices and hourly energy savings from the specific measures installed and technologies or behaviors conducted, and correlates both of these to weather. This allows the model to capture and apply appropriate values to low-probability, high-consequence weather events, capturing a more accurate view of the efficiency measure's value compared to other supply options. To complete the analysis, DSMore requires several inputs, as summarized in the *Program-Related Inputs* section.

To determine the hourly price used for this study, the evaluation team analyzed historical hourly price data, which we matched with hourly weather details to measure the price-to-weather covariance. This analysis allowed the team to measure the overall variation and portion attributable to weather, arriving at a normal weather price distribution. Price variation can result from several uncertain variables, including weather. Using over 30 years of weather data, regressed from two years of actual price data, DSMore measures the full range of possible outcomes, reported as Minimum, Todays (expected), and Maximum test ratios.

Program-Related Inputs

The evaluated team added many details into DSMore: program participation rates, incentives paid, measure savings, measure EUL, implementation costs, administrative costs, and incremental costs to participants. These inputs derived from EM&V activities that the evaluation team supplied to Integral Analytics for cost-effectiveness analysis. The team applied measured kilowatt-hour savings to appropriate hours for each customer, based on load curves for the customer group most likely to install the measure. For example, the team used commercial load curves for commercial measures (and often used various commercial load curves, depending on the measure type and size installed).

The evaluation team calculated the value of electric energy savings by hour, based on that hour's market value for the measure's energy savings. The value of capacity savings is calculated from demand reductions at the time of system peak, based on the market value of avoided capacity at system peak. The calculated avoided costs (energy and capacity) served as the present value cost, with all savings valued to dollars as of the year 2020.

Effective Useful Life

The evaluation team counted and valued energy savings from each type of installed energy efficiency program measure over that measure's full EUL. In addition, the team incorporated energy savings into the cost-effectiveness analysis for technologies with a remaining useful life. In such situations, energy savings reflect a higher impact for the remaining useful life, then slowly decrease to a level consistent with the current baseline EUL.

Freeridership

Freeriders are program participants who would have installed the same energy-efficient equipment in the program's absence. Many programs include freeriders, who are often early adopters of a technology and have many differing motivations to participate beyond the program incentive.

Spillover

Spillover arises from participants' energy savings that result from program activities, but that have not been captured through the program. This can happen in two ways:

- A customer, due to the program's influence, buys multiple units of a qualifying piece of efficient equipment but obtains a rebate for only one unit.
- A program participant obtains a rebate in one location, then replicates the program-induced purchasing decision in another building but does not apply for a rebate for the second purchase.

In both cases, the program influenced the customer to the extent that their short-term, program-induced actions spilled into other efficient purchases or behaviors not rebated or tracked by a program.

For this evaluation, the team identified and included spillover savings in the benefit/cost assessment as short-term actions taken between the participation period and the evaluation effort. As a result, the included spillover represents a fraction of the total spillover that may have been achieved; it does not include longer-term spillover from actions taken due to the program, which is spread over many years and reflects a program changing the way a market operates or the way a participant behaves.

Utility Inputs

DSMore requires utility rates, escalation rates, avoided energy and capacity costs, and discount rates for the utility, society, and participants, all of which were supplied by IPL for this report, in addition to line loss ratios.

Avoided Costs

The evaluation team developed each measure's valuation using a bottom-up approach that allowed us to estimate an hourly avoided cost using forward-looking, incremental cost elements for that hour. The resulting hourly, avoided electricity costs vary by hour of day, day of week, and time of year. Weather-dependent results require a normal weather outcome and a distribution of weather-related variation in outcomes.

Electric avoided costs, by cost component, include three factors:

- ***Generation Costs****:* Variable by hour, the annual forecast of avoided generation costs is allocated according to an hourly price shape, obtained from historical, participant-specific data that reflects the actual competitive market environment and expected weather variations. IPL provided average annual prices.
- ***Capacity Costs****:* Associated with generation or capacity markets, these reflect the cost of acquiring the additional capacity. IPL provided these cost estimates.
- ***Transmission and Distribution Costs****:* Variable by hour, non-peak hours produce zero avoided transmission and distribution capacity costs, reflecting that transmission and distribution capacity investments are used for equipment that serves peak hours. IPL provided these cost estimates.

Net Present Value

The evaluation team calculated an energy efficiency measure's cost-effectiveness based on the NPV of costs and benefits valued in each test, discounted over the EUL for each type of installed measure. The team used a 6.52% discount rate for the present value calculations.

Results Based on Evaluated Savings Excluding General Service Lighting

DSMore provides insight regarding energy efficiency programs' cost-effectiveness, per the UCT, TRC, RIM, and PCT, reporting results at the program level, summed to the customer class and portfolio levels.

Note that based on an agreement with the Office of Utility Consumer Counselor in 2019, IPL agreed to remove benefits associated with the general service lighting from the cost-effectiveness analysis for the CBL and Lighting and Appliance programs. Those adjustments are incorporated into the results presented below in Table 270 through Table 274.

Table 270 summarizes cost-effectiveness results for the electric portfolio based on the full evaluated savings, costs, and benefits.

Table 270. 2020 Electric Portfolio Cost-Effectiveness Results Based on Evaluated Savings (no GSL)

Program	Cost-Effectiveness Test			
	UCT	TRC	RIM	PCT
Residential				
Demand Response	1.56	2.29	1.28	N/A
Appliance Recycling	1.30	1.79	0.50	N/A
Community Based Lighting	-	-	-	N/A
Income Qualified Weatherization	0.84	0.84	0.43	N/A
Lighting and Appliance	3.63	2.96	0.75	9.69
Multifamily Direct Install	1.88	1.88	0.55	N/A
Peer Comparison	2.88	2.88	0.63	N/A
School Kit	5.26	5.26	0.71	N/A
Whole Home	1.13	1.16	0.62	7.07
Total Residential	**1.71**	**1.82**	**0.67**	**16.99**
Commercial and Industrial				
Demand Response	0.29	0.36	0.29	N/A
Custom Incentives	3.99	2.52	0.80	4.58
Prescriptive Rebates	6.09	4.45	0.97	4.89
Small Business Direct Install	3.12	3.12	0.84	N/A
Total Commercial and Industrial	**5.27**	**3.79**	**0.92**	**4.97**
Total 2020 Electric Portfolio	**3.51**	**3.01**	**0.85**	**6.15**

The evaluation team based these tests on an evaluation of actual program costs, load impacts, and utility avoided cost benefits. Individually, all residential programs except the IQW program passed the UCT and TRC cost-effectiveness tests. Only the residential Demand Response program passed the RIM test. When compared to 2019 results, some programs improved in cost-effectiveness while others declined in cost-effectiveness.

Overall, the 2020 residential program UCT and TRC results improved slightly compared to 2019 results. The overall residential performance rose slightly from a UCT of 1.58 to 1.71, which can be primarily attributed to cost management (while the overall benefits are slightly lower, total costs declined (-2.9%) such that the UCT score rose slightly). The overall residential portfolio passed the UCT, TRC, and PCT cost-effectiveness tests.

All the energy efficiency C&I programs passed the UCT, TRC, and PCT, except the Demand Response program. The performance of the C&I Demand Response program declined significantly, indicating a need to review the program's operation and future plans. The 2020 cost-effectiveness results for individual C&I programs varied relative to 2019 results. Overall, the results for the C&I programs, including for the Demand Response program, were slightly lower than the prior year results, with the UCT declining from 5.87 to 5.27. The total C&I portfolio passed the UCT, TRC, and PCT, but not the RIM test.

The 2020 total portfolio of electric programs proved cost-effective for the UCT, TRC, and PCT. Table 271, Table 272, Table 273, and Table 274 show estimates of the present value benefits and costs, as well as the NPV of program benefits, for each of the four tests—UCT, TRC, RIM, and PCT—respectively. The tables provide values for each electric program, by customer segment, and for the total portfolio of programs. The NPVs represent the difference between the present value of benefits and the present value of costs, including indirect costs (as applicable).

Table 271. Net Present Value of Program Benefits: Utility Cost Test (no GSL)

Program	Total Benefits	Total Costs	Present Value of Net Benefits
	UCT		
Residential			
Demand Response	$4,761,563	$3,053,524	$1,708,039
Appliance Recycling	$856,613	$660,836	$195,777
Community Based Lighting	$-	$415,670	$(415,670)
Income Qualified Weatherization	$1,478,726	$1,764,452	$(285,726)
Lighting and Appliance	$5,574,865	$1,536,915	$4,037,950
Multifamily Direct Install	$2,807,322	$1,494,127	$1,313,195
Peer Comparison	$2,374,976	$824,244	$1,550,731
School Kit	$3,014,936	$573,370	$2,441,567
Whole Home	$4,009,544	$3,551,384	$458,160
Indirect Portfolio Costs	$-	$712,354	$(712,354)
Total Residential	**$24,878,546**	**$14,586,877**	**$10,291,669**
Commercial and Industrial			
Demand Response	$29,353	$99,759	$(70,406)
Custom Incentives	$14,539,526	$3,645,838	$10,893,688
Prescriptive Rebates	$61,212,611	$10,045,203	$51,167,408
Small Business Direct Install	$2,925,497	$937,976	$1,987,521
Indirect Portfolio Costs	$-	$207,294	$(207,294)
Total Commercial and Industrial	**$78,706,987**	**$14,936,069**	**$63,770,918**
Total 2020 Electric Portfolio	**$103,585,533**	**$29,522,946**	**$74,062,587**

Table 272. Net Present Value of Program Benefits: Total Resource Cost Test (no GSL)

Program	Total Benefits	Total Costs	Present Value of Net Benefits
	TRC		
Residential			
Demand Response	$4,761,563	$2,079,494	$2,682,069
Appliance Recycling	$856,613	$478,121	$378,492
Community Based Lighting	$-	$415,670	$(415,670)
Income Qualified Weatherization	$1,478,726	$1,764,452	$(285,726)
Lighting and Appliance	$5,574,865	$1,882,387	$3,692,477
Multifamily Direct Install	$2,807,322	$1,494,127	$1,313,195
Peer Comparison	$2,374,976	$824,244	$1,550,731
School Kit	$3,014,936	$573,370	$2,441,567
Whole Home	$4,009,544	$3,467,607	$541,937
Indirect Portfolio Costs	$-	$712,354	$(712,354)
Total Residential	**$24,878,546**	**$13,691,827**	**$11,186,719**

Program	Total Benefits	Total Costs	Present Value of Net Benefits
	TRC		
Commercial and Industrial			
Demand Response	$29,353	$81,554	$(52,201)
Custom Incentives	$14,539,526	$5,758,951	$8,780,575
Prescriptive Rebates	$61,212,611	$13,764,244	$47,448,366
Small Business Direct Install	$2,925,497	$937,976	$1,987,521
Indirect Portfolio Costs	$-	$207,294	$(207,294)
Total Commercial and Industrial	**$78,706,987**	**$20,750,020**	**$57,956,967**
Total 2020 Electric Portfolio	**$103,585,533**	**$34,441,847**	**$69,143,686**

Table 273. Net Present Value of Program Benefits: Ratepayer Impact Measure Test (no GSL)

Program	Total Benefits	Total Costs	Present Value of Net Benefits
	RIM		
Residential			
Demand Response	$4,761,563	$3,719,630	$1,041,933
Appliance Recycling	$856,613	$1,710,583	$(853,970)
Community Based Lighting	$-	$415,670	$(415,670)
Income Qualified Weatherization	$1,478,726	$3,473,763	$(1,995,036)
Lighting and Appliance	$5,574,865	$7,460,145	$(1,885,280)
Multifamily Direct Install	$2,807,322	$5,064,913	$(2,257,590)
Peer Comparison	$2,374,976	$3,741,406	$(1,366,430)
School Kit	$3,014,936	$4,227,168	$(1,212,231)
Whole Home	$4,009,544	$6,505,688	$(2,496,143)
Indirect Portfolio Costs	$-	$712,354	$(712,354)
Total Residential	**$24,878,546**	**$37,031,319**	**$(12,152,773)**
Commercial and Industrial			
Demand Response	$29,353	$99,865	$(70,511)
Custom Incentives	$14,539,526	$18,176,650	$(3,637,124)
Prescriptive Rebates	$61,212,611	$63,366,515	$(2,153,904)
Small Business Direct Install	$2,925,497	$3,496,655	$(571,158)
Indirect Portfolio Costs	$-	$207,294	$(207,294)
Total Commercial and Industrial	**$78,706,987**	**$85,346,978**	**$(6,639,991)**
Total 2020 Electric Portfolio	**$103,585,533**	**$122,378,297**	**$(18,792,764)**

Table 274. Net Present Value of Program Benefits: Participant Cost Test (no GSL)

Program	Total Benefits	Total Costs	Present Value of Net Benefits
	PCT		
Residential			
Demand Response	$1,640,136	$-	$1,640,136
Appliance Recycling	$2,170,460	$-	$2,170,460
Community Based Lighting	$-	$-	$-
Income Qualified Weatherization	$1,709,310	$-	$1,709,310
Lighting and Appliance	$13,188,981	$1,361,123	$11,827,858
Multifamily Direct Install	$3,674,663	$-	$3,674,663
Peer Comparison	$2,917,162	$-	$2,917,162
School Kit	$4,050,143	$-	$4,050,143
Whole Home	$4,439,235	$627,859	$3,811,375
Total Residential	**$33,790,090**	**$1,988,982**	**$31,801,107**
Commercial and Industrial			
Demand Response	$18,311	$-	$18,311
Custom Incentives	$18,591,465	$4,057,906	$14,533,559
Prescriptive Rebates	$69,254,878	$14,152,655	$55,102,222
Small Business Direct Install	$2,627,498	$-	$2,627,498
Total Commercial and Industrial	**$90,492,151**	**$18,210,561**	**$72,281,590**
Total 2020 Electric Portfolio	**$124,282,241**	**$20,199,543**	**$104,082,697**

Results Based on Evaluated Savings Including General Service Lighting

The results presented in the previous section reflected the agreement with the Office of Utility Consumer Counselor to remove benefits associated with the general service lighting from the cost-effectiveness analysis for the CBL and Lighting and Appliance programs. In order to provide IPL with program cost-effectiveness estimates that include the full benefits of the programs, the evaluation team ran a second set of analysis including general service lighting for CBL and Lighting and Appliance. Those results are presented below in Table 275 through Table 279. Table 275 summarizes the cost-effectiveness results for the electric portfolio based on the full evaluated savings, costs, and benefits.

Table 275. 2020 Electric Portfolio Cost-Effectiveness Results Based on Evaluated Savings (with GSL)

Program	Cost-Effectiveness Test			
	UCT	TRC	RIM	PCT
Residential				
Demand Response	1.56	2.29	1.28	N/A
Appliance Recycling	1.30	1.79	0.50	N/A
Community Based Lighting	6.83	6.83	0.85	N/A
Income Qualified Weatherization	0.84	0.84	0.43	N/A
Lighting and Appliance	5.10	3.55	0.80	8.99
Multifamily Direct Install	1.88	1.88	0.55	N/A
Peer Comparison	2.88	2.88	0.63	N/A
School Kit	5.26	5.26	0.71	N/A
Whole Home	1.13	1.16	0.62	7.07
Total Residential	**2.06**	**2.14**	**0.71**	**16.15**
Commercial and Industrial				
Demand Response	0.29	0.36	0.29	N/A
Custom Incentives	3.99	2.52	0.80	4.58
Prescriptive Rebates	6.09	4.45	0.97	4.89
Small Business Direct Install	3.12	3.12	0.84	N/A
Total Commercial and Industrial	**5.27**	**3.79**	**0.92**	**4.97**
Total 2020 Electric Portfolio	**3.68**	**3.13**	**0.85**	**6.32**

When general service lighting is included, the CBL program results in a UCT of 6.83 and the Lighting and Appliance program result increased from a UCT of 3.63 to 5.10. The overall residential performance rose slightly from a UCT of 1.71 to 2.06 by including general service lighting.

Table 276. Net Present Value of Program Benefits: Utility Cost Test (with GSL)

Program	Total Benefits	Total Costs	Present Value of Net Benefits
	UCT		
Residential			
Demand Response	$4,761,563	$3,053,524	$1,708,039
Appliance Recycling	$856,613	$660,836	$195,777
Community Based Lighting	$2,841,097	$415,670	$2,425,427
Income Qualified Weatherization	$1,478,726	$1,764,452	$(285,726)
Lighting and Appliance	$7,843,596	$1,536,915	$6,306,681
Multifamily Direct Install	$2,807,322	$1,494,127	$1,313,195
Peer Comparison	$2,374,976	$824,244	$1,550,731
School Kit	$3,014,936	$573,370	$2,441,567
Whole Home	$4,009,544	$3,551,384	$458,160
Indirect Portfolio Costs	$-	$712,354	$(712,354)
Total Residential	**$29,988,375**	**$14,586,877**	**$15,401,498**

Program	Total Benefits	Total Costs	Present Value of Net Benefits
	UCT		
Commercial and Industrial			
Demand Response	$29,353	$99,759	$(70,406)
Custom Incentives	$14,539,526	$3,645,838	$10,893,688
Prescriptive Rebates	$61,212,611	$10,045,203	$51,167,408
Small Business Direct Install	$2,925,497	$937,976	$1,987,521
Indirect Portfolio Costs	$-	$207,294	$(207,294)
Total Commercial and Industrial	**$78,706,987**	**$14,936,069**	**$63,770,918**
Total 2020 Electric Portfolio	**$108,695,362**	**$29,522,946**	**$79,172,416**

Table 277. Net Present Value of Program Benefits: Total Resource Cost Test (with GSL)

Program	Total Benefits	Total Costs	Present Value of Net Benefits
	TRC		
Residential			
Demand Response	$4,761,563	$2,079,494	$2,682,069
Appliance Recycling	$856,613	$478,121	$378,492
Community Based Lighting	$2,841,097	$415,670	$2,425,427
Income Qualified Weatherization	$1,478,726	$1,764,452	$(285,726)
Lighting and Appliance	$7,843,596	$2,210,338	$5,633,259
Multifamily Direct Install	$2,807,322	$1,494,127	$1,313,195
Peer Comparison	$2,374,976	$824,244	$1,550,731
School Kit	$3,014,936	$573,370	$2,441,567
Whole Home	$4,009,544	$3,467,607	$541,937
Indirect Portfolio Costs	$-	$712,354	$(712,354)
Total Residential	**$29,988,375**	**$14,019,777**	**$15,968,597**
Commercial and Industrial			
Demand Response	$29,353	$81,554	$(52,201)
Custom Incentives	$14,539,526	$5,758,951	$8,780,575
Prescriptive Rebates	$61,212,611	$13,764,244	$47,448,366
Small Business Direct Install	$2,925,497	$937,976	$1,987,521
Indirect Portfolio Costs	$-	$207,294	$(207,294)
Total Commercial and Industrial	**$78,706,987**	**$20,750,020**	**$57,956,967**
Total 2020 Electric Portfolio	**$108,695,362**	**$34,769,797**	**$73,925,565**

Table 278. Net Present Value of Program Benefits: Ratepayer Impact Measure Test (with GSL)

Program	Total Benefits	Total Costs	Present Value of Net Benefits
	RIM		
Residential			
Demand Response	$4,761,563	$3,719,630	$1,041,933
Appliance Recycling	$856,613	$1,710,583	$(853,970)
Community Based Lighting	$2,841,097	$3,334,291	$(493,194)
Income Qualified Weatherization	$1,478,726	$3,473,763	$(1,995,036)
Lighting and Appliance	$7,843,596	$9,789,672	$(1,946,076)
Multifamily Direct Install	$2,807,322	$5,064,913	$(2,257,590)
Peer Comparison	$2,374,976	$3,741,406	$(1,366,430)
School Kit	$3,014,936	$4,227,168	$(1,212,231)
Whole Home	$4,009,544	$6,505,688	$(2,496,143)
Indirect Portfolio Costs	$-	$712,354	$(712,354)
Total Residential	**$29,988,375**	**$42,279,467**	**$(12,291,092)**
Commercial and Industrial			
Demand Response	$29,353	$99,865	$(70,511)
Custom Incentives	$14,539,526	$18,176,650	$(3,637,124)
Prescriptive Rebates	$61,212,611	$63,366,515	$(2,153,904)
Small Business Direct Install	$2,925,497	$3,496,655	$(571,158)
Indirect Portfolio Costs	$-	$207,294	$(207,294)
Total Commercial and Industrial	**$78,706,987**	**$85,346,978**	**$(6,639,991)**
Total 2020 Electric Portfolio	**$108,695,362**	**$127,626,445**	**$(18,931,083)**

Table 279. Net Present Value of Program Benefits: Participant Cost Test (with GSL)

Program	Total Benefits	Total Costs	Present Value of Net Benefits
	PCT		
Residential			
Demand Response	$1,640,136	$-	$1,640,136
Appliance Recycling	$2,170,460	$-	$2,170,460
Community Based Lighting	$2,918,621	$-	$2,918,621
Income Qualified Weatherization	$1,709,310	$-	$1,709,310
Lighting and Appliance	$16,796,986	$1,869,167	$14,927,819
Multifamily Direct Install	$3,674,663	$-	$3,674,663
Peer Comparison	$2,917,162	$-	$2,917,162
School Kit	$4,050,143	$-	$4,050,143
Whole Home	$4,439,235	$627,859	$3,811,375
Total Residential	**$40,316,716**	**$2,497,026**	**$37,819,689**
Commercial and Industrial			
Demand Response	$18,311	$-	$18,311
Custom Incentives	$18,591,465	$4,057,906	$14,533,559
Prescriptive Rebates	$69,254,878	$14,152,655	$55,102,222
Small Business Direct Install	$2,627,498	$-	$2,627,498
Total Commercial and Industrial	**$90,492,151**	**$18,210,561**	**$72,281,590**
Total 2020 Electric Portfolio	**$130,808,867**	**$20,707,587**	**$110,101,279**

Conclusions

This cost-effectiveness analysis, both including and excluding general service lighting, indicates that IPL's total electric energy efficiency portfolio operates very cost-effectively. For results excluding general service lighting, based on the UCT test results, the 2020 electric portfolio generates over $74 million in net benefits on a present value basis. Based on the TRC test results, the portfolio generates almost $69 million in net benefits. Including general service lighting, the portfolio generates over $79 million in net benefits based on the UCT test results and nearly $74 million based on the TRC test result. These program results indicate that the portfolio is very successful at providing financial value to IPL and its customers.

Appendix A. Evaluation, Measurement, and Verification Definitions

Table A-1. Evaluation, Measurement, and Verification Definitions

Category	Definition	Purpose	Method
Audited Quantity and Savings	An intermediate step in determining savings. This is the project tracking data savings values, which are checked and adjusted (if needed) for alignment with the less granular *ex ante* data.	Allows for checking the accuracy of the tracking system. Program savings are based on adjusted program tracking data.	To calculate this value, we reviewed the program tracking databases and a sample of hardcopy program applications to verify consistency with data recorded in program tracking databases.
Ex Ante Savings	Reported savings values in IPL's scorecards.	Provides claimed savings values after utility reconciliation with implementer tracking data.	As reported.
Ex Post Gross Savings	The evaluation team's savings calculations, adjusted from verified values, considering best available information from all primary and secondary sources. These methods may differ from program-specified data and methods and inform program updates.	Informs best estimate of savings using provided project data and secondary sources.	Typical methods to calculate this value include engineering analysis, building simulation modeling, billing analysis, metering analysis, or other accepted methods. In some cases we changed baseline assumptions to adjust for weather, occupancy levels, production levels, and other factors.
Ex Post Net Savings	*Ex post* gross savings multiplied by NTG.	Informs program design improvements, program planning, cost-effectiveness analysis, and calculations of lost revenues.	The team determined this value by adjusting the *ex post* gross savings estimates to account for circumstances such as savings-weighted freeridership and spillover effects.
Goal	Target for claimed savings by utility.	Used for goal setting.	As reported.
Verified Savings	A calculation that further adjusts the audited savings.	Confirms program reach and persistence of installed and operating measures. Where custom measures are installed, we reviewed engineering assumptions for a statistically representative sample of projects. We sometimes adjusted this step to address several types of issues: • Measures rebated but never installed • Measures not meeting program qualifications • Measures installed but later removed • Measures improperly installed	The team followed several steps to calculate this value: • Checked *ex ante* deemed savings estimates and calculations to ensure that the implementer or utility applied the pre-agreed-upon values correctly • Adjusted program tracking data to correct any errors or omissions identified above, using the Indiana TRM (v2.2) or other program-specified data and methods (such as best available estimate without the benefit of hindsight and in conformance with program methods) • Recalculated program savings based on the adjusted program tracking data • Applied an ISR

Appendix B. Self-Report Net-to-Gross Methodology

This appendix describes the team's methodologies to evaluate NTG for the Prescriptive Rebates, Custom Incentives, the Whole Home programs' rebated HVAC measures, as well as the Lighting and Appliance program appliance and IPL Marketplace measures. NTG estimates serve a critical role in DSM program impact evaluations, allowing utilities to determine gross energy savings influenced by and attributable to DSM programs, free from other influences.

NTG can be divided into two components: freeridership and spillover. Freeriders are customers who would have purchased a measure without the program's influence. Spillover is the amount of additional savings customers obtained by investing in energy-efficient measures or activities due to their program participation. Various methods can be used to estimate program freeridership and spillover. In 2020, the evaluation team used self-reports, procured through participant surveys.

Survey Design

For the 2020 Custom Incentives and Prescriptive Rebates programs' survey design, the evaluation team modified our previous freeridership measurements, first implemented in 2016. Prior to 2016, the team determined IPL freeridership based on customers' self-reported intentions to purchase a measure in the absence of program incentives, where survey questions addressed the incentive's effect on the efficiency, quantity, and timing of purchases. This portion of freeridership measurement has not changed since 2016. Persistent conjecture in the industry, however, indicates that intention-based self-reports may be subject to biases, yielding inflated freeridership values.[67] To address this and to triangulate approaches to the estimate (a desirable measurement principle), the team integrated a second set of survey questions in 2016 (used again in 2017, 2018, 2019, and 2020) to measure the program's perceived *influence* on respondents' purchasing decisions.

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[67] Some identified biases could lead to underestimated freeridership rates (per literature, the net biasing effect remains unknown). See: Peters, J., and M. McRae. 2008. "Freeridership Measurement Is Out of Sync with Program Logic…or, We've Got the Structure Built, but What's Its Foundation." Proceedings of the ACEEE Summer Study on Energy Efficiency in Buildings, Washington, DC.;
Ridge, R., P. Willems, J. Fagan, and K. Randazzo. 2009. "The Origins of the Misunderstood and Occasionally Maligned Self-Report Approach to Estimating Net-to-Gross Ratio." Paper presented at Energy Program Evaluation Conference, Portland, Oregon.; and
Keating, K. 2009. "Freeridership Borscht: Don't Salt the Soup." Paper presented at International Energy Program Evaluation Conference, Portland, Oregon.
www.aceee.org/files/proceedings/2008/data/papers/5_491.pdf

By savings weighting the previously used *intention* methodology with an *influence* methodology, the evaluation team produced a program freeridership score.[68] The team calculated the arithmetic mean of *intention* and *influence* freeridership components to estimate final program freeridership:

$$\text{Final Freeridership} = \frac{\textit{Intention}\ \text{Freeridership Score}\ + \textit{Influence}\ \text{Freeridership Score}}{2}$$

Using responses to survey spillover questions, the evaluation team determined whether program participants installed other energy-saving measures after participating in the program. We considered savings that participants received from additional measures as spillover if they met two conditions:

- The program significantly influenced the customer's decision to purchase additional measures
- The customer did not receive additional incentives for those measures

If the participant installed one or more measures, additional survey questions addressed the quantity they installed and the program's influence on their purchasing decisions (*very important*, *somewhat important*, *not too important*, or *not at all important*). The team combined freeridership and spillover questions in the same survey, asking both questions of randomly selected program participants, for the Prescriptive Rebates program, Custom Incentives program, Whole Home program–rebated HVAC measures, and Lighting and Appliance program appliance rebate measures and IPL Marketplace measures.

Intention Freeridership Methodology

The evaluation team estimated *intention* freeridership scores for all participants, based on their responses to *intention*-focused freeridership questions. As part of past IPL evaluations, the team developed a transparent, straightforward matrix approach to assign a single score to each participant based on survey responses.

Direct questions (such as "Would you have installed measure X without the program incentive?") tend to result in exaggerated "yes" responses. Participants often provide answers that they believe surveyors seek, so a question becomes the equivalent of asking, "Would you have done the right thing on your own?" Effectively avoiding such bias involves asking a question in several different ways, then checking for consistent responses.

Determining *intention* freeridership estimates from a series of questions (rather than using a single question) helped the team understand the program's influence on the participant (whether the program affected the timing of their decision and, if so, by how many months or years; whether the program affected the efficiency of equipment installed and, if so, by how much; and whether the program affected the quantity of technology installed and, if so, by how much). The team also used multiple questions to check the consistency of each participant's responses.

Not all questions were weighted equally. For example, if the respondent would not have installed measures at the same efficiency level in the program's absence, they automatically became a 0%

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68 *Intention* and *influence* freeridership scores both have a maximum of 100%.

intention freerider. If a residential respondent would not have installed the measures within one year in the program's absence (or a nonresidential respondent would not have installed the measures within two years), they automatically became a 0% *intention* freerider. Other questions included in the *intention* freeridership analysis were assigned partial weights for responses indicative of a non-freerider.

The *intention* freeridership survey questions addressed several core freeridership dimensions:

- Would participants have installed measures without the program?
- Were participants planning to order or install the measures before learning about the program?
- Would participants have installed the measures at the same efficiency levels without the program incentive?
- Would participants have installed the same quantity of measures without the program?
- In the program's absence, would participants have installed the measures at a different time?
- Were the measure purchases included in the organization's most recent capital budget? (Prescriptive Rebates and Custom Incentives programs only)
- Was the program incentive key to meeting a minimum acceptable ROI or hurdle rate when selecting the energy efficiency project? (Prescriptive Rebates and Custom Incentives programs only)

The survey design included several skip patterns, allowing the evaluation team to confirm answers previously provided by respondents by asking the same question in a different format.

After assigning an *intention* freeridership score to every survey respondent, the evaluation team calculated a savings-weighted average *intention* freerider score for the program category (weighting respondents' *intention* freerider scores by the estimated savings of installed equipment):

$$Savings\ Weighted\ Intention\ Freeridership = \frac{\sum[\text{Respondent } Intention \text{ Freeridership Score}] * [Ex\ Post \text{ Measure Energy Savings}]}{\sum[\text{All Respondents Measure Energy Savings}]}$$

Intention Freeridership Scoring

The following tables illustrated how the team translated program participant survey responses into being "yes," "no," or "partially" indicative of *intention* freeridership (in parentheses). Table B-1 shows results for the initial Prescriptive Rebates (Non-Midstream delivery channel) and Custom Incentive programs, while Table B-2 shows results for the Prescriptive Rebates (Midstream delivery channel) program, Table B-3 shows results for Retro-Commissioning measures, Table B-4 shows results for the initial Whole Home program–rebated HVAC measures, Table B-5 shows results for the Lighting and Appliance program appliance rebate measures, and Table B-6 shows results for IPL Marketplace measures. For all tables, the values in brackets are the scoring decrement associated with each response option. Each participant *intention* freeridership score starts at 100%, then decreases based on responses to the survey questions.

Table B-1. 2020 Prescriptive Rebates Program (Non-Midstream) and 2020 Custom Incentives Program (Non-Retro-Commissioning) Raw Survey Responses Translation to Intention Freeridership Scoring Matrix

D1. Without the incentive and information or education from IPL, would you have still purchased [MEASURE]?	D2. [ASK IF D1=Yes or DK] Had your organization already ordered or purchased the [MEASURE] before you heard about the program?	D3. Did your organization have specific plans to install the [MEASURE] before learning about the IPL program's incentive?	D4. [ASK IF D3=Yes or DK] Prior to hearing about the program incentive, was the purchase of the [MEASURE] included in your organization's capital budget?	D5. [ASK IF D1=No] So, without the incentive and information or education from IPL, you would not have installed [MEASURE] at all. Is that correct?	D6. And would you have installed the same quantity of [MEASURE] without the incentive and information or education from IPL?	D7. Without the incentive and information and education from IPL, would you most likely have purchased a lower-efficiency [MEASURE], the same-efficiency [MEASURE], or a higher-efficiency [MEASURE]?	D8. Without the incentive and program information from IPL, when would you have installed this equipment without the program? Would you have installed it …	D9. Does your company use a minimum acceptable ROI or hurdle rate when selecting energy efficiency projects?	D10. Was the program incentive key to meeting this ROI rate?
Yes (Yes) [-0%]	Yes (Yes) [-100%]	Yes (Yes) [-0%]	Yes (Yes) [-0%]	Yes/correct, would not have installed without the program incentive (No) [-100%]	Yes, most likely the same quantity (Yes) [-0%]	Lower efficiency (No) [-100%]	In the same year (Yes) [-0%]	Yes (No) [-0%]	Yes, the program incentive was key to meeting the ROI (No) [-50%]
No (No) [-50%]	No (No) [-0%]	No (No) [-50%]	No (No) [-50%]	No/not correct, would have installed without the incentive (Yes) [-0%]	No, most likely would have installed fewer (No) [-50%]	Same efficiency (Yes) [-0%]	Within one to two years (Partial) [-25%]	Yes (Yes) [-0%]	No, the program incentive was not key to meeting the ROI (Yes) [-0%]
Don't know (Partial) [-25%]	Don't know (Partial) [-0%]	Don't know (Partial) [-25%]	Don't know (Partial) [-25%]	Don't know (Partial) [-25%]	No, most likely would not have installed any (No) [-100%]	Higher efficiency (Yes) [-0%]	Within three to five years (No) [-100%]	Don't know (Partial) [-0%]	Don't know (Partial) [-0%]
-	-	-	-	-	No, would have installed more (Yes) [-0%]	Don't know (Partial) [-25%]	In more than five years (No) [-100%]	-	-
-	-	-	-	-	Don't know (Partial) [-25%]	-	Never (No) [-100%]	-	-
-	-	-	-	-	-	-	Don't know (Partial) [-25%]	-	-

Table B-2. 2020 Prescriptive Rebates Program (Midstream) Raw Survey Responses Translation to Intention Freeridership Scoring Matrix

D13. Without the per-unit discount of [$], would you still have purchased [MEASURE]?	D14. Did your organization have specific plans to install the [MEASURE] before learning about the per-unit discount of [$]?	D15. [ASK IF D14=No] So, without the per-unit discount of [$], you would not have installed [MEASURE] at all. Is that correct?	D15. Would you have installed the same quantity of [MEASURE] without the per-unit discount of [$]?	D16. Without the per-unit discount of [$], would you most likely have purchased a lower-efficiency [MEASURE], the same-efficiency [MEASURE], or a higher-efficiency [MEASURE]?	D17. Without the per-unit discount of [$], when would you have installed this equipment without the program? Would you have installed it … [READ LIST]	D18. Does your company use a minimum acceptable ROI or hurdle rate when selecting energy efficiency projects?	D19. Was the program discount key to meeting this ROI rate?
Yes (Yes) [-0%]	Yes (Yes) [-0%]	Yes/correct, we would not have installed anything without the program incentive (No) [-100%]	Yes, most likely the same quantity (Yes) [-0%]	Lower efficiency (No) [-100%]	In the same year (Yes) [-0%]	Yes (No) [-0%]	Yes, the program discount was key to meeting the ROI (No) [-50%]
No (No) [-50%]	No (No) [-50%]	No/not correct, would have installed something without the incentive (Yes) [-0%]	No, most likely would have installed fewer (No) [-50%]	Same efficiency (Yes) [-0%]	Within one to two years (Partial) [-25%]	Yes (Yes) [-0%]	No, the program discount was not key to meeting the ROI (Yes) [-0%]
Don't know (Partial) [-25%]	Don't know (Partial) [-25%]	Don't know (Partial) [-25%]	No, most likely would not have installed any at all[a] (No) [-100%]	Higher efficiency (Yes) [-0%]	Within three to five years (No) [-100%]	Don't know (Partial) [-0%]	Don't know (Partial) [-0%]
-	-	-	No, would have installed more (Yes) [-0%]	Don't know (Partial) [-25%]	In more than five years (No) [-100%]	-	-
-	-	-	Don't know (Partial) [-25%]	-	Don't know (Partial) [-25%]	-	-

[a] No participants answered with this response.

Table B-3. 2020 Custom Incentives Program Non-Retro-Commissioning Measures Raw Survey Responses Translation to Intention Freeridership Scoring Matrix

F1. Without the incentive and information or education from IPL, would you have still pursued Retro-Commissioning program and implemented the upgrades identified as part of the study?	F2. [ASK IF F1=Yes or DK] Had your organization already identified and planned to implement some of the upgrades identified in the Retro-Commissioning study BEFORE you heard about the program?	F3. Did your organization have specific plans to conduct a Retro-Commissioning study or energy project before learning about the IPL program incentive?	F4. [ASK IF F3=Yes or DK] Prior to hearing about the program incentive, was the cost of conducting a Retro-Commissioning study or implementing the identified upgrades included in your organization's capital budget?	F5. [ASK IF F1=No] So, without the incentive and information or education from IPL, you would not have pursued a Retro-Commissioning study this year and would not have implemented the upgrades identified within the study this year. Is that correct?	F6. And would you have most likely pursued as many energy efficiency measures as those identified in the study without the incentive and information or education from IPL?	F7. If applicable, without the incentive and information or education from IPL, would you most likely have purchased equipment with a lower efficiency, same efficiency, or higher efficiency than the equipment specified in the study?	F8. Without the incentive and program information from IPL, when would you have implemented all the measures? Would you have implemented them…	F9. Does your company use a minimum acceptable ROI or hurdle rate when selecting energy efficiency projects?	F10. Was the program incentive key to meeting this ROI rate?
Yes (Yes) [-0%]	Yes (Yes) [-100%]	Yes (Yes) [-0%]	Yes (Yes) [-0%]	Yes/correct, would not have implemented any without program incentive (No) [-100%]	Yes, most likely the same scope (Yes) [-0%]	Lower efficiency (No) [-100%]	In the same year (Yes) [-0%]	Yes (No) [-0%]	Yes, program incentive was key to meeting ROI (No) [-50%]
No (No) [-50%]	No (No) [-0%]	No (No) [-50%]	No (No) [-50%]	No/not correct, would have implemented some without incentive (Yes) [-0%]	No, most likely would have identified and pursued fewer (No) [-50%]	Same efficiency (Yes) [-0%]	Within one to two years (Partial) [-25%]	Yes (Yes) [-0%]	No, program incentive was not key to meeting ROI (Yes) [-0%]
Don't know (Partial) [-25%]	Don't know (Partial) [-0%]	Don't know (Partial) [-25%]	Don't know (Partial) [-25%]	Don't know (Partial) [-25%]	No, most likely would not have pursued any[a] (No) [-100%]	Higher efficiency (Yes) [-0%]	Within three to five years (No) [-100%]	Don't know (Partial) [-0%]	Don't know (Partial) [-0%]
-	-	-	-	-	No, would have pursued more (Yes) [-0%]	Don't know (Partial) [-25%]	In more than five years (No) [-100%]	-	-
-	-	-	-	-	Don't know (Partial) [-25%]	-	Don't know (Partial) [-25%]	-	-

[a] No participants answered with this response.

Table B-4. 2020 Whole Home Program–Rebated HVAC Measures Raw Survey Responses Translation to Intention Freeridership Scoring Matrix

H1. Before you heard about the IPL eScore program, had you already planned to purchase the [MEASURE]?	H2. [ASK IF H1 =Yes] Before you heard anything about the IPL eScore program, had you already purchased or installed your [MEASURE]?	H3. [ASK IF H2=Yes] To confirm, you installed your new [MEASURE] before you heard anything about the IPL eScore program, correct?	H4. Would you have installed the same [MEASURE] without the in-home energy assessment and IPL rebate?	H5. [ASK IF H4=No or DK] Would you have installed a different [MEASURE] without the in-home energy assessment and IPL rebate, or would you have decided not to purchase it?	H6. Without the in-home energy assessment and rebate from IPL, would you have purchased and installed a [MEASURE] that was just as efficient, less efficient, or more efficient than what you purchased?	H7. Would you have installed the same quantity of [MEASURE] without the in-Home Energy Assessment and rebate from IPL?	H8. Thinking about timing, without the in-Home Energy Assessment and IPL rebate, would you have installed the [MEASURE]…
Yes (Yes) [-0%]	Yes (Yes) [-0%]	Yes, that's correct (Yes) [-100%]	Yes (Yes) [-0%]	I would have installed a different [MEASURE] (Yes) [-0%]	Just as efficient (Yes) [-0%]	Yes, the same quantity (Yes) [-0%]	At the same time (Yes) [-0%]
No (No) [-50%]	No (No) [-0%]	No, not that's not correct (No) [-0%]	No (No) [-25%]	I would have decided not to replace it (No) [-100%]	Less efficient (No) [-100%]	No, would have installed fewer (No) [-50%]	Within the same year (Partial) [-25%]
Don't know (Partial) [-25%]	Don't know (Partial) [-0%]	Don't know (Partial) [-0%]	Don't know (Partial) [-0%]	Don't know (Partial) [-25%]	More efficient (Yes) [-0%]	No, would have installed more (Yes) [-0%]	Within one to two years (No) [-100%]
-	-	-	-	-	Don't know (Partial) [-25%]	Don't know (Partial) [-25%]	More than two years out or Never (No) [-100%]
-	-	-	-	-	-	-	Don't know (Partial) [-25%]

Table B-5. 2020 Lighting and Appliance Program Appliance Rebate Measures Raw Survey Responses Translation to Intention Freeridership Scoring Matrix

C1. Before you heard about the IPL rebate program, had you already planned to purchase the [MEASURE]?	C2. [ASK IF C1=Yes] Before you heard anything about the IPL rebate program, had you already purchased or installed your [MEASURE]?	C3. [ASK IF C2=Yes] To confirm, you installed your new [MEASURE] before you heard anything about the IPL rebate program, correct?	C4. Would you have installed the same [MEASURE] without the rebate from IPL?	C5. [ASK IF C4=No or DK] Would you have installed a different [MEASURE] without the IPL rebate, or would you have decided not to purchase it?	C6. Without the rebate from IPL, would you have purchased and installed a [MEASURE] that was just as efficient, less efficient, or more efficient than what you purchased?	C7. Without the rebate from IPL, what kind of thermostat would you have installed?	C8. Would you have installed the same quantity of [MEASURE] without the incentive from IPL?	C9. Thinking about timing, without the IPL rebate, would you have installed the [MEASURE]…
Yes (Yes) [-0%]	Yes (Yes) [-0%]	Yes (Yes) [100% FR]	Yes (Yes) [-0%]	I would have installed a different [MEASURE] (Yes) [-0%]	Just as efficient (Yes) [-0%]	A smart or learning thermostat (Yes) [-0%]	Yes, the same quantity (Yes) [-0%]	At the same time (Yes) [-0%]
No (No) [-50%]	No (No) [-0%]	No (No) [-0%]	No (No) [-25%]	I would have decided not to replace it (No) [-100%]	Less efficient (No) [-100%]	A Wi-Fi thermostat (Yes) [-0%]	No, would have installed fewer (No) [-50%]	Within the same year (Partial) [-25%]
Don't know (Partial) [-25%]	Don't know (Partial) [-0%]	Don't know (Partial) [-0%]	Don't know (Partial) [-0%]	Don't know (Partial) [-25%]	More efficient (Yes) [-0%]	A programmable or manual thermostat (No) [-100%]	No, would have installed more (Yes) [-0%]	Within one to two years (No) [-100%]
-	-	-	-	-	Don't know (Partial) [-25%]	Would not have installed a new thermostat (No) [-100%]	Don't know (Partial) [-25%]	More than two years out or Never (No) [-100%]
-	-	-	-	-	-	Don't know (Partial) [-25%]	-	Don't know (Partial) [-25%]

Table B-6. 2020 IPL Marketplace Measures Raw Survey Responses Translation to Intention Freeridership Scoring Matrix

C1. Before you heard about the IPL Marketplace, had you already planned to purchase the [MEASURE](s)?	C2. Would you have installed the same [MEASURE] without the instant rebate from IPL?	C3. [ASK IF D2=No or DK] Would you have installed a different [MEASURE] without the IPL instant rebate, or would you have decided not to purchase it?	C4. Without the IPL instant rebate, would you have purchased and installed a [Field-MEASURE] that was just as efficient, less efficient or more efficient than what you purchased?	C5. Without the instant rebate from IPL, what kind of thermostat would you have installed?	C6. Would you have installed the same quantity of [MEASURE] without the instant rebate from IPL?	C7. Thinking about timing, without the IPL Marketplace instant rebate, would you have installed the [MEASURE]…
Yes (Yes) [-0%]	Yes (Yes) [-0%]	I would have installed a different [MEASURE] (Yes) [-0%]	Just as efficient (Yes) [-0%]	A smart or learning thermostat (Yes) [-0%]	Yes, the same quantity (Yes) [-0%]	At the same time (Yes) [-0%]
No (No) [-50%]	No (No) [-25%]	I would have decided not to replace it (No) [-100%]	Less efficient (No) [-100%]	A Wi-Fi thermostat (Yes) [-0%]	No, would have installed fewer (No) [-50%]	Within the same year (Partial) [-25%]
Don't know (Partial) [-25%]	Don't know (Partial) [-0%]	Don't know (Partial) [-25%]	More efficient (Yes) [-0%]	A programmable or manual thermostat (No) [-100%]	No, would have installed more (Yes) [-0%]	Within one to two years (No) [-100%]
-	-	-	Don't know (Partial) [-25%]	Would not have installed a new thermostat (No) [-100%]	Don't know (Partial) [-25%]	More than two years out or Never (No) [-100%]
-	-	-	-	Don't know (Partial) [-25%]	-	Don't know (Partial) [-25%]

Influence Freeridership Methodology and Scoring

To estimate an *influence* freeridership score, the evaluation team asked respondents to rate the importance of program elements on their purchasing decisions. The surveys captured responses using a four-point scale, with 1 meaning *not at all important* and 4 meaning *very important*. A surveyed participant's overall *influence* rating equaled the maximum importance of any single program element. This methodology was based on an underlying principle: if a single element had a substantial influence on a respondent's purchasing decision, the program had successfully influenced that respondent.

For example, the team included the survey question shown in Table B-7 to capture respondents' perspectives on elements driving them to take energy-efficient actions.[69] A rating of 4 represents the maximum program influence, which determined the *influence* freeridership component score.

Table B-7. Example of *Influence* Freeridership Component Question

How important was each of the following factors in deciding which equipment to install?	Rate Influence of Program Elements					
	1 - Not at all important	*2 - Not too important*	*3 - Somewhat important*	*4 - Very important*	Don't Know	Not Applicable
Recommendation from contractor or vendor	1	2	(3)	4	DK	N/A
Information provided by IPL on energy-savings opportunities	1	2	3	4	(DK)	N/A
Information on payback period	1	(2)	3	4	DK	N/A
The IPL incentive	1	2	3	(4)	DK	N/A
Previous participation in a IPL energy efficiency program	1	2	(3)	4	DK	N/A

High program-*influence* levels and freeridership maintain an inverse relationship: the greater the program's *influence*, the lower the participant's final freeridership score. Table B-8 presents the freeridership level implied by each *influence* rating.

[69] The question wording and program factors included in surveys varied slightly based on the specific program component. The *Influence Freeridership* sections in the program report chapters list the factors included for each specific program component.

Table B-8. *Influence* Freeridership Implied by Response to Influence Items

Influence Rating	*Influence* Freeridership Score
1 - Not at all important	100%
2 - Not too important	75%
3 - Somewhat important	25%
4 - Very important	0%
Don't know	50%
Not applicable	50%

Spillover

Spillover refers to additional savings generated by program participants due to their program participation, but not captured by program records. Spillover occurs when participants choose to purchase energy-efficient measures or adopt energy-efficient practices due to a program's influence, but they do not receive a financial incentive for the additional measures. As these customers did not receive a financial incentive, they did not appear in program tracking data or savings records.

Spillover Methodology

An energy efficiency program's spillover effect is an additional impact added to the program's direct results. The evaluation team measured spillover by asking a sample of participants who purchased a particular measure and received an incentive whether they installed another efficient measure or undertook another energy efficiency activity due to the program. Survey respondents rated the program's (and incentive's) relative influence as *very important*, *somewhat important*, *not too important*, or *not at all important* on their decisions to pursue additional savings.

Participant Spillover Analysis

The team used a top-down approach to calculate spillover savings, beginning the analysis with a subset containing only survey respondents who indicated that they installed additional energy-saving measures after participating in the program. The team removed participants from this subset who indicated that the program had little influence on their decisions to purchase additional measures; thus, the subset only retained participants who rated the program as *very important* on their purchasing decisions.

From these participants, the team then estimated energy savings for additional measures installed, based on average savings calculated for this evaluation (and using the Indiana TRM [v2.2] as a reference when evaluation data could not be used).

The evaluation team calculated the percentage of spillover per program category, dividing the sum of additional spillover savings reported by respondents for a given program category by total incentivized *ex post* gross savings achieved by all respondents in the program category:

$$Spillover\ \% = \frac{\sum \text{Spillover Measure Energy Savings for All Survey Respondents}}{\sum \text{Program Measure Energy Savings for All Survey Respondents}}$$

Appendix C. Demand Response Program Per-Unit *Ex Post* Savings Detailed Methodology

This appendix provides details of the savings methodology for the L+G switches and smart thermostats provided through the Demand Response program. In both cases, regressions excluded all holidays and weekends because demand response events occurred only on weekdays. The team used only the top 20 hottest non-event days in the season to estimate the regression models because these provided the most realistic baseline conditions against which to estimate demand reductions due to demand response events.

L+G Switches

The evaluation team modeled AC consumption by the specifications shown in the following equation, which we used to estimate what AC consumption would have been absent the event:

$$kw_{it} = \alpha_i + \sum_{h=1}^{24} \beta_{1h} Hour_h + \sum_{h=1}^{24} \beta_{2h} (Hour_h \times CDH_{it}) + \sum_{j=1}^{6} \sum_{k=14}^{17} \beta_{3kj} (Hour_k \times Event_j) + \sum_{j=1}^{6} \sum_{k=1}^{13} \beta_{4kj} (Pre\ Hour_k \times Event_j) + \sum_{j=1}^{6} \sum_{k=18}^{24} \beta_{5kj} (Post\ Hour_k \times Event_j) + \varepsilon_{it}$$

Where:

kw_{it}	=	Hourly demand in hour 't' for participant 'i'
α_i	=	Average hourly demand for participant 'i'
β_{1h}	=	Change in hourly demand expected for each hour 'h' of the day
$Hour_h$	=	Set of 24 indicator variables for the hour 'h' of the day
β_{2h}	=	Change in hourly demand associated with a change in CDH in hour 'h' of the day
CDH_{it}	=	Cooling degree hours observed for each hour 't' and participant 'i'
$Hour_h \times CDH_{it}$	=	Set of variables indicating hour 'h' interacted with CDH
β_{3kj}	=	Change in hourly demand associated with hour 'k' of event 'j'
$Hour_k \times Event_j$	=	Set of variables indicating whether hour 't' fell during hour 'k' of event 'j'
β_{4kj}	=	Change in hourly demand associated with pre-event hour 'k' of event 'j'
$Pre\ Hour_k \times Event_j$	=	Set of variables indicating whether hour 't' fell during pre-event hour 'k' of event 'j'
β_{5kj}	=	Change in hourly demand associated with post-event hour 'k' of event 'j'
$Post\ Hour_k \times Event_j$	=	Set of variables indicating whether hour 't' fell during post-event hour 'k' of event 'j'
ε_{it}	=	Error term

Smart Thermostats

The evaluation team collected runtime data for Nest and Ecobee thermostats from the manufacturers. This data did not include wattage information, instead providing fan and compressor run times for each device in 15-minute intervals across the event season. The team converted the run times to wattages using the following equation from Cutler 2013,[70] then aggregated these to the hour. The formula estimates the instantaneous kilowatts for the AC unit, including power for the unit's condenser and evaporator fans and compressor, as a function of unit size (tonnage), efficiency, and indoor wet-bulb and outdoor dry-bulb temperatures:

$$Instantaneous\ System\ kW = \frac{(Tons * 12{,}000 * CAP * \frac{3.413}{EER} * EIR)}{3{,}413}$$

Where:

Tons	=	Tonnage of central AC (since this was not collected during thermostat installation, the evaluation team used the average of 2.42 tons for central ACs as defined in the Indiana TRM (v2.2))
12,000	=	Conversion factor to convert tons to Btu
EER	=	EER of central AC unit (since this was not collected during thermostat installation, the evaluation team converted the average 11.15 SEER defined in the Indiana TRM (v2.2) to EER by multiplying by 0.9, leading to 10.035)

The team calculated CAP (total capacity) and EIR (energy input ratio) using two equations:

$$CAP = a_{CAP} + (b_{CAP} * EWB) + (c_{CAP} * EWB^2) + (d_{CAP} * ODB) + (e_{CAP} * ODB^2) + (f_{CAP} * EWB * ODB)$$

$$EIR = a_{EIR} + (b_{EIR} * EWB) + (c_{EIR} * EWB^2) + (d_{EIR} * ODB) + (e_{EIR} * ODB^2) + (f_{EIR} * EWB * ODB)$$

The terms "*a*" through "*f*" are standardized performance curve coefficients obtained from the Cutler 2013 study, while ODB is the outdoor dry-bulb temperature and EWB is the indoor wet-bulb temperature. The evaluation team assumed an indoor wet-bulb temperature of 67°F, the AHRI standard, as indoor wet-bulb temperatures were not available in the thermostat data. The evaluation team used outdoor dry-bulb temperatures collected from the nearest weather station for each participant, or from the Indianapolis International Airport when participant premise zip codes were unavailable.

For each hour, the evaluation team multiplied the central AC runtime by the instantaneous kilowatts to estimate the unit's kilowatt-hours per hour.

The evaluation team estimated per-unit demand reduction for Nest and Ecobee smart thermostats by modeling demand on the top 20 hottest non-event weekdays and estimating a baseline during event hours using the same regression model described above for L+G switches. Differences in hourly baseline and actual demand provided demand reduction attributable to the events. The evaluation team estimated the regression model with standard errors clustered on households.

[70] Cutler, D., J. Winkler, N. Kruis, and C. Christensen. January 2013. *Improved Modeling of Residential Air Conditioners and Heat Pumps for Energy Calculations.* NREL Technical Report, NREL/TP-5500-56354. http://www.nrel.gov/docs/fy13osti/56354.pdf

Appendix D. Demand Response Program Regression Model Accuracy

To verify that our regression models accurately predicted demand, the evaluation team plotted each model's average predicted values on non-event days against the actual average demand in each hour. These figures show that the models we used to estimate demand reduction for each device type were highly accurate in predicting demand on non-event days, which validates the savings we estimate using these models on demand response event days. Figure D-1, Figure D-2, and Figure D-3 provide these comparisons for L&G, Ecobee, and Nest devices. Overall, each model is highly accurate in predicting AC energy consumption on the top 20 hottest non-event days in 2020. However, these figures also show two issues with the runtime data:

- First, note the jagged Ecobee curve in comparison to the smooth L+G and Nest curves. Most Ecobee devices often recorded zero runtime between 6 p.m. and midnight, resulting in the jagged curve shown. However, there was no way to accurately identify true zero runtimes from false zeroes. False zeroes, or perhaps an accidental event trigger on a non-event day, may also explain the decrease in average consumption between 1 p.m. and 2 p.m.
- Second, note that the average AC energy associated with Nest devices is approximately double the AC energy of Ecobee or L+G devices. L+G devices record actual energy consumption, suggesting that the average demand of just over 1.6 kW from 4 p.m. to 7 p.m. on hot non-event days is accurate. Ecobee and Nest devices only record runtime, not actual kilowatts, but the estimated average energy consumption of 1.3 kW for Ecobee devices is not far off the estimate for L+G devices, suggesting that the Indiana TRM (v2.2)–sourced average AC tonnage and EER values the evaluation team used in the Nest and Ecobee runtime-to-kilowatt conversions are broadly accurate. Despite using the same AC size and efficiency assumptions for Nest devices, the average kilowatts for Nest devices is nearly double that of Ecobee and L+G devices. The evaluation team confirmed that this result stemmed from the original Nest runtime data, not the runtime-to-kilowatt conversion.

Figure D-1. L+G Logger Non-Event Day Model Verification (Event Days + Top 20 Hottest Days)

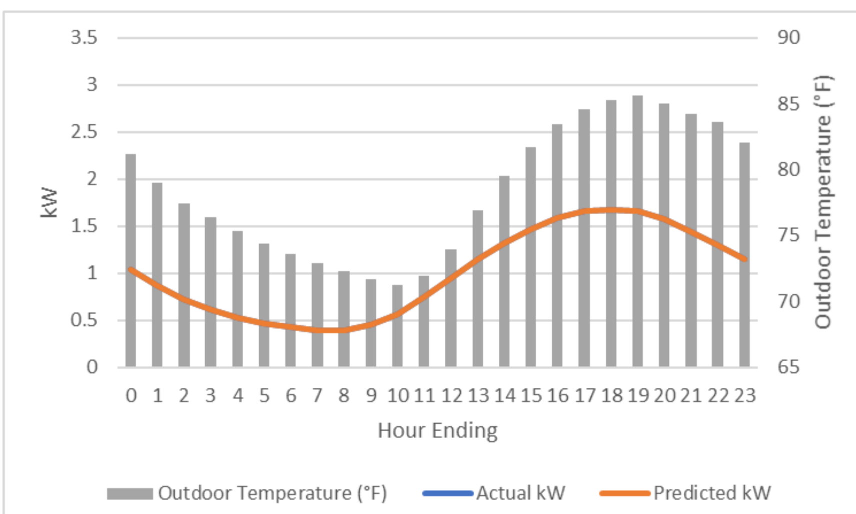


Figure D-2. Ecobee Non-Event Day Model Verification (Event Days + Top 20 Hottest Days)

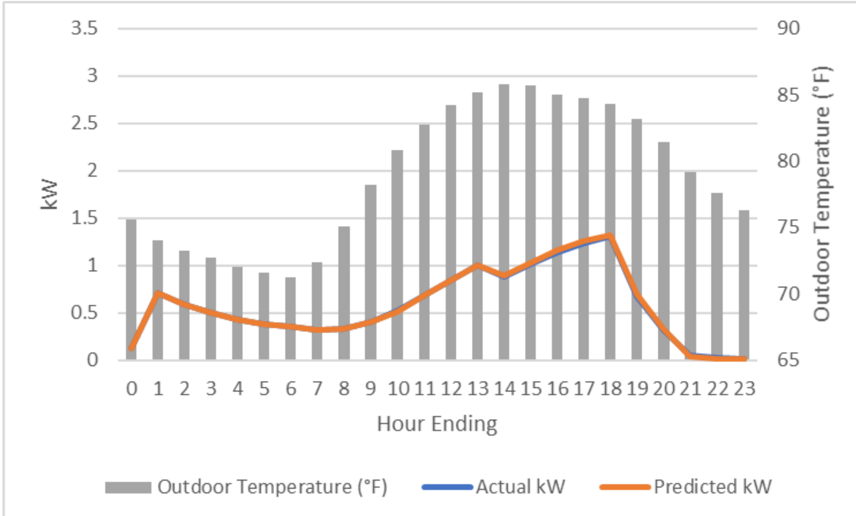
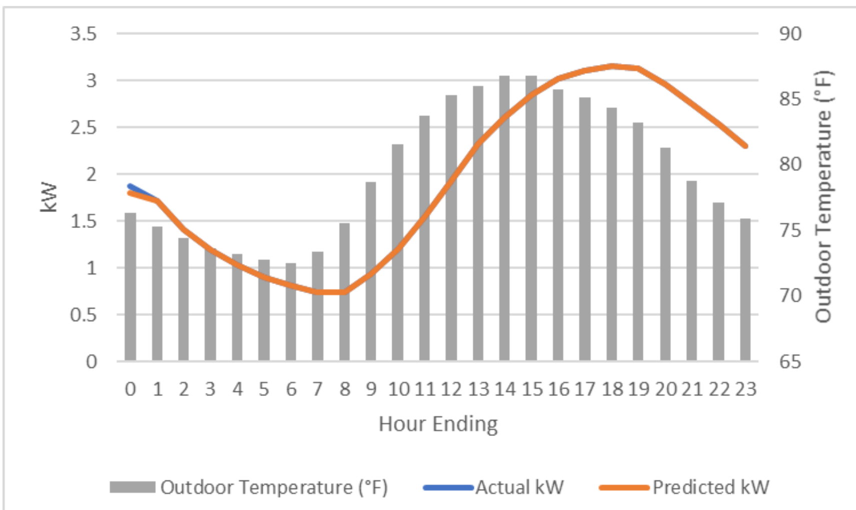


Figure D-3. Nest Non-Event Day Model Verification (Event Days + Top 20 Hottest Days)



Appendix E. Appliance Recycling Program Measures, Assumptions, and Algorithms

For the 2020 program year, the evaluation team estimated per-unit savings estimates for recycled refrigerators and freezers using meter data and multivariate regression models.

Refrigerator Regression Model

Table E-1 shows the UMP model specification used to estimate the annual unit energy consumption (UEC) of refrigerators recycled in 2020, along with the model's estimated coefficients.

Table E-1. 2020 Appliance Recycling Program Refrigerator Unit Energy Consumption Regression Model Estimates (Dependent Variable = Average Daily Kilowatt-Hours, R-Square = 0.38)

Independent Variable	Coefficient	p-Value
Intercept	0.81	0.134
Age (years)	0.021	0.035
Dummy: Manufactured Pre-1990	1.04	0.000
Size (cubic feet)	0.06	0.021
Dummy: Single Door	-1.75	0.000
Dummy: Side-by-Side	1.12	0.000
Dummy: Primary	0.56	0.003
Interaction: Unconditioned Space * HDDs [a]	-0.04	0.000
Interaction: Unconditioned Space * CDDs [a]	0.03	0.239

[a] The evaluation team derived HDDs and CDDs from the weighted average from TMY3 data for weather stations we mapped to participating appliance zip codes. TMY3 uses median daily values for a variety of weather data collected from 1991 through 2005.

Freezer Regression Model

Table E-2 details the final model specifications the evaluation team used to estimate the energy consumption of participating recycled freezers, along with the results.

Table E-2. 2020 Appliance Recycling Program Freezer Unit Energy Consumption Regression Model Estimates (Dependent Variable = Average Daily Kilowatt-Hours, R-Square = 0.38)

Independent Variable	Coefficient	p-Value
Intercept	-0.96	0.236
Age (years)	0.045	0.010
Dummy: Manufactured Pre-1990	0.54	0.202
Size (cubic feet)	0.12	0.001
Dummy: Chest Freezer	0.30	0.273
Interaction: Unconditioned Space * HDDs	-0.03	0.035
Interaction: Unconditioned Space * CDDs	0.08	0.026

Extrapolation

After estimating the final regression models, the evaluation team analyzed the corresponding characteristics (the independent variables) for participating appliances (as captured in ARCA's program database). Table E-3 summarizes program averages or proportions for each independent variable.

Table E-3. 2020 Appliance Recycling Program Participant Mean Explanatory Variables

Appliance	Independent Variable	Participant Population Mean Value
Refrigerator	Age (years)	17.41
	Dummy: Manufactured Pre-1990	0.05
	Size (cubic feet)	18.99
	Dummy: Single Door	0.04
	Dummy: Side-by-Side	0.33
	Dummy: Primary	0.53
	Interaction: Unconditioned Space * HDDs [a]	6.06
	Interaction: Unconditioned Space * CDDs [a]	1.08
Freezer	Age (years)	21.43
	Dummy: Manufactured Pre-1990	0.17
	Size (cubic feet)	14.41
	Dummy: Chest Freezer	0.43
	Interaction: Unconditioned Space * HDDs [a]	11.53
	Interaction: Unconditioned Space * CDDs [a]	2.05

[a] The evaluation team derived HDDs and CDDs from the weighted average from TMY3 data for weather stations that we mapped to participating appliance zip codes. TMY3 uses median daily values for a variety of weather data collected from 1991 through 2005.

The following regression model shows how the UMP-defined model would be used. For the refrigerator UEC calculation, the evaluation team included average appliance characteristics:

$$UEC_{Ref} = 365.25 * [0.81 + (0.021 * (17.41\ years)) + \left(1.04 * (5\%\ \text{manufactured before 1990})\right) + (0.06 * 18.99\ ft.^3) - (1.75 * 4\%\ \text{single door units}) + (1.12 * 33\%\ \text{side} - \text{by} - \text{side}) + (0.56 * 53\%\ \text{primary usage}) + (0.03 * 1.08\ unconditioned\ CDDs) - (0.04 * 6.06\ unconditioned\ HDDs)]$$

Using the values from Table E-1, Table E-2, and Table E-3, the evaluation team estimated the *ex post* annual UEC for an average program refrigerator and freezer. Table E-4 displays estimated *ex post* estimates compared to program initial *ex ante* values. The team determined *ex ante* values using average gross usage by measure type in the program tracking database. ARCA based these *ex ante* values on IPL's 2015 ARP verified savings values for refrigerators and freezers.

Table E-4. 2020 Appliance Recycling Program Average Unit Energy Consumption by Appliance Type

Appliance	*Ex Ante* Annual UEC (kWh/year)	*Ex Post* Annual UEC (kWh/year)	Relative Precision (90% Confidence)
Refrigerators	765.09	1,006	±11
Freezers	543.22	647	±35

Demand Reduction Impacts

The team used adjustment factors shown in Table E-5, drawn from the Indiana TRM (v2.2), to calculate per-measure demand reduction separately for refrigerators and freezers, using the following equation:

$$kW\ reduction = \frac{Average\ per\ Measure\ kWh\ Savings}{8{,}760} * TAF * LSAF$$

Where:

TAF = Temperature adjustment factor

LSAF = Load shape adjustment factor

Table E-5. 2020 Appliance Recycling Program Demand Reduction Assumptions for Recycled Refrigerators and Freezers

Variable	Recycled Appliance Value
Temperature Adjustment Factor	1.21
Load Shape Adjustment Factor	1.06

Part-Use Factor

Part-use, an adjustment factor specific to appliance recycling, is used to convert a UEC into an average per-unit gross savings value. The UEC itself does not equal the gross savings value for two reasons:

- The UEC model yields an estimate of annual consumption
- Not all recycled refrigerators would have operated year-round if they had not been decommissioned through the program

The part-use methodology relies on information collected from surveyed customers regarding pre-program usage patterns (that is, how many months of the year, prior to recycling, the customer had the appliance plugged in and running).

The final part-use estimate reflects how appliances would likely have been operated, had they not been recycled (rather than being based on how they were previously operated). For example, a primary refrigerator, operated year-round, could become a secondary appliance that operated part time.

This methodology accounts for potential shifts in usage; specifically, it calculates part-use with a weighted average of three prospective part-use categories and factors:

- Appliances that would have been run full-time (part-use = 1.0)
- Appliances that would not have been run at all (part-use = 0.0)
- Appliances that would have been operated for a portion of the year (part-use = between 0.0 and 1.0)

The evaluation team calculated a weighted average part-use factor representing the three participant usage categories as defined by each appliance's operational status during the year prior to recycling. For example, the team assigned a part-use factor of zero to participants who did not use their appliance at all during the year prior to recycling, as no immediate savings were generated by retiring the appliance.

Using information gathered through participant surveys, the evaluation team followed three steps to determine part use:

1. The team determined whether recycled refrigerators were primary or secondary units (treating all stand-alone freezers as secondary units).
2. The team asked participants who had recycled a secondary refrigerator or freezer if they had operated that appliance year-round, for a portion of the preceding year, or had it unplugged (not operational). The team assumed all primary units operated year-round.
3. The team asked participants who operated their secondary refrigerator or freezer for only a portion of the preceding year to estimate the total number of months that the appliance remained plugged in. This allowed the team to calculate the portion of the year that the appliance remained in use. The team determined that the average refrigerator, operating part-time, had a part-use factor of 0.27 (roughly 3.2 months). Freezers operating part-time had a part-use factor of 0.58 (roughly 7.0 months).

These three steps produced information about how refrigerators and freezers were operated prior to recycling, as shown in Table E-6.

Table E-6. 2020 Appliance Recycling Program Historical Part-Use Factors by Category

Usage Type and Part-Use Category	Percentage of Recycled Units	Part-Use Factor	Per-Unit Energy Savings (kWh/Year)
Secondary Refrigerators Only (n=30)			
Not in Use	0%	0.00	-
Used Part Time	13%	0.27	272
Used Full Time	87%	1.00	1,006
Weighted Average	N/A	0.90	908
All Refrigerators (Primary and Secondary; n=69)			
Not in Use	0%	0.00	-
Used Part Time	6%	0.27	272
Used Full Time	94%	1.00	1,006
Weighted Average	N/A	0.96	963
All Freezers (n=65)			
Not in Use	8%	0.00	-
Used Part Time	8%	0.58	377
Used Full Time	85%	1.00	647
Weighted Average	N/A	0.89	577

In many cases, historical use of an appliance (prior to recycling) did not indicate how the appliance would have been used had it not been recycled. To account for this, the evaluation team asked surveyed participants how they would (likely) have operated their appliance had they not recycled it through the program. For example, if surveyed participants indicated they would have kept a primary refrigerator in the program's absence, the team asked if they would have continued to use the appliance as their primary refrigerator or if they would have relocated it, using it as a secondary refrigerator.

The team did not ask participants who said they would have discarded their appliance independently of the program about future usage of that appliance, as that would be determined by another customer. As discarded refrigerators' future use remained unknown, the team applied the weighted part-use average of all units (0.96) for all refrigerators that would have been discarded independently of the program. Using this approach, the team acknowledged that discarded appliances might be used as primary or secondary units in a would-be recipient's home.

The team then combined the part-use factors shown in Table E-6 with participants' self-reported actions had the program *not* been available. This resulted in the distribution of likely future usage scenarios and corresponding part-use estimates.

The weighted average of these future scenarios, shown in Table E-7, produced the 2020 part-use factor for refrigerators (0.95, up from 0.89 in 2018) and freezers (0.89, up from 0.82 in 2018). The part-use increase resulted from a decrease in the number of respondents saying their appliances were not in use for the year prior to recycling, in addition to an increase in full-time use. For refrigerators, no respondents in 2020 (compared to 6% in 2018) indicated that their unit had not been in use. For freezers, 8% of respondents in 2020 (compared to 13% in 2018) indicated that their unit had not been in use.

Table E-7. 2020 Appliance Recycling Program Part-Use Factors by Appliance Type

Use Prior to Recycling	Likely Use Independent of Recycling	Part-Use Factor	Percentage of Participants
Primary Refrigerators	Kept (as primary unit)	1.00	7%
	Kept (as secondary unit)	0.90	4%
	Discarded	0.96	43%
Secondary Refrigerators	Kept	0.90	7%
	Discarded	0.96	40%
Overall		**0.95**	**100%**
Freezers	Kept	0.89	35%
	Discarded	0.89	65%
Overall		**0.89**	**100%**

Applying the part-use factors calculated from Table E-7 to the modeled annual consumption from Table E-4 yielded average, per-unit gross energy savings. Table E-8 shows average gross savings for refrigerators of 956 kWh and average gross savings for freezers of 576 kWh.

Table E-8. 2020 Appliance Recycling Program Per-Unit Gross Energy Savings by Measure

Appliance	Average Per-Unit Annual Energy Consumption (kWh/Year)	Part-Use Factor	Adjusted Per-Unit Gross Energy Savings (kWh/Year)	Relative Precision at 90% Confidence
Refrigerators	1,006	0.95	956	±8%
Freezers	647	0.89	576	±23%

Room Air Conditioners

The evaluation team used the following equations from the Indiana TRM (v2.2) to calculate *ex post* per-measure energy savings and demand reduction for recycled room ACs:

$$kWh\ savings = \frac{EFLH_c * \text{Btuh}}{1{,}000} * \left(\frac{1}{EER_{exist}} - \frac{\%_{replaced}}{EER_{new}}\right)$$

$$kW\ reduction = \frac{Btuh * CF}{1{,}000} * \left(\frac{1}{EER_{exist}} - \frac{\%_{replaced}}{EER_{new}}\right)$$

Where:

$EFLH_c$	=	Equivalent full-load cooling hours for residents in Indianapolis, Indiana
Btuh	=	Actual size of the recycled room AC in Btuh units (where 1 ton = 12,000 Btuh)
EER_{exist}	=	Energy efficiency rating of the recycled room AC
$\%_{replaced}$	=	Average percentage of recycled room ACs replaced with new room ACs
EER_{new}	=	Energy efficiency rating of the newly installed room AC
CF	=	Coincidence factor, a number between 0 and 1 indicating how many room ACs are expected to be in use and saving energy during the peak summer demand period

Table E-9 shows a summary of the recycled room AC savings assumptions and assumption source.

Table E-9. 2020 Appliance Recycling Program Variable Assumptions for Recycled Room Air Conditioners

Variable	Room Air Conditioner Value	Source
Equivalent Full-Load Cooling Hours ($EFLH_c$)	332	Indiana TRM (v2.2)
Btuh	11,357	
Energy Efficiency Rating – Existing (EER_{exist})	7.7	
Percentage Replaced ($\%_{replaced}$)	76%	
Energy Efficiency Rating – New (EER_{new})	10.9	
Coincidence Factor (CF)	0.30	

Table E-10 shows *ex ante* deemed savings and resulting *ex post* per-measure savings for recycled room ACs.

Table E-10. 2020 Appliance Recycling Program Room Air Conditioner *Ex Ante* and *Ex Post* Per-Measure Savings

Measure	*Ex Ante* Deemed Savings		*Ex Post* Per-Measure Savings	
	kWh	kW	kWh	kW
Room Air Conditioner	226.78	0.160	226.78	0.205

Dehumidifiers

Dehumidifier recycling is not included in the Indiana TRM (v2.2) therefore the evaluation team used the default values from the Mid-Atlantic TRM (v10) to calculate *ex post* per-measure energy savings and demand reduction for recycled dehumidifiers. The evaluation team applied the default, average usage and savings values provided in Mid-Atlantic TRM because the program tracking data does not capture all necessary inputs for the savings equation.

Additionally, the Mid-Atlantic TRM includes a default replacement rate to account for recycled dehumidifiers that are replaced. The replacement dehumidifier is assumed to be a new, federal baseline dehumidifier.

Savings for replaced dehumidifiers are equal to:

$$kWh\ savings\ = Recycled\ kWh * (1 - RR) + ((Recycled\ kWh - Federal\ kWh) * RR)$$

$$kW\ reduction\ = \frac{kWh\ Saved}{Hours} * CF$$

Where:

Recycled kWh	=	1,260 kWh
RR	=	Replacement rate (= 80%)
Federal kWh	=	908 kWh
Hours	=	Annual operating hours (= 1,632)
CF	=	Summer peak coincidence factor for measure (= 0.37)

Table E-11. 2020 Appliance Recycling Program
Dehumidifiers *Ex Ante* and *Ex Post* Per-Measure Savings

Measure	*Ex Ante* Deemed Savings		*Ex Post* Per-Measure Savings	
	kWh	kW	kWh	kW
Dehumidifier	1,000.00	0.00	533.60	0.121

Light Emitting Diode Bulbs

ARCA distributed three 9-watt LEDs to program participants who were present at the time of their scheduled appliance pick-up appointment. The evaluation team used the following equations from the Indiana TRM (v2.2) to calculate *ex post* per-measure energy savings and demand reduction for the distributed LEDs:

$$kWh\ savings\ per\ pack\ = kWh\ savings\ per\ lamp * 3$$

$$kWh\ savings\ per\ lamp = \frac{(W_{base} - W_{LED})}{1{,}000} * ISR * \ AOH * \ (1 + WHFe)$$

$$kW\ savings\ per\ pack\ = kW\ savings\ per\ lamp * 3$$

$$kW\ reduction = \frac{(W_{base} - W_{LED})}{1{,}000} * ISR * (1 + WHFd) * CF$$

Where:

W_{base}	=	Baseline wattage of existing bulb replaced with an LED
W_{LED}	=	LED wattage of the actual distributed LEDs
ISR	=	In-service rate, or the percentage of rebated bulbs installed
AOH	=	Average hours of use per year
WHFe	=	Waste heat factor for energy use, accounting for the effects of more efficient lighting on cooling energy use
WHFd	=	Waste heat factor for demand, accounting for the effects of more efficient lighting on cooling demand
CF	=	Coincidence factor, a number between 0 and 1 indicating the ratio of LEDs expected to be in use and saving energy during the peak summer demand period

Table E-12 summarizes *ex post* savings assumptions for the distributed LEDs and each assumption's source.

Table E-12. 2020 Appliance Recycling Program Variable Assumptions for LEDs

Variable	LED Value	Source
Baseline Wattage (W_{base})	43	Compared lumens with ENERGY STAR and applied the EISA halogen baseline equivalent wattages
LED Wattage (W_{LED})	9	Actual wattage of distributed LEDs
In-Service Rate (ISR)	59%	Illinois TRM (V9.0); LED Screw Based Omnidirectional Bulbs; Efficiency Kits; LED Distribution
Hours per Year (AOH)	902	Indiana TRM (v2.2); Cadmus. July 29, 2013. *Indiana Core Lighting Logger Hours of Use Study.*
Waste Heat Factor for Energy Use (WHFe)	-0.061	Indiana TRM (v2.2) for Indianapolis, weighted based on HVAC type
Waste Heat Factor for Demand (WHFd)	0.055	Indiana TRM (v2.2) for Indianapolis, weighted based on HVAC type
Coincidence Factor (CF)	0.11	Indiana TRM (v2.2)

Table E-13 shows *ex ante* deemed savings (updated with removed installation rates) and the resulting per-measure *ex post* savings for distributed LEDs. To determine the demand reduction per bulb, the evaluation team followed the Indiana TRM (v2.2). The team assumed that small differences in per-measure savings for the current program year resulted from rounding.

Table E-13. 2020 Appliance Recycling Program LEDs *Ex Ante* and *Ex Post* Per-Measure Savings

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
9-Watt LEDs (per bulb)	28.80	0.002	28.80	0.004
9-Watt LEDs (per pack of three)	86.39	0.007	86.39	0.012

The evaluation team relied on the UMP to calculate lifetime ISRs through 2022 to account for future installations of bulbs in storage. The methodology is based on assuming that 24% of all bulbs in storage are installed in each subsequent year after purchase. To account for the time sensitivity of these added savings (which stem from increased ISRs but take place after 2020), the team discounted the lifetime ISR by 10% annually to determine NPV lifetime ISRs for each LED. Table E-14 shows a comparison of first-year and lifetime ISRs, showing how marginal increases to first-year ISRs using the UMP methodology results in the NPV lifetime ISRs used in measure impact calculations.

Table E-14. 2020 Appliance Recycling Program First-Year and Lifetime In-Service Rate Calculations

Measure	First-Year ISR	2021	2022	2023	Lifetime ISR	NPV ISR
General Service LED	59%	10%	8%	N/A	79%	77%

Notes: Percentages are rounded. General service lamps were not anticipated to have gross savings post 2023 because of pending EISA implementation.

Net-to-Gross

The evaluation team used the following formula to estimate net savings for recycled refrigerators.

$$Net\ savings = Gross\ Savings - Freeridership$$

Where:

Gross Savings = The evaluated *in situ* UEC for the recycled unit, adjusted for part-use

Freeridership = Program savings that would have occurred from freeridership and secondary market impacts even in the program's absence

Determining secondary market impacts requires a decision-tree approach to calculating and presenting net program savings. The decision tree—populated by responses of surveyed participants—presents savings under all possible scenarios concerning participants' actions in regard to the recycled equipment. Through these scenarios, the evaluation team used a weighted savings average to calculate net savings attributable to the program. This section includes specific decision-tree portions to highlight specific aspects of net savings analysis. At the end of this section, Figure E-3 and Figure E-4 present the full decision trees.

Freeridership

For our freeridership analysis, the evaluation team first asked participants if they considered discarding the participating appliance prior to learning of the program. If participants did not previously consider appliance disposal, the team categorized them as non-freeriders and excluded them from subsequent freeridership analysis.

The team then asked all remaining participants (those who considered discarding their existing appliance before learning about the program) a series of questions to determine, in the program's absence, the distribution of participating units likely to have been kept versus discarded. Actions independent of program intervention followed three scenarios:

- The unit would be discarded and transferred to someone else
- The unit would be discarded and destroyed
- The unit would be kept in the home

To determine the percentage of participants in each scenario, the team asked about the likely fate of the recycled appliances, had they not been decommissioned through the program. The team organized participant responses into several categories:

- Kept the appliance
- Sold the appliance to someone directly (friend, family member, Craigslist ad)
- Sold or gave the appliance to a used appliance dealer
- Gave the appliance to someone for free or left it on a curb with a "free" sign
- Gave the appliance to a charity organization
- Had the appliance removed by the dealer supplying the new or replacement appliance
- Took the appliance to a dump or recycling center (by themselves or with a friend)
- Had someone else take the appliance to a dump or recycling center (such as a handyman or local waste management company)

After the evaluation team established final assessments of participants' actions in absence of the program, we calculated the percentage of refrigerators and freezers kept or discarded. Table E-15 shows the results.

Table E-15. 2020 Appliance Recycling Program Final Distribution of Kept and Discarded Appliances

Stated Action Absent Program	Indicative of Freeridership	Refrigerators (n=73)	Freezer (n=80)
Kept	No	18%	35%
Discarded	Varies by Discard Method	82%	65%

As shown, 82% of respondents would not have kept their refrigerator. Of those disposing of the appliance, 33% would have discarded it through one of the following means:

- Had it removed by the dealer from which they purchased the new or replacement appliance
- Took it to a dump or recycling center (by themselves or with a friend)
- Had someone else take it to a dump or recycling center (such as a handyman or local waste management company)

Having the retailer pick the appliance up was not necessarily indicative of freeridership; it would depend on whether the retailer decides to resell the unit. Not all appliances would be viable for resale. The evaluation team used age as a proxy for secondary market viability, assuming that a retailer would be unlikely to resell appliances over 15 years old. Together, these actions resulted in a 27% reduction in gross savings due to refrigerator freeridership:

Refrigerator Freeridership = 82% of respondents would not keep their appliance * 33% of respondents reporting one of the three actions leading to freeridership = 23%

Freeridership for freezer recyclers took a similar route. Of 65% of respondents who would not have kept their freezers, 29% would have taken one of the three freeridership actions listed above, leading to the appliance's removal from the grid, for a 19% freeridership for freezers:

Freezer Freeridership = 65% * 29% = 19%

Secondary Market Impacts

If, in the program's absence, a participant would have directly or indirectly (through a market actor) transferred the program-recycled unit to another customer, the evaluation team estimated what actions the would-be acquirer might have taken, given that the unit would be unavailable without the program.

Some would-be acquirers in the market for a refrigerator or freezer would find another unit. Others would not seek another unit (only taking the unit opportunistically). Difficulties arose in trying to quantify the change in the total number of refrigerators and freezers in use (overall and used units) before and after program implementation, and in determining the program's effect on the total. Without this information, the UMP recommends that evaluators assume that one-half of would-be acquirers would find an alternate unit. Without information to the contrary, the evaluation team applied the UMP recommendation to this evaluation.

The team then determined whether the alternate unit would be another used appliance (such as those recycled through the program) or a new standard-efficiency unit (presuming fewer used appliances would be available due to program activity).[71]

As discussed, definitively estimating this distribution proved difficult. The UMP recommends adopting a midpoint approach when primary research is unavailable: evaluators should assume that half those who would have acquired an alternate unit would find a similar used appliance and half would acquire a new, standard-efficiency unit.

Consequently, to determine energy consumption for new, standard-efficiency appliances, the evaluation team used the average of federal baseline UEC refrigerators from the Indiana TRM (v2.2) and an average UEC of federal baseline freezers from ENERGY STAR's data. The team averaged the reported energy

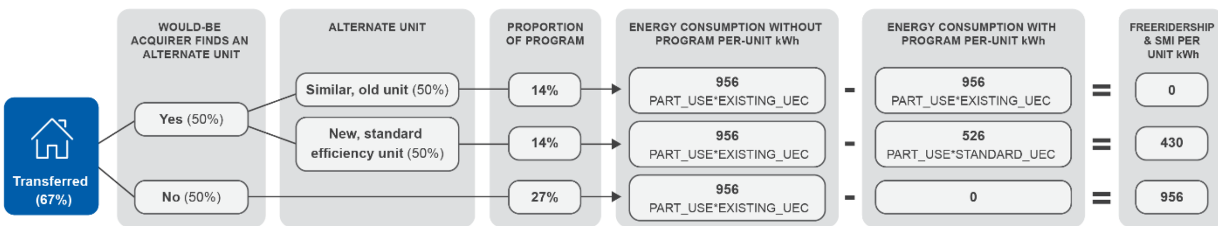
71 It is possible that the would-be acquirer would select a new ENERGY STAR unit. However, the team assumed that most customers in the market for a used appliance would upgrade to the next-lowest price point (a baseline, standard-efficiency unit).

consumption of new, standard-efficiency appliances, with sizes and configurations comparable to program units.

Figure E-1 details the methodology for assessing the program's impact on the secondary refrigerator market and for applying the recommended midpoint assumptions when primary data were unavailable. Accounting for market effects resulted in three savings scenarios:

- Full per-unit gross savings
- No savings
- Partial savings (the difference between the program measure's UEC and that of the new, standard-efficiency appliance, acquired alternatively)

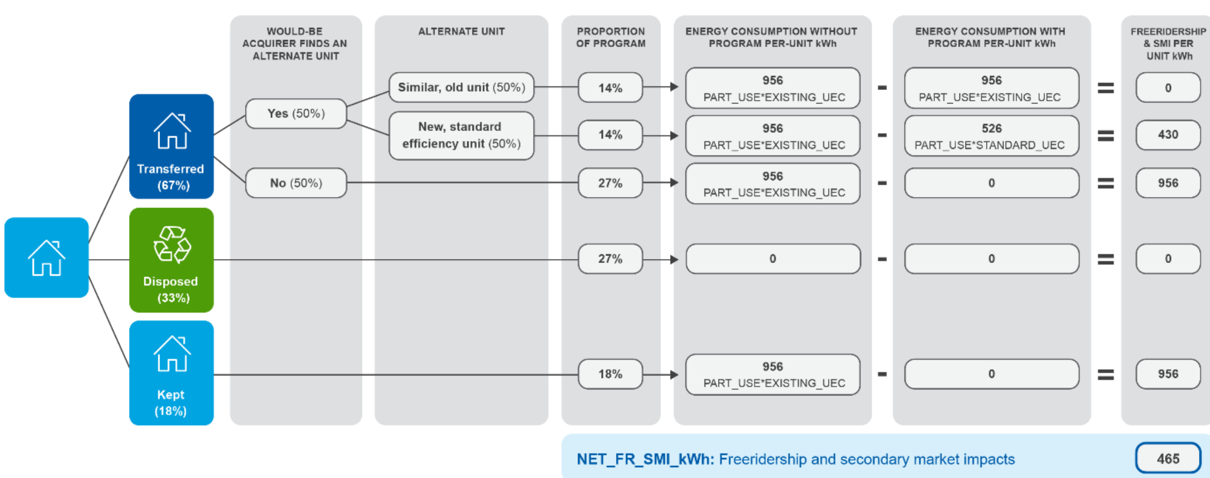
Figure E-1. 2020 Appliance Recycling Program Secondary Market Impacts—Refrigerators



Integration of Freeridership and Secondary Market Impacts

After estimating the parameters of freeridership and secondary market impacts, the evaluation team used the UMP decision tree to calculate average, per-unit program savings, net of their combined effects. Figure E-2 shows how the team integrated these values into a savings estimate net of freeridership and secondary market impacts. The team calculated final savings, net of freeridership and secondary market impacts, as the weighted average of savings for each decision-tree category.

Figure E-2. 2020 Appliance Recycling Program Savings Net of Freeridership and Secondary Market Impacts—Refrigerators



Spillover

Spillover refers to additional savings generated by program participants due to their participation, but not captured by program records. Spillover occurs when participants choose to purchase energy-efficient measures or adopt energy-efficient practices due to being influenced by a program or marketing activities, but not applying for an incentive (and, therefore, not captured through other IPL programs). These customers' savings are not automatically counted toward the utility's programmatic savings. In contrast with freeridership impacts (which reduce net program savings), spillover impacts increase net program savings.

As recommended in the UMP, the evaluation team did not include spillover in program net savings estimates. Due to uncertainty in spillover savings associated with other energy efficiency programs offered, spillover of similar measures related to appliance recycling is limited by the number of appliances in a home that can be recycled. Spillover of unrelated measures is unlikely to occur since appliance recycling programs do not provide comprehensive energy education, which is provided through most other programs. The UMP suggests that, while appliance recycling programs promote enrollment in other energy-efficient programs, associated savings will be captured by other programs.

Final Net-to-Gross

As summarized in Table E-16 and Table E-17, the evaluation team determined final net savings as evaluated per-unit gross savings, less per-unit freeridership and secondary market impacts. The final net calculation did not include spillover. The team calculated impacts by applying the demand reduction calculation in the Indiana TRM (v2.2). Values in the following tables are displayed as rounded figures.

Table E-16. 2020 Appliance Recycling Program Net-to-Gross Values (kWh)

Appliance	Gross Per-Unit Savings (kWh)	Freeridership and Secondary Market Impacts (kWh)	Net Per-Unit Savings (kWh)	NTG
Refrigerator	956	465	491	51%
Freezer	576	228	348	60%

Table E-17. 2020 Appliance Recycling Program Net-to-Gross Values(kW)

Appliance	Gross Per-Unit Savings (kW)	Freeridership and Secondary Market Impacts (kW)	Net Per-Unit Savings (kW)	NTG
Refrigerator	0.132	0.065	0.067	51%
Freezer	0.084	0.034	0.050	60%

Figure E-3 and Figure E-4 present the full decision trees for APR refrigerators and freezers, respectively.

Figure E-3. 2020 Appliance Recycling Program Refrigerator Net-to-Gross Combined Decision Tree

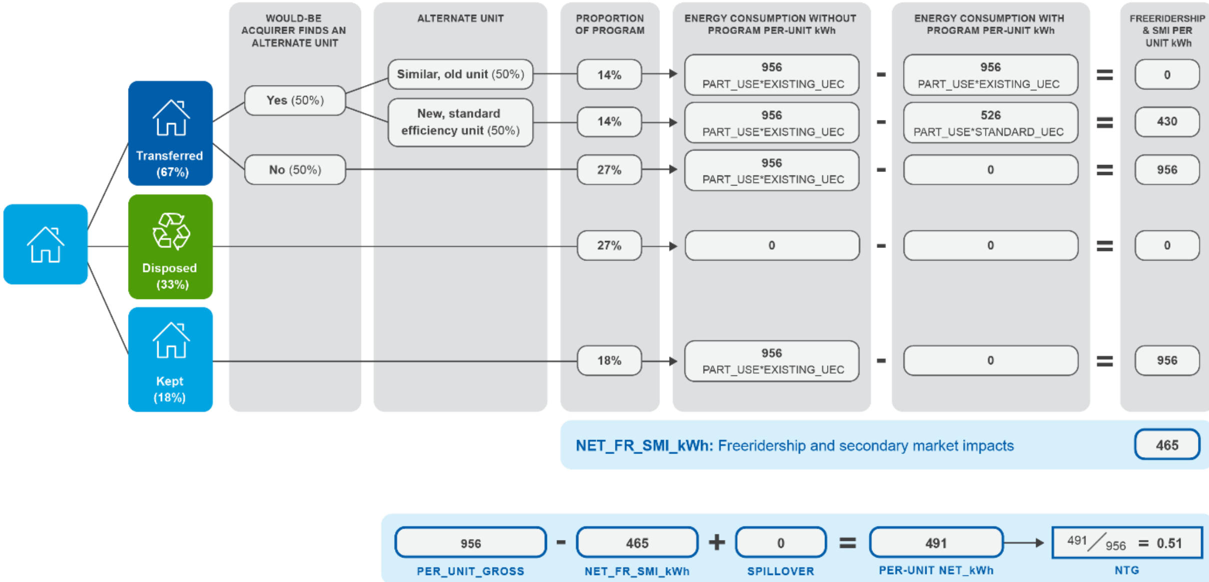
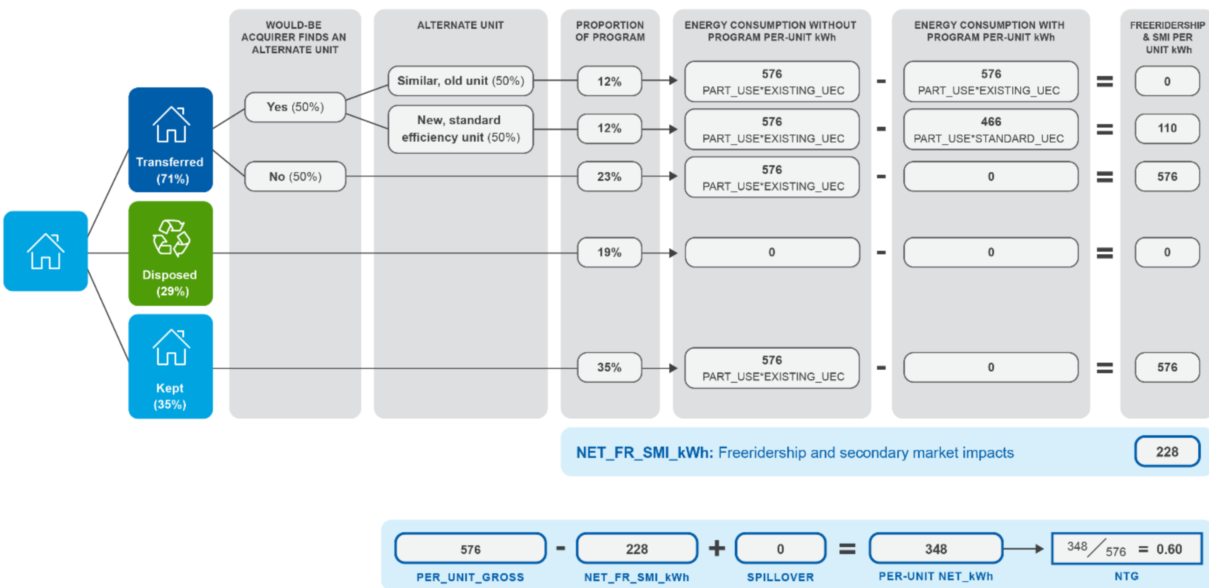


Figure E-4. 2020 Appliance Recycling Program Freezer Net-to-Gross Combined Decision Tree



LED Freeridership

At the time of appliance pick-up, ARP participants received a free kit with three LEDs. To determine freeridership for these LEDs, the evaluation team asked participants what their purchasing behaviors and decisions would have been in absence of the LED kit offering.

To determine freeridership, the team asked participants whether, in absence of the ARP, they would have purchased LEDs. Based on survey feedback, the team calculated overall freeridership for the pack of program bulbs as 41%, shown in Table E-18.

Table E-18. 2020 Appliance Recycling Program Freeridership Results

Measure	Sample (n)	Freeridership
9-watt LED—3 Pack	71	45%

The evaluation team estimated measure-level freeridership for each participant based on their responses to the following questions:

- FR1. "If you had not received the kit, would you have purchased LEDs on your own?"
- FR2. "When would you have purchased the LEDs?"

If a participants answered No to FR1, the team estimated them as a 0% freerider. If a participant said they "already have the measure installed in all available locations" to FR1, the team estimated them as a 100% freerider. If a participant answered Yes to FR1, the team estimated their freeridership based on their answer to FR2. Table E-19 shows response options to the freeridership questions, freeridership scores associated with each response, and the response frequency for each measure type.

Table E-19. 2020 Appliance Recycling Program LED Freeridership Responses and Scoring

FR1. If you had not received the kit, would you have purchased LEDs on your own?	Freeridership Score	Frequency of Responses
No	0%	8
Already have the measure installed in all available locations	100%	10
Don't know	25%	11
Yes. FR2. When would you have purchased the [MEASURE]?		
Around the same time I received the kit	100%	6
Later but within one year	50%	23
More than one year later	0%	5
Don't know or N/A	25%	8
Total	**N/A**	**71**

Net-to-Gross Ratio Summary

Table E-20 summarizes the final NTGs used in the 2020 evaluation.

Table E-20. 2020 Appliance Recycling Program Net-to-Gross Percentages

Appliance	NTG
Refrigerator	51%
Freezer	60%
Room Air Conditioner	100%
Dehumidifier	100%
9-Watt LED – Three Pack	55%

Appendix F. Community Based Lighting Program Measures, Assumptions, and Algorithms

This appendix details the algorithms and savings for LED bulbs provided through the CBL program.

Algorithms and Variable Assumptions

CLEAResult distributed four-packs of 9-watt LEDs to two food banks within IPL's territory. The team used the following equations from the UMP to calculate *ex post* per-measure energy savings and demand reduction for the distributed LEDs:

$$kWh\ savings\ per\ pack\ = kWh\ savings\ per\ lamp * 4$$

$$kWh\ savings\ per\ lamp = \frac{(W_{base} - W_{LED})}{1{,}000} * ISR * \ AOH * \ (1 + WHFe)$$

$$kW\ reduction\ per\ pack\ = kW\ reduction\ per\ lamp * 4$$

$$kW\ reduction = \frac{(W_{base} - W_{LED})}{1{,}000} * \ ISR * \ (1 + WHFd)$$

Where:

W_{base}	=	Baseline wattage of existing bulb replaced with an LED
W_{LED}	=	Wattage of the distributed LEDs
1,000	=	Constant to convert watts to kilowatts
ISR	=	In-service rate, or the percentage of rebated bulbs that get installed
AOH	=	Average hours of use per year
WHFe	=	Waste heat factor for energy use, accounting for the effects of more efficient lighting on cooling energy use
WHFd	=	Waste heat factor for demand, accounting for the effects of more efficient lighting on cooling energy demand

Table F-1 summarizes *ex post* savings assumptions and the sources of each assumption for the distributed LEDs.

Table F-1. 2020 CBL Program Variable Assumptions for LEDs

Variable	LED Value	Source
Baseline Wattage (W_{base})	31	Compared lumens with ENERGY STAR and applied the EISA baseline equivalent wattages from the UMP for each of the four main types of lighting responses (Incandescent, Halogen, CFL, LED) then weighted by response frequency in 2019 and 2020 participant surveys
LED Wattage (W_{LED})	9	Actual wattage of distributed LEDs
First-Year Installation Rate (ISR)	75%	2020 participant survey
Carryover Installation Rate (ISR)	87%	Lifetime ISR for lamps that are installed in later years
Hours Per Year (AOH)	902	Indiana TRM (v2.2); Cadmus. July 29, 2013. *Indiana Core Lighting Logger Hours of Use Study*.
Waste Heat Factor for Energy Use (WHFe)	-0.061	Indiana TRM (v2.2) for Indianapolis, weighted based on HVAC type
Waste Heat Factor for Demand (WHFd)	0.055	Indiana TRM (v2.2) for Indianapolis, weighted based on HVAC type

Lifetime Installation Rate Summary

The evaluation team relied on the UMP to calculate lifetime ISRs through 2023 to account for future installations of bulbs in storage. The methodology assumes that 24% of all bulbs in storage will be installed in each subsequent year after receipt. To account for the time sensitivity of these added savings, which stem from increased ISRs but take place after 2020, we discounted the lifetime ISR by 10% annually to achieve NPV lifetime ISRs for each LED. Table F-2 includes first-year and lifetime ISRs, showing how marginal increases to first-year ISRs using the UMP methodology result in the NPV lifetime ISRs used in measure impact calculations.

Table F-2. 2020 CBL Program First-Year and Lifetime ISR Calculations

Measure	First-Year ISR	2021	2022	2023	2024	Lifetime ISR	NPV ISR
General Service LED	75%	5%	4%	3%	N/A	97%	87%

Note: General service lamps were not anticipated to have gross savings post–EISA 2020 implementation; however, recent rule changes have delayed that implementation beyond 2020. The evaluation team assumes that these lamps will eventually become baseline around 2023. As such, the final lifetime NPV ISR is capped at 87% (and percentages are rounded).

Savings Summary

Table F-3 shows *ex ante* deemed savings (without installation rates) and the resulting *ex post* per-measure savings for distributed LEDs.

Table F-3. 2020 CBL Program LEDs *Ex Ante* and *Ex Post* Per-Measure Savings

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
9-watt LEDs (per bulb)	8.6	0.0012	16.2	0.0022
9-watt LEDs (per four-pack)	34.3	0.0047	64.8	0.0089

Appendix G. Income Qualified Weatherization Program Measures, Assumptions, and Algorithms

This appendix presents information for several IQW program measures, including algorithms, variable assumptions and sources, and differences between *ex ante* and *ex post* per-measure savings:

- LEDs (9-watt, 11 watt, 16 watt, 5-watt globe, 5-watt candelabra, 7-watt track, and R30)
- Bathroom and kitchen aerators
- Low-flow showerheads
- Pipe wrap insulation
- Smart power strips
- Programmable thermostats
- Smart thermostats
- Water heater setback
- Attic insulation
- Radiant barrier
- Duct sealing
- Air sealing
- Refrigerator Replacement
- LED night-lights
- Filter whistles
- Audit recommendations

Unless otherwise specified, these algorithms, variable assumptions, and measure savings apply to direct install and energy-savings kits measures. For measures where 2019 installations are claimed in the 2020 evaluation, the 2019 and 2020 per-measure *ex ante* savings are presented.

LEDs

Algorithms and Variable Assumptions

The evaluation team used two equations from the Indiana TRM (v2.2) to calculate the *ex post* per-measure energy savings and demand reduction for LEDs:

$$kWh\ savings = \frac{(W_{base} - W_{LED}) * (Hrs/day * 365) *\ (1 + WHFe)}{1{,}000}$$

$$kW\ reduction = \frac{(W_{base} - W_{LED}) *\ CF *\ (1 + WHFd)}{1{,}000}$$

Where:

W_{base} = Baseline wattage of existing bulb being replaced with a LED (= varies by measure; see Table G-1)

Table G-1. 2020 IQW Program LED Baseline Wattages

Measure	Baseline Wattage
9-watt LED	43
11-watt LED	53
16-watt LED	65
5-watt globe LED	40
5-watt candelabra LED	40
7-watt track LED	50
R30, 10-watt LED	65

W_{LED} = Actual installed LED wattage

Hrs/day = Average number of hours per day the light is in use

WHF_e = Waste heat factor for energy use; this accounts for the effects of more efficient lighting on cooling energy use

CF = Coincidence factor; a number between 0 and 1 indicating the ratio of LEDs expected to be in use and saving energy during the peak summer demand period

WHF_d = Waste heat factor for demand; this accounts for the effects of more efficient lighting on cooling energy demand

Table G-2 summarizes the *ex post* assumptions and sources for the installed LEDs.

Table G-2. 2020 IQW Program *Ex Post* Variable Assumptions for LEDs

Variable	Value	Source
Baseline wattage (W_{base})	As shown in Table G-1	Lumens compared with ENERGY STAR and EISA halogen baseline equivalent wattages applied
LED wattage (W_{LED})	As shown in Table G-1	Wattages of installed LED
Hours per day (Hrs/day – interior lights – direct install)	902	Indiana TRM (v2.2)
Hours per day (Hrs/day – interior lights – kits)	1,135	Indiana TRM (v2.2)
Hours per day (Hrs/day - 9-watt exterior lights)	1,607	Indiana TRM (v2.2)
Weighted average waste heat factor for energy (WHFe)	-0.061 for interior 0 for exterior	Indiana TRM (v2.2) for Indianapolis
Coincidence factor (CF)	0.11	Indiana TRM (v2.2)
Weighted average waste heat factor for demand (WHFd)	0.055 for interior 0 for exterior	Indiana TRM (v2.2) for Indianapolis

Savings Summary for LEDs

Table G-3 shows the *ex ante* deemed savings and the resulting *ex post* per-measure savings for LEDs.

Table G-3. 2020 IQW Program *Ex Ante* and *Ex Post* Per-Measure Savings for LEDs

Measure	*Ex Ante* Savings				*Ex Post* Savings	
	2019		2020			
	kWh	kW	kWh	kW	kWh	kW
Direct Install						
9-watt LED	18.14	0.002	8.73	0.001	28.80	0.004
16-watt LED	32.66	0.004	21.78	0.003	41.50	0.006
5-watt globe LED	26.67	0.004	12.92	0.002	29.64	0.004
5-watt candelabra LED	25.56	0.004	5.28	0.001	29.64	0.004
7-watt track LED	10.89	0.002	5.63	0.001	36.42	0.005
R30, 10-watt LED	26.73	0.006	14.06	0.002	46.58	0.006
9-watt exterior LED	28.27	0.000	16.98	0.000	54.64	0.000
Kits						
9-watt LED [a]	-	-	7.73	0.001	36.24	0.004
11-watt LED	N/A	N/A	11.94	0.002	44.76	0.005
16-watt LED	N/A	N/A	21.08	0.003	52.22	0.006

[a] The 2019 ex ante kit savings were not provided by measure type.

Ex ante and *ex post* savings differ for one reason:

- ***Differences in baseline wattage calculations for LEDs:*** CLEAResult used the post-2020 EISA requirements for the baseline wattage. However, the EISA backstop was not enforced, so the evaluation team applied the UMP baseline wattages, consistent with previous evaluation years. Additionally, the 2020 *ex ante* savings calculations include embedded ISRs but the *ex post* savings calculations do not. Lastly, the evaluation team applied 1,135 AOH for kits rather than 902 AOH which the Indiana TRM (v2.2) specifies for direct install.

Carryover Bulbs

To calculate carryover bulbs, the team referenced the UMP to estimate how many bulbs would be installed each year. The team used the initial first-year installation rate for kit measures and extrapolated out the estimated lifetime installation rates for these bulbs using the 24% estimation, plus a discount factor to account for installation delays. The team applied a lifetime cumulative installation rate of 87% (Table G-4) rather than the original calculated installation rate for kit LEDs to account for future installations of bulbs in storage.

Table G-4. 2020 IQW Program Adjusted Lifetime Installation Rates for Kit and Virtual Audit Lighting Measures

Year	Calendar Year	Cumulative ISR
Year 1	2020	74%
Year 2	2021	79%
Year 3	2022	83%
Year 4	2023	87%

Bathroom and Kitchen Faucet Aerators

Algorithms and Variable Assumptions

The evaluation team used two equations from the Indiana TRM (v2.2) to calculate *ex post,* per-measure energy savings and demand reduction for bathroom and kitchen faucet aerators installed in homes with an electric water heater:

$$kWh\ savings_{aerator} = (gpm_{base} - gpm_{low})\ x\ MPD * \frac{PH}{FH} * \mathrm{DRF} * \mathrm{S} * EF * (T_{mix} - T_{Inlet}) * \frac{365}{RE * 3{,}412}$$

$$kW\ reduction_{aerator} = (gpm_{base} - gpm_{low}) * 60 * \mathrm{DRF} * S * \frac{(T_{mix} - T_{Inlet})}{RE * 3{,}412} * CF * EF$$

Where:

gpm_{base}	=	Baseline flow rate of existing faucet in gallons per minute
gpm_{low}	=	Low-flow rate of aerator in gallons per minute
MPD	=	Average minutes of faucet use per day per person
PH	=	Average number of people per household
FH	=	Average number of faucets per household
DRF	=	Drain recovery factor representing the percentage of water flowing down the drain
S	=	Constant used to convert the weight of water from gallons to pounds (8.3 lbs/gallon)
T_{mix}	=	Temperature of water leaving the aerator (°F)
T_{inlet}	=	Temperature of water entering the water heater (°F)
RE	=	Recovery efficiency of the electric water heater in operation
CF	=	Coincidence factor; a number between 0 and 1 indicating the ratio of aerators expected to be in use and saving energy during the peak summer demand period
EF	=	Percentage of electric water heaters in Indiana

Table G-5 summarizes *ex post* assumptions and sources for installed faucet aerators.

Table G-5. 2020 IQW Program *Ex Post* Variable Assumptions for Faucet Aerators

Variable	Value		Source
	Bathroom	Kitchen	
Baseline flow rate (gpm_{base})	1.9	2.44	Indiana TRM (v2.2)
Low-flow rate (gpm_{low})	1.0	1.5	Gallons per minute of installed aerators
Minutes per person per day (MPD)	1.6	4.5	Indiana TRM (v2.2)
People per household (PH)	2.64	2.64	Indiana TRM (v2.2)
Faucets per household (FH)	2.04	1	Indiana TRM (v2.2)
Drain recovery factor (DRF)	0.7	0.5	Indiana TRM (v2.2)
Conversion factor (S)	8.3	8.3	Engineering constant in units of Btu/(gal°F)
Mixed temperature (T_{mix})	86	93	Indiana TRM (v2.2)
Inlet temperature (T_{inlet})	58.1	58.1	Indiana TRM (v2.2) for Indianapolis
Recovery efficiency (RE)	0.98	0.98	Indiana TRM (v2.2)
Coincidence factor (CF)	0.0012	0.0033	Indiana TRM (v2.2)
Energy Factor (EF)	0.27 for kits, or 1 for direct install	0.27 for kits, or 1 for direct install	Indiana TRM (v2.2)

Savings Summary for Faucet Aerators

Table G-6 shows *ex ante* deemed savings and the resulting *ex post,* per-measure savings for faucet aerators. The evaluation team calculated savings for faucet aerators installed through the IQW program using efficient faucet information and the Indiana TRM (v2.2).

Table G-6. 2020 IQW Program *Ex Ante* and *Ex Post* Per-Measure Savings for Faucet Aerators

Measure	*Ex Ante* Savings				*Ex Post* Savings	
	2019		2020			
	kWh	kW	kWh	kW	kWh	kW
Bathroom Aerators	31.33	0.003	32.97	0.003	32.97	0.003
Kitchen Aerators	167.73	0.008	176.55	0.008	176.55	0.008

The differences between *ex ante* and *ex post* savings resulted for one reason:

- ***Deemed versus Indiana TRM (v2.2) calculated savings for 2019 installations:*** For the *ex ante* analysis, CLEAResult cited a deemed savings value for 2019 installations, while the evaluation team leveraged the Indiana TRM (v2.2).

As shown in the table, there are no differences between *ex ante* and *ex post* savings for 2020 bathroom and kitchen faucet aerators.

Low-Flow Showerheads

Algorithms and Variable Assumptions

The evaluation team used two equations from the Indiana TRM (v2.2) to calculate *ex post,* per-measure energy savings and demand reduction for low-flow showerheads installed in homes with an electric water heater:

$$kWh\ savings_{Showerhead} = (gpm_{base} - gpm_{low}) * \text{MS} * \text{SPD} * \frac{PH}{SH} * S * (T_{mix} - T_{Inlet}) * \frac{365}{RE * 3{,}412} * EF$$

$$kW\ reduction_{Showerhead} = (gpm_{base} - gpm_{low}) * 60 * S * \frac{(T_{mix} - T_{Inlet})}{RE * 3{,}412} * CF * EF$$

Where:

gpm_{base}	=	Baseline flow rate of existing showerhead in gallons per minute
gpm_{low}	=	Low-flow rate of efficient showerhead in gallons per minute
MS	=	Average minutes per shower per person per day
SPD	=	Average number of showers per person per day
PH	=	Average number of people per household
SH	=	Average number of showerheads per household
S	=	Constant used to convert the weight of water from gallons to pounds (8.3 lbs/gallon)
T_{mix}	=	Temperature of water leaving the showerhead (°F)
T_{inlet}	=	Temperature of water entering the water heater (°F)
RE	=	Recovery efficiency of electric water heater in operation
CF	=	Coincidence factor; a number between 0 and 1 indicating the ratio of showerheads expected to be in use and saving energy during the peak summer demand period
EF	=	Percentage of electric water heaters in Indiana

Table G-7 summarizes *ex post* assumptions and sources for installed low-flow showerheads.

Table G-7. 2020 IQW Program *Ex Post* Variable Assumptions for Low-Flow Showerheads

Variable	Value	Source
Baseline flow rate (gpm_{base})	2.63	Indiana TRM (v2.2)
Low-flow rate (gpm_{low})	1.5	Gallons per minute of installed showerhead
Minutes per shower per person per day (MS)	7.8	Indiana TRM (v2.2)
Showers per person per day (SPD)	0.6	Indiana TRM (v2.2)
People per household (PH)	2.64	Indiana TRM (v2.2)
Showerheads per household (SH)	1.6	Indiana TRM (v2.2)
Conversion factor (S)	8.3	Engineering constant in units of Btu/(gal°F)
Mixed temperature (T_{mix})	101	Indiana TRM (v2.2)
Inlet temperature (T_{inlet})	58.1	Indiana TRM (v2.2)
Recovery efficiency (RE)	0.98	Indiana TRM (v2.2)
Coincidence factor (CF)	0.0023	Indiana TRM (v2.2)
Energy Factor (EF)	0.27 for kits, or 1 for direct install	Indiana TRM (v2.2)

Savings Summary for Low-Flow Showerheads

For this measure, an efficient, low-flow showerhead replaces an existing, less-efficient showerhead. Table G-8 shows *ex ante* deemed savings and the resulting *ex post* per-measure savings for low-flow showerheads installed through the IQW program.

Table G-8. 2020 IQW Program *Ex Ante* and *Ex Post* Per-Measure Savings for Low-Flow Showerheads

Measure	*Ex Ante* Savings				*Ex Post* Savings	
	2019		2020			
	kWh	kW	kWh	kW	kWh	kW
Low-Flow Showerhead	322.20	0.016	339.16	0.017	339.16	0.017

The differences between *ex ante* and *ex post* savings resulted for one reason:

- ***Deemed versus Indiana TRM (v2.2) calculated savings for 2019 installations:*** For the *ex ante* analysis in 2019, CLEAResult cited a deemed savings value, while the evaluation team leveraged the Indiana TRM (v2.2).

As shown in the table, there are no differences between *ex ante* and *ex post* savings for 2020 low-flow showerheads.

Pipe Wrap Insulation

Algorithms and Variable Assumptions

The evaluation team used two equations from the Indiana TRM (v2.2) to calculate *ex post,* per-measure energy savings and demand reduction for pipe wrap insulation installed in homes with an electric water heater:

$$kWh\ savings_{pipe\ insulation} = \frac{\left(\frac{1}{R_{existing}} - \frac{1}{R_{new}}\right) * L * C * (\Delta T) * Hrs/yr}{3{,}412 * EF_{electric\ WH}}$$

$$kW\ reduction_{pipe\ insulaton} = \frac{kWh\ savings_{pipe\ insulation}}{Hrs/yr}$$

Where:

$R_{existing}$ = R-value of uninsulated hot water pipe

R_{new} = R-value after installing new pipe insulation

L = Total linear feet of installed pipe insulation

C = Circumference of hot water pipe in feet (assumed pipe diameter of 0.5 inches): C = $\pi * pipe\ diameter * 0.083$

ΔT = Difference between ambient temperature where the water heater is installed and temperature of the distributed hot water

Hrs/yr = Total number of hours per year the water heater is in operation

EF = Energy factor of the electric water heater in operation

Table G-9 summarizes *ex post* assumptions and sources for the installed pipe wrap insulation.

Table G-9. 2020 IQW Program *Ex Post* Variable Assumptions for Pipe Wrap Insulation

Variable	Value	Source
Existing R-value ($R_{existing}$)	1	Indiana TRM (v2.2)
New R-value (R_{new})	3	Indiana TRM (v2.2)
Pipe length (L)	1	To calculate savings in 1-foot increments
Pipe circumference (C)	0.19635	Assumes 0.75-inch diameter pipe
Temperature change (ΔT)	65	Indiana TRM (v2.2)
Hours per year (Hrs/yr)	8760	Indiana TRM (v2.2)
Energy factor (EF)	0.98	Indiana TRM (v2.2)

Savings Summary for Pipe Wrap Insulation

Table G-10 shows *ex ante* deemed savings and the resulting *ex post* savings for pipe wrap insulation, per installed foot.

Table G-10. 2020 IQW Program *Ex Ante* and *Ex Post* Per-Installed Foot Savings for Pipe Wrap Insulation

Measure	*Ex Ante* Savings				*Ex Post* Savings	
	2019		2020			
	kWh	kW	kWh	kW	kWh	kW
Pipe Wrap Insulation	26.84	0.003	22.29	0.003	22.29	0.003

The differences between *ex ante* and *ex post* savings resulted for one reason:

- ***Deemed versus Indiana TRM (v2.2) calculated savings:*** For the *ex ante* analysis in 2019, CLEAResult cited deemed savings, while the evaluation team leveraged the Indiana TRM (v2.2).

As shown in the table, there are no differences between *ex ante* and *ex post* savings for 2020 pipe wrap insulation.

Smart Power Strips

Algorithms and Variable Assumptions

The evaluation teamed used two deemed values from the Illinois TRM (v8) to determine energy savings and demand reduction from computer and audio-visual equipment:

$$kWh\ savings_{Smart\ Strip} = deemed = 150.00$$

$$kW\ reduction_{Smart\ Strip} = deemed = 0.027$$

Savings Summary for Smart Power Strips

Ex ante deemed savings and resulting *ex post,* per-measure savings for smart power strips are shown in Table G-11.

Table G-11. 2020 IQW Program *Ex Ante* and *Ex Post* Per-Measure Savings for Smart Power Strips

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Smart Power Strips	150.00	0.027	150.00	0.027

As shown in the table, there are no differences between *ex ante* and *ex post* savings for smart power strips.

Programmable Thermostats

Algorithms and Variable Assumptions

The evaluation team used three equations from the Indiana TRM (v2.2) to calculate *ex post,* per-measure energy savings and demand reduction for programmable thermostats:

$$kWh\ savings_{PStat} = kWh\ savings_{AC\ cooling} + kWh\ savings_{Elec\ htg}$$

$$kWh\ savings_{AC\ cooling} = \frac{1}{n_{cool}} * FLH_{cool} * \frac{Btuh_{cool}}{1{,}000} * ESF_{cool}$$

$$kWh\ savings_{Elec\ htg} = FLH_{heat} * \frac{Btuh_{heat}}{n_{heat} * 3{,}412} * ESF_{heat}$$

Where:

n_{cool} = Efficiency of existing cooling system controlled by programmable thermostat (in SEER units)

FLH_{cool} = Full-load cooling hours for Indianapolis

$Btuh_{cool}$ = Capacity of cooling system (Btu/hour)

ESF_{cool} = Energy-savings factor for cooling

FLH_{heat} = Full-load heating hours for Indianapolis

$Btuh_{heat}$ = Capacity of heating system (Btu/hour)

n_{heat} = Efficiency of an existing heating system controlled by a programmable thermostat (in units of coefficient of performance)

ESF_{heat} = Energy-savings factor for heating

Table G-12 summarizes *ex post* assumptions and sources for installed programmable thermostats.

Table G-12. 2020 IQW Program *Ex Post* Variable Assumptions for Programmable Thermostats

Variable	Value	Source
Efficiency of existing cooling system (n_{cool})	11.15	Indiana TRM (v2.2)
Full-load cooling hours (FLH_{cool})	487	Indiana TRM (v2.2) for Indianapolis
Capacity of cooling system ($Btuh_{cool}$)	28,994	Indiana TRM (v2.2)
Energy-savings factor for cooling (ESF_{cool})	0.09	Indiana TRM (v2.2)
Full-load heating hours (FLH_{heat})	1,341	Indiana TRM (v2.2) for Indianapolis
Capacity of heating system ($Btuh_{heat}$)	32,000	2016 Pennsylvania TRM
Efficiency of an existing heating system (n_{heat} - electric resistance)	1	Indiana TRM (v2.2)
Efficiency of an existing heating system (n_{heat} - heat pump)	2.26	Indiana TRM (v2.2)
Energy-savings factor for heating (ESF_{heat})	0.068	Indiana TRM (v2.2)

Savings Summary for Programmable Thermostats

Table G-13 shows *ex ante* deemed savings and the resulting *ex post,* per-measure savings for programmable thermostats.

Table G-13. 2020 IQW Program *Ex Ante* and *Ex Post* Per-Measure Savings for Programmable Thermostats

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Programmable Thermostat (Electric Heat + Central AC)	969.20	0	969.20	0
Programmable Thermostat (Air-Source Heat Pump)	492.39	0	492.39	0
Programmable Thermostat (Natural Gas Heat + Central AC)	113.97	0	113.97	0

As shown in the table, there are no differences between *ex ante* and *ex post* savings for programmable thermostats.

Smart Thermostats

Algorithms and Variable Assumptions

The evaluation team used three equations from the Indiana TRM (v2.2) to calculate *ex post,* per-measure energy savings and demand reduction for smart thermostats:

$$kWh\ savings_{PStat} = kWh\ savings_{AC\ cooling} + kWh\ savings_{Elec\ htg}$$

$$kWh\ savings_{AC\ cooling} = \frac{1}{n_{cool}} * FLH_{cool} * \frac{Btuh_{cool}}{1{,}000} * ESF_{cool}$$

$$kWh\ savings_{Elec\ htg} = FLH_{heat} * \frac{Btuh_{heat}}{n_{heat} * 3{,}412} * ESF_{heat}$$

Where:

n_{cool} = Efficiency of existing cooling system controlled by programmable thermostat (in units of SEER)

FLH_{cool} = Full-load cooling hours for Indianapolis

$Btuh_{cool}$ = Capacity of cooling system (Btu/hour)

ESF_{cool} = Energy-savings factor for cooling

FLH_{heat} = Full-load heating hours for Indianapolis

$Btuh_{heat}$ = Capacity of heating system (Btu/hour)

n_{heat} = Efficiency of existing heating system controlled by programmable thermostat (in units of coefficient of performance)

ESF_{heat} = Energy-savings factor for heating

Table G-14 summarizes *ex post* assumptions and sources for installed smart thermostats.

Table G-14. 2020 IQW Program *Ex Post* Variable Assumptions for Smart Thermostats

Variable	Value	Source
Efficiency of existing cooling system (n_{cool})	11.15	Indiana TRM (v2.2)
Full-load cooling hours (FLH_{cool})	487	Indiana TRM (v2.2) for Indianapolis
Capacity of cooling system ($Btuh_{cool}$)	28,994	Indiana TRM (v2.2)
Energy-savings factor for cooling (ESF_{cool})	0.049 if replacing programmable in use, else 0.139	Vectren 2015 report
Full-load heating hours (FLH_{heat})	1,341	Indiana TRM (v2.2) for Indianapolis
Capacity of heating system ($Btuh_{heat}$)	32,000	2016 Pennsylvania TRM
Efficiency of an existing heating system (n_{heat} - electric resistance)	1	Indiana TRM (v2.2)
Efficiency of an existing heating system (n_{heat} - heat pump)	2.26	Indiana TRM (v2.2)
Efficiency of existing cooling system (n_{cool})	0.057 if replacing programmable in use, else 0.125	Vectren 2015 report

Savings Summary for Smart Thermostats

Table G-15 shows *ex ante* deemed savings and the resulting *ex post,* per-measure savings for smart thermostats.

Table G-15. 2020 IQW Program *Ex Ante* and *Ex Post* Per-Measure Savings for Smart Thermostats

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Smart Thermostat (Electric Heat + Central AC)	1,239.90	0	1,530.55	0
Smart Thermostat (Air-Source Heat Pump)	566.02	0	659.92	0
Smart Thermostat (Natural Gas Heat + Central AC)	144.61	0	144.61	0

As shown in the table, there are no differences between *ex ante* and *ex post* savings for smart thermostats.

Water Heater Setback

Algorithms and Variable Assumptions

The evaluation team used two equations from the Illinois TRM (v8) to calculate *ex post,* per-measure energy savings and demand reduction for water heater setback:

$$kWh\ savings_{WH} = \frac{\left(U * A * \left(T_{pre} - T_{post}\right) * AOH * ISR\right)}{3{,}412 * RE_{elec}}$$

$$kW\ reduction_{WH} = \Delta kWh/\ AOH * CF$$

Where:

U = Overall heat transfer coefficient of tank (Btu/hr-F-ft^2)

A = Surface area of tank (square feet)

T_{pre} = Hot water setpoint prior to adjustment (°F)

T_{post} = Hot water setpoint after adjustment (°F)

AOH = Hours per year

ISR = In-service rate

RE_{elec} = Recovery efficiency of electric water heater

CF = Coincidence factor

Table G-16 summarizes *ex post* assumptions and sources for water heater setback.

Table G-16. 2020 IQW Program *Ex Post* Variable Assumptions for Water Heater Setback

Variable	Value	Source
Overall heat transfer coefficient of tank (U)	0.083	Illinois TRM (v8)
Surface area of tank (A)	Actual	Program tracking data or Illinois TRM (v8) when actual not provided
Hot water setpoint prior to adjustment (T_{pre})	Actual	Program tracking data or Illinois TRM (v8) when actual not provided
Hot water setpoint after adjustment (T_{post})	120	Illinois TRM (v8)
Hours per year (AOH)	8,766	Illinois TRM (v8)
In-service rate (ISR)	1	Illinois TRM (v8)
Recovery efficiency of electric water heater (RE_{elec})	0.98	Illinois TRM (v8)
Coincidence factor (CF)	1.0	Illinois TRM (v8)

Savings Summary for Water Heater Setback

Table G-17 shows *ex ante* deemed savings and the resulting *ex post,* per-measure savings for water heater setbacks.

Table G-17. 2020 IQW Program *Ex Ante* and *Ex Post* Per-Measure Savings for Water Heater Setback

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Water Heater Setback	101.19	0.012	83.36	0.010

The differences between *ex ante* and *ex post* savings resulted for one reason:

- ***Actual versus assumed water heater tank size and outlet temperature prior to setback for some projects:*** CLEAResult provided the water heater tank size or heater outlet temperature prior to setback for nine of the 26 projects. When actual data was not provided, the evaluation team referenced the Illinois TRM (v8) and assumed default values.

Attic Insulation

Algorithms and Variable Assumptions

The evaluation team used two equations from the Indiana TRM (v2.2) to calculate *ex post,* per-measure energy savings and demand reduction for attic insulation:

$$kWh\ savings_{Insulation} = kSF * \left(\frac{\Delta kWh}{kSF}\right)$$

$$kW\ reduction_{Insulation} = kSF * \left(\frac{\Delta kW}{kSF}\right) * CF$$

Where:

kSF	=	Total area (in 1,000 square feet) of installed insulation
ΔkWh/kSF	=	Energy savings for every 1,000 square feet of installed insulation, accounting for pre- and post-installation R-value conditions (varies by HVAC equipment)
ΔkW/kSF	=	Demand reduction for every 1,000 square feet of installed insulation, accounting for pre- and post-installation R-value conditions (varies by HVAC equipment)
CF	=	Coincidence factor; a number between 0 and 1 indicating the ratio of cooling equipment expected to be in use and saving energy during the peak summer demand period

The Indiana TRM (v2.2) provides lookup tables that include expected energy savings and demand reduction (per 1,000 square feet of installed insulation) for different pre- and post-insulation R-values. The evaluation team calculated these R-values using a three-step process:

1. Determine variables for insulation compression, R-value ratios, and void factors.
2. Calculate the adjusted R-values.
3. Interpolate within Indiana TRM (v2.2) tables (in Appendix C – Insulation Measures in Single Family Buildings) using the adjusted R-values and obtain savings per 1,000 square feet of insulation (ΔkWh/kSF and ΔkW/kSF).

Step 1: Determine Variables for Insulation Compression, R-Value Ratios, and Void Factors

Insulation Compression

Insulation that gets compressed during installation results in reduced R-values. Therefore, it is important to account for compression when calculating insulation savings. There was no information for this evaluation that supports adjusting R-values due to compression, so the team assumed 0% compression.

R-Value Ratio

The void factor varies based on the ratio between the full assembly R-value and the nominal R-value with the inclusion of compression effects. The evaluation team used this ratio to identify the void factor in lookup tables provided in the Indiana TRM (v2.2). The team calculated pre- and post-installation R-value ratios using an equation from Indiana TRM (v2.2):

$$R_{ratio} = (R_{nominal} * F_{compression})/((R_{nominal} + R_{frame\ \&\ air})$$

Where:

$R_{nominal}$ = Pre- or post-installation R-value provided in program database

$F_{compression}$ = Compression factor dependent on the percentage of insulation compression (= 1, assuming 0% compression)

$R_{frame\ \&\ air}$ = R-value for materials, framing, and air space for the area where insulation is installed (= R-5 per the Indiana TRM (v2.2))

Void Factor

Table G-18 outlines the void factor based on the calculated R-value ratio. The evaluation team assumed a 2% void for pre- and post-insulation installation, as this information remained unknown.

Table G-18. 2020 IQW Program Insulation Void Factors

R-Value Ratio	Void Factor	
	2% Void (Grade II) [a]	5% Void (Grade III)
0.50	0.96	0.90
0.55	0.96	0.90
0.60	0.95	0.88
0.65	0.94	0.87
0.70	0.94	0.85
0.75	0.92	0.83
0.80	0.91	0.79
0.85	0.88	0.74
0.90	0.83	0.66
0.95	0.71	0.49
0.99	0.33	0.16

Source: Indiana TRM (v2.2).

[a] The evaluation team assumed a 2% void.

Step 2: Calculate the Adjusted R-Values

The evaluation team used R-values from the 2020 program tracking database to calculate adjusted R-values that accounted for factors such as compression, void factors, and installation grade levels via the following formula:

$$Rvalue_{Adjusted} = R_{nominal} * F_{compression} * F_{void}$$

Where:

$R_{nominal}$ = Pre- or post-installation R-value provided in program database

$F_{compression}$ = Compression factor dependent on the percentage of insulation compression (= 1, assuming 0% compression)

F_{void} = Void factor dependent on the installed insulation grade level and percentage of coverage

Step 3: Interpolate within Indiana TRM (v2.2) Tables

The evaluation team interpolated per-measure energy savings and demand reduction values found in the Indiana TRM (v2.2) to determine savings per 1,000 square feet for the adjusted pre- and post-installation R-values (calculated in Step 2).

Savings Summary for Attic Insulation

The evaluation team calculated *ex ante* and *ex post* savings using a custom approach that leveraged project-specific information where available (such as pre- and post-installation R-values), therefore developing unique savings per participant. Rather than display all unique savings values, Table G-19 shows average savings per participant.

Table G-19. 2020 IQW Program *Ex Ante* and *Ex Post* Per-Participant Savings for Attic Insulation

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Attic Insulation – Electric Heat	0.55	0.000	1.03	0.000 [a]

[a] *Ex post* savings are 0.0001 kW per square foot.

The differences between *ex ante* and *ex post* savings resulted for one reason:

- ***Actual pre- and post-installation R-values:*** CLEAResult applied the Indiana TRM (v2.2) deemed kilowatt-hours per thousand square feet and kilowatts per thousand square feet values that most closely resembled the pre-determined R-value bins, while the evaluation team interpolated within the Indiana TRM (v2.2) deemed savings values such that savings reflected actual pre- and post-installation conditions.

Radiant Barrier

Algorithms and Variable Assumptions

The evaluation team applied an *ex post* radiant barrier value from the *IPL 2018-2020 DSM Programs Technical Specifications*, consistent with CLEAResult's approach.

Savings Summary for Audit Recommendations

Table G-20 shows a comparison of *ex ante* and *ex post,* per-square-foot savings for radiant barrier.

Table G-20. 2020 IQW Program *Ex Ante* and *Ex Post* Per-Square-Foot Savings for Radiant Barrier

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Radiant Barrier	0.48	0.000 [a]	0.48	0.000 [a]

[a] *Ex ante* and *ex post* savings are both 0.000067 kW per square foot.

Duct Sealing

Algorithms and Variable Assumptions

The evaluation team used four equations from the Indiana TRM (v2.2) to calculate *ex post,* per-measure energy savings and demand reduction for duct sealing:

$$kWh\ savings_{PStat} = kWh\ savings_{heat} + kWh\ savings_{cool}$$

$$kWh\ Savings_{heat} = \frac{(DE_{After} - DE_{Before})}{DE_{After}} * \frac{FLH_{heat} * Btuh_{heat}}{n_{heat} * 3{,}412}$$

$$kWh\ Savings_{cool} = \frac{(DE_{After} - DE_{Before})}{DE_{After}} * \frac{FLH_{cool} * Btuh_{cool}}{SEER * 1{,}000}$$

$$kW\ Savings = \frac{(DE_{After} - DE_{Before})}{DE_{After}} * \frac{Btuh_{cool}}{EER * 1{,}000} * CF$$

Where:

DE_{After} = Distribution system efficiency after duct sealing

DE_{Before} = Distribution system efficiency before duct sealing

FLH_{heat} = Full-load heating hours for Indianapolis

$Btuh_{heat}$ = Capacity of heating system (Btu/hour)

n_{heat} = Efficiency of existing heating system controlled by a programmable thermostat (in units of coefficient of performance)

FLH_{cool} = Full-load cooling hours for Indianapolis

$Btuh_{cool}$ = Capacity of cooling system (Btu/hour)

SEER = Seasonal average efficiency of AC equipment (in SEER units)

EER = Peak efficiency of AC equipment in EER units (if unknown, EER = SEER * 0.9)

CF = Coincidence factor

Table G-21 summarizes *ex post* assumptions and sources for duct sealing.

Table G-21. 2020 IQW Program *Ex Post* Variable Assumptions for Duct Sealing

Variable	Value	Source
Distribution system efficiency after duct sealing (DE_{After} - cool)	Actual	Program tracking data
Distribution system efficiency after duct sealing (DE_{After} - heat)	Actual	Program tracking data
Distribution system efficiency before duct sealing (DE_{Before} - cool)	Actual	Program tracking data
Distribution system efficiency before duct sealing (DE_{Before} - heat)	Actual	Program tracking data
Full-load heating hours (FLH_{heat})	1,341	Indiana TRM (v2.2)
Capacity of heating system ($Btuh_{heat}$)	Actual	Program tracking data
Efficiency of existing heating system (n_{heat} - heat pump)	2.26	Indiana TRM (v2.2), heat pump
Efficiency of existing heating system (n_{heat} - electric furnace)	1	Indiana TRM (v2.2), electric furnace
Full-load cooling hours (FLH_{cool})	487	Indiana TRM (v2.2)
Capacity of cooling system ($Btuh_{cool}$)	Actual	Program tracking data
Seasonal average efficiency of AC equipment SEER)	11.15	Program tracking data
Peak efficiency of AC equipment (EER)	10.035	Program tracking data
Coincidence factor (CF)	0.88	Indiana TRM (v2.2)

Savings Summary for Duct Sealing

Table G-22 shows *ex ante* deemed savings and resulting *ex post,* per-measure savings for duct sealing.

Table G-22. 2020 IQW Program *Ex Ante* and *Ex Post* Per-Measure Savings for Duct Sealing

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Duct Sealing (Electric Heat Only)	212.03	0.042	212.03	0.00
Duct Sealing (Heat Pump)	396.93	0.300	396.93	0.300

There is one reason for the difference between *ex ante* and *ex post* demand reduction:

- ***Demand reduction for electric heat:*** CLEAResult applied demand reduction for the electric heat–only measure. However, the evaluation team followed the Indiana TRM (v2.2), which does not assign demand reduction when central AC is not present.

Air Sealing

Algorithms and Variable Assumptions

The evaluation team used two equations from the Indiana TRM (v2.2) to calculate *ex post,* per-measure energy savings and demand reduction for air sealing:

$$kWh\ savings_{Air\ Sealing} = (CFM50_{existing} - CFM50_{air\ sealed}) * \frac{\left(\frac{\Delta kWh}{cfm}\right)}{N_{factor}}$$

$$kW\ reduction_{Air\ Sealing} = (CFM50_{existing} - CFM50_{air\ sealed}) * \frac{\left(\frac{\Delta kW}{CFM}\right)}{N_{factor}} * CF$$

Where:

$CFM50_{existing}$	=	Initial blower door results, measured in CFM and pressurized at 50 pascal, of the amount of leakage in the home prior to air-sealing measures
$CFM50_{air\ sealed}$	=	Blower door results, in CFM and pressurized at 50 pascal, of the amount of leakage in the home after installing air-sealing measures
ΔkWh/CFM	=	Energy savings for each CFM reduction (varies by HVAC equipment)
N_{factor}	=	Constant used to convert 50-pascal airflow to natural airflow (the latter dependent on exposure levels)
ΔkW/CFM	=	Demand reduction for each CFM reduction (varies by HVAC equipment)
CF	=	Coincidence factor; a number between 0 and 1 indicating the ratio of cooling equipment expected to be in use and saving energy during the peak summer demand period

Table G-23 summarizes *ex post* assumptions and sources for the air-sealing measure.

Table G-23. 2020 IQW Program *Ex Post* Variable Assumptions for Air Sealing

Variable	Value	Source
Initial blower door results ($CFM50_{existing}$)	Actual	IQW program data
Post–air sealing blower door results ($CFM50_{air\ sealed}$)	Actual	
Energy savings (ΔkWh/CFM - electric resistance heat and AC)	50.1	Indiana TRM (v2.2)
Energy savings (ΔkWh/CFM - heat pump)	30.9	
Energy savings (ΔkWh/CFM - electric heat only)	48.2	
Energy savings (ΔkWh/CFM - natural gas heat and AC)	2.4	
Constant to convert to natural airflow (N_{factor})	16.3	Indiana TRM (v2.2) for unknown number of stories and exposure
Demand reduction (ΔkW/CFM - electric resistance heat and AC)	0.006	Indiana TRM (v2.2)
Demand reduction (ΔkW/CFM - heat pump)	0.003	
Demand reduction (ΔkW/CFM - natural gas heat and AC)	0.001	
Coincidence factor (CF)	0.88	Indiana TRM (v2.2)

Savings Summary for Air Sealing

Table G-24 shows *ex ante* deemed savings and resulting *ex post,* per-measure savings for air sealing.

Table G-24. 2020 IQW Program *Ex Ante* and *Ex Post* Per-Measure Savings for Air Sealing

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Air Sealing (Electric Heat with Central AC)	3,963.87	0.418	3,963.87	0.418
Air Sealing (Heat Pump)	472.78	0.040	472.78	0.040
Air Sealing (Natural Gas Heat with Central AC)	62.85	0.023	62.85	0.023

As shown in the table, there are no differences between *ex ante* and *ex post* savings for air sealing.

Refrigerator Replacement

Algorithms and Variable Assumptions

The evaluation team used two equations from the Indiana TRM (v2.2) to calculate *ex post,* per-measure energy savings and demand reduction for low-income, early refrigerator replacement.

$$kWh\ savings = UEC_{exist} - UEC_{efficient}$$

$$kW\ reduction = \frac{\Delta kWh}{8{,}760} * TAF * (LSAFexist - LSAFefficient)$$

Where:

UEC_{exist} = Unit energy consumption of existing refrigerator

$UEC_{efficient}$ = Unit energy consumption of new ENERGY STAR refrigerator

TAF = Temperature adjustment factor

$LSAF_{exist}$ = Load shape adjustment factor for existing refrigerator

$LSAF_{efficient}$ = Load shape adjustment factor of new ENERGY STAR refrigerator

Table G-25 summarizes *ex post* assumptions and sources for the refrigerator replacement measure.

Table G-25. 2020 IQW Program *Ex Post* Variable Assumptions for Refrigerator Replacement

Variable	Value	Source
Unit energy consumption of existing refrigerator (UEC_{exist})	1,696	Indiana TRM (v2.2)
Unit energy consumption of new refrigerator ($UEC_{efficient}$)	397	Indiana TRM (v2.2)
Temperature adjustment factor (TAF)	1.21	Indiana TRM (v2.2)
Load shape adjustment factor for existing refrigerator ($LSAF_{exist}$)	1.06	Indiana TRM (v2.2)
Load shape adjustment factor for new refrigerator ($LSAF_{efficient}$)	1.124	Indiana TRM (v2.2)

Savings Summary for Refrigerator Replacement

Table G-26 shows *ex ante* deemed savings and resulting *ex post,* per-measure savings for refrigerator replacements.

Table G-26. 2020 IQW Program *Ex Ante* and *Ex Post* Per-Measure Savings for Refrigerator Replacement

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Refrigerator Replacement	1,299.00	0.187	1,299.00	0.187

As shown in the table, there are no differences between *ex ante* and *ex post* savings for refrigerator replacement.

LED Night-Lights

Algorithms and Variable Assumptions

The evaluation team used an equation from the Indiana TRM (v2.2) to calculate *ex post,* per-measure energy savings and demand reduction for LED night-lights provided in the kits.

$$kWh\ savings = \frac{\left(W_{base} - W_{Night-light}\right) * (AOH)}{1{,}000}$$

Where:

W_{base} = Baseline wattage of existing night-light replaced with LED night-light (= 5 watts)

$W_{Night\text{-}Light}$ = Actual wattage of installed LED night-light (= 0.5 watts)

AOH = Average number of hours per year the night-light remains in use

Table G-27 summarizes *ex post* assumptions and sources for LED night-lights.

Table G-27. 2020 IQW Program *Ex Post* Variable Assumptions for LED Night-Lights

Variable	Value	Source
Baseline wattage (W_{base})	5	Indiana TRM (v2.2)
LED night-light wattage ($W_{Night\text{-}light}$)	0.33	Indiana TRM (v2.2)
Hours of use per year for night-light (AOH)	2,920	Indiana TRM (v2.2)

Savings Summary for LED Night-Lights

Table G-28 shows *ex ante* deemed savings and resulting *ex post,* per-measure savings for LED night-lights.

Table G-28. 2020 IQW Program *Ex Ante* and *Ex Post* Per-Measure Savings for LED Night-Lights

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
LED Night-Lights	13.64	0	13.64	0

As shown in the table, there are no differences between *ex ante* and *ex post* savings for night-lights.

Filter Whistle

Algorithms and Variable Assumptions

The evaluation team used four equations from the 2016 Pennsylvania TRM to calculate the *ex post,* per-measure energy savings and demand reduction for filter whistles:

$$kWh\ savings_{Filter\ Whistle} = \Delta \text{kWh}/yr\ savings_{\ heat} + \Delta \text{kWh}/yr\ savings_{\ cool}$$

$$kWh/yr\ savings_{heat} = \text{kW}_{motor} * FLH_{heat} * EI * ISR$$

$$kWh/yr\ savings_{cool} = \text{kW}_{motor} * FLH_{cool} * EI * ISR$$

$$kW\ reduction_{Filter\ Whistle} = \frac{kWh/yr\ savings_{cool}}{FLH_{cool}} * \text{CF}$$

Where:

kW_{motor}	=	Average motor full load electric demand
FLH_{heat}	=	Full-load heating hours
EI	=	Efficiency improvement
ISR	=	In-service rate
FLH_{cool}	=	Full-load cooling hours
CF	=	Coincidence factor

Table G-29 summarizes *ex post* assumptions and sources for filter whistles.

Table G-29. 2020 IQW Program *Ex Post* Variable Assumptions for Filter Whistles

Variable	Value	Source
Average motor full load electric demand (kW_{motor})	0.5	2016 Pennsylvania TRM
Full-load heating hours (FLH_{heat})	1,341	Indiana TRM (v2.2) for Indianapolis
Efficiency improvement (EI)	0.15	2016 Pennsylvania TRM
In-service rate (ISR)	1	Assumed for analysis
Full-load cooling hours (FLH_{cool})	487	Indiana TRM (v2.2) for Indianapolis
Coincidence factor (CF)	0.647	2016 Pennsylvania TRM

Home heating and cooling types are not tracked for kit recipients, so the evaluation team used the weighting factors shown in Table G-30 for HVAC system type to assign filter whistle savings across kit recipients.

Table G-30. 2020 IQW Program *Ex Post* HVAC Assumptions for Filter Whistles

Variable	Value	Source
Percentage of homes with natural gas heat + central AC	63%	Indiana TRM (v2.2)
Percentage of homes with electric heat + Central AC	18%	Indiana TRM (v2.2)
Percentage of homes with electric heat only	2%	Indiana TRM (v2.2)
Percentage of homes with natural gas heat only	13%	Indiana TRM (v2.2)

Savings Summary for Filter Whistles

Table G-31 shows *ex ante* deemed savings and resulting *ex post,* per-measure savings for filter whistles provided in the kits.

Table G-31. 2020 IQW Program *Ex Ante* and *Ex Post* Per-Measure Savings for Filter Whistles

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Filter Whistle – electric heating and central AC	137.10	0.049	137.10	0.049
Filter Whistle – central AC	137.10	0.049	36.53	0.049
Filter Whistle – electric heating only	137.10	0.049	100.58	0.000
Filter Whistle – gas heating only	137.10	0.049	0.00	0.000

The differences between *ex ante* and *ex post* savings for filter whistles are due to assumptions about HVAC system type. The evaluation team applied the Indiana TRM (v2.2) distribution of HVAC system types across the kit participants to assume system type and assigned the energy savings and demand reduction based on system type.

Audit Recommendations

Algorithms and Variable Assumptions

The evaluation team applied an *ex post* audit recommendation value from the 2014 *Energizing Indiana Statewide Core Program Report*, consistent with CLEAResult's approach.

Savings Summary for Audit Recommendations

Table G-32 shows a comparison of *ex ante* and *ex post,* per-measure savings for the audit recommendations.

Table G-32. 2020 IQW Program *Ex Ante* and *Ex Post* Per-Measure Savings for Audit Recommendations

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Audit Recommendations	75.70	0	75.70	0

As shown in the table, there are no differences between *ex ante* and *ex post* savings for audit recommendations.

As the evaluation team did not conduct survey customers in 2019 or 2020 regarding audit upgrades, we recommend that future assessments include a follow-up survey with program participants to determine the number who are implementing one or more audit recommendations. The team will leverage such survey results with a per-measure Indiana TRM (v2.2) evaluation to inform and estimate savings that more closely reflect real results from implementing audit measures.

Appendix H. Lighting and Appliances Program Measures, Assumptions, and Algorithms

This appendix contains the algorithms and assumptions for calculating energy savings and demand reduction for measures offered through the Lighting and Appliances program—LED lighting, smart thermostats, dehumidifiers, air purifiers, smart power strips, clothes washers and dryers, pool pumps, ceiling fans, refrigerators, room ACs, and televisions. The evaluation team compared each assumption used in the savings algorithms against the Indiana TRM (v2.2), as well as to other state and industry approaches.

LED Lighting

The evaluation team used two equations to calculate energy savings and demand reduction for LEDs:

$$\Delta kWh = \frac{(W_{base} - W_{LED})}{1{,}000} * AOH * (1 + WHF_e) * ISR$$

$$\Delta kW = \frac{(W_{base} - W_{LED})}{1{,}000} * CF * (1 + WHF_d) * ISR$$

Where:

W_{base}	=	Weighted average wattage of bulb being replaced
W_{LED}	=	Wattage of LED bulb
1,000	=	Constant to convert watts to kilowatts
AOH	=	Average hours of use per year
WHF_e	=	Waste heat factor for energy to account for HVAC interactions with lighting (value depends on location)
ISR	=	In-service rate, lifetime NPV
CF	=	Summer peak coincidence factor
WHF_d	=	Waste heat factor for demand to account for HVAC interactions with lighting (value depends on location)

Table H-1 lists the input assumptions and sources for the LEDs measure savings calculations.

Table H-1. 2020 Lighting and Appliance Program *Ex Post* Variable Assumptions for LEDs

Input	Value	Source
W_{base}	Varies	ENERGY STAR lumens bins
W_{LED}	Varies	2020 tracking data
AOH	902	Indiana TRM (v2.2)
WHF_e	-0.061	Indiana TRM (v2.2), Indianapolis values
ISR	First Year, all lamps: 86% General service: 92% Reflector/specialty: 96%	2014 Indiana Market Effects Study, augmented using UMP
CF	0.11	Indiana TRM (v2.2)
WHF_d	0.055	Indiana TRM (v2.2), Indianapolis values

Baseline Wattages for Non–PAR, MR, and MRX Lamp Types

Table H-2 shows the distribution of baseline wattages the team applied using the lumen equivalence method. This approach is specified in the UMP and uses the ENERGY STAR online database to calculate final baseline wattages for all program LEDs except certain PAR, MR, and MRX lamp types (depending on their stated lumen output).

Table H-2. Baseline Wattages for 2020 Lighting and Appliance Program Qualifying LED Lamps by Lumens and Shape

Lamp Shape	Lumen Range		
	Lower	Upper	$Watts_{base}$
Omnidirectional, Medium Screw-Base Lamps (A, BT, P, PS, S or T) See exceptions in gray rows below	250	309	25
	310	749	29
	750	1,049	43
	1,050	1,489	53
	1,490	2,600	72
	2,601	3,300	150
	3,301	3,999	200
	4,000	6,000	300
S Shape ≤749 lumens and T Shape ≤749 lumens or T Shape >10-inches long	250	309	25
	310	749	40
Decorative, Medium Screw-Base Lamps (G) See exceptions in gray rows below	250	309	25
	310	749	29
	750	1,049	43
	1,050	1,300	53
G16-1/2, G25, and G30 ≤499 lumens	250	309	25
	310	349	25
	350	499	40
G Shape with diameter ≥5 inches	250	349	25
	350	499	40
	500	574	60
	575	649	75
	650	1,099	100

Lamp Shape	Lumen Range		
	Lower	Upper	$Watts_{base}$
	1,100	1,300	150
Decorative, Medium Screw-Base Lamps (B, BA, C, CA, DC, F, and ST) See exceptions in gray rows below	70	89	10
	90	149	15
	150	299	25
	300	309	40
	310	499	29
	500	699	29
B, BA, CA, and F ≤499 lumens	70	89	10
	90	149	15
	150	299	25
	300	309	40
	310	499	40
Omnidirectional, Intermediate Screw-Base Lamps (A, BT, P, PS, S or T) See exceptions in gray rows below	250	309	25
	310	749	40
S Shape with a first number ≤12.5 and T Shape with a first number ≤8 and nominal overall length <12 inches	250	309	25
	310	749	40
Decorative, Intermediate Screw-Base Lamps (G) See exceptions in gray rows below	250	309	25
	310	349	25
	350	499	40
G Shape with a first number ≤12.5 or diameter ≥5 inches	250	349	25
	350	499	40
Decorative, Intermediate Screw-Base Lamps (B, BA, C, CA, DC, F, and ST)	70	89	10
	90	149	15
	150	299	25
	300	309	40
	310	499	40
Omnidirectional, Candelabra Screw-Base Lamps (A, BT, P, PS, S, and T) See exceptions in gray rows below	250	309	25
	310	749	40
	750	1,049	60
S Shape with a first number ≤12.5 and T Shape with a first number ≤8 and nominal overall length <12 inches	250	309	25
	310	749	40
	750	1,049	60
Decorative, Candelabra Screw-Base Lamps (G) See exceptions in gray rows below	250	309	25
	310	349	25
	350	499	40
	500	574	60
G Shape with a first number ≤12.5 or diameter ≥5 inches	250	349	25
	350	499	40
	500	574	60
Decorative, Candelabra Screw-Base Lamps (B, BA, C, CA, DC, F, and ST)	70	89	10
	90	149	15
	150	299	25
	300	309	40
	310	499	40

Lamp Shape	Lumen Range Lower	Lumen Range Upper	$Watts_{base}$
	500	699	60
Directional, Medium Screw-Base Lamps with Diameter ≤2.25 Inches	400	449	40
	450	499	45
	500	649	50
	650	1,199	65
Directional, Medium Screw-Base Lamps (R, ER, BR, BPAR, and similar bulb shapes with diameter >2.5 inches) See exceptions in gray rows below	640	739	40
	740	849	45
	850	1,179	50
	1,180	1,419	65
	1,420	1,789	75
	1,790	2,049	90
	2,050	2,579	100
	2,580	3,300	120
	3,301	3,429	120
	3,430	4,270	150
Directional, Medium Screw-Base Lamps (R, ER, BR, BPAR, and similar bulb shapes with medium screw bases and diameter >2.26 inches and ≤2.5 inches See exceptions in gray rows below	540	629	40
	630	719	45
	720	999	50
	1,000	1,199	65
	1,200	1,519	75
	1,520	1,729	90
	1,730	2,189	100
	2,190	2,899	120
	2,900	3,300	120
	3,301	3,850	150
ER30, BR30, BR40, or ER40	400	449	40
	450	499	45
	500	649 to 1,179	50
BR30, BR40, or ER40	650	1419	65
R20	400	449	40
	450	719	45
All reflector lamps below lumen ranges specified above	200	299	20
	300	399 to 639	30
Rough Service, Shatter Resistant, 3-Way Incandescent, and Vibration	250	309	25
	310	749	40
	750	1,049	60
	1,050	1,489	75
	1,490	2,600	100
	2,601	3,300	150
	3,301	3,999	200
	4,000	6,000	300

Baseline Wattages for PAR, MR, and MRX Lamp Types

For highly focused directional lamps, center beam candle power and beam angle measurements are needed to accurately estimate the equivalent baseline wattage. The evaluation team used a $Watts_{Base}$ algorithm based on the ENERGY STAR Center Beam Candle Power tool:[72]

$$Watts_{Base} = 375.1 - 4.355(D) - \sqrt{227{,}800 - 937.9(D) - 0.9903(D^2) - 1{,}479(BA) - 12.02(D * BA) + 14.69(BA^2) - 16{,}720 * \ln(CBCP)}$$

Where:

D	=	Bulb diameter (= 20 for PAR20 D)
BA	=	Beam angle
CBCP	=	Center beam candle power

The team rounded down the result of the equation above to the nearest wattage established by ENERGY STAR, presented in Table H-3.

Table H-3. Baseline Wattages for 2020 Lighting and Appliance Program Qualifying LED PAR, MR, and MRX Lamps

Lamp Diameter	Permitted Wattages
16	20, 35, 40, 45, 50, 60, 75
20	50
30S	40, 45, 50, 60, 75
30L	50, 75
38	40, 45, 50, 55, 60, 65, 75, 85, 90, 100, 120, 150, 250

If center beam candle power and beam angle information were not available or if the equation returned a negative (or undefined) value, the evaluated team used the manufacturer's recommended baseline wattage equivalent.

First Year, Lifetime, and Net Present Value In-Service Rates

The evaluation team relied on the UMP to calculate lifetime ISRs through 2023 to account for future installations of bulbs in storage. The methodology assumes that 24% of all bulbs in storage will be installed in each subsequent year after purchase. To account for the time sensitivity of these added savings, which stem from increased ISRs but take place after 2020, we discounted the lifetime ISR by 10% annually to achieve NPV lifetime ISRs for each LED. Table H-4 shows a comparison of first-year and lifetime ISRs for upstream lighting, revealing how marginal increases to first-year ISRs using the UMP methodology result in the NPV lifetime ISRs used in measure impact calculations.

72 The ENERGY STAR Center Beam Candle Power tool does not accurately model baseline wattages for lamps with certain bulb characteristic combinations, specifically for lamps with very high center beam candle power (http://www.energystar.gov/ia/products/lighting/iledl/IntLampCenterBeamTool.zip).

Table H-4. First-Year and Lifetime In-Service Rate Calculations for 2020 Lighting and Appliance Program

Measure	First-Year ISR	2021	2022	2023	2024	Lifetime ISR	NPV ISR
General Service LED	86%	3%	2%	2%	N/A [a]	97%	92%
Specialty/Reflector LED	86%	3%	2%	2%	2%	97%	96%

Note: Table percentages are rounded.

[a] The evaluation team did not anticipate for general service lamps to have gross savings post-EISA 2020 implementation; however, rule changes under the Trump administration delayed that implementation beyond 2020. The evaluation team now assumes that these lamps will become baseline around 2023. As such, we capped the final NPV lifetime ISR at 92%.

Waste Heat Factors

The evaluation team applied Indiana TRM (v2.2) WHFs for Indianapolis to each program lamp (these values are shown in Table H-5).

Table H-5. Indiana TRM (v2.2) Waste Heat Factors by City for 2020 Lighting and Appliance Program

HVAC Type	Waste Heat Factors		Distribution
	Energy	Demand	
Indianapolis	***-0.061***	***0.055***	***-0.0018***
South Bend	-0.070	0.038	-0.0019
Evansville	-0.034	0.092	-0.0017
Ft Wayne	-0.082	0.038	-0.0019
Terre Haute	-0.048	0.061	-0.0018
Statewide	**-0.059**	**0.057**	**-0.0018**

Smart Thermostats

The evaluation team applied two Indiana TRM (v2.2) equations to calculate energy savings for smart thermostats:

$$\Delta kWh = 1/SEER * EFLH_{COOL} * Btuh_{COOL}/1{,}000 * ESF_{COOL}$$

$$\Delta kWh = EFLH_{HEAT} * Btuh_{HEAT}/\eta_{HEAT} * 3{,}412 * ESF_{HEAT}$$

Where:

SEER	=	Seasonal average energy efficiency ratio (Btu/watt-hour; = actual, 10 for equipment installed before 2006, 11.15 for equipment installed after 2006)
$EFLH_{COOL}$	=	Equivalent full-load cooling hours (= 487 for Indianapolis)
$Btuh_{COOL}$	=	Cooling system capacity in Btu per hour (= actual; otherwise assume 28,994 Btuh)
1,000	=	Conversion from watts to kilowatt-hours
ESF_{COOL}	=	Cooling energy-savings fraction (= 0.139; Cadmus 2015)
$EFLH_{HEAT}$	=	Equivalent full-load heating hours (= 1,341 for Indianapolis)

$Btuh_{HEAT}$ = Heating system capacity in Btu per hour (= actual; otherwise assume 77,386 Btuh)

η_{HEAT} = Efficiency in coefficient of performance of heating equipment (= actual, 2.00 for heat pump equipment installed before 2006, 2.26 for heat pump equipment installed after 2006, 1.00 for resistance heat)

3,412 = Conversion from Btuh to kilowatts

ESF_{HEAT} = Heating energy-savings fraction (= 0.125; Cadmus 2015)

The evaluation team found that savings appeared overestimated for smart thermostats replacing manual thermostats. Reported savings appeared to be using 429 kWh based on the Cadmus 2015 report. In the absence of detailed information on the homes and HVAC systems in which smart thermostats were installed, we calculated smart thermostat savings using the equation below:

$$Annual\ kWh\ savings = ISR * \Delta kWh * \frac{Indianapolis\ EFLH_{COOL}}{Evansville\ EFLH_{COOL}}$$

The evaluation team calculated savings using inputs from the Indiana TRM (v2.2). The Cadmus 2015 report listed electric savings of 429 kWh for smart thermostats; however, the evaluation team adjusted savings to reflect the cooling needs of Indianapolis customers using the Indiana TRM (v2.2) ratio of full-load cooling hours for Indianapolis (as opposed to Evansville, where units were metered for the Cadmus 2015 study). The values determined by the evaluation team are shown in Table H-6.

Table H-6. 2020 Lighting and Appliance Program Smart Thermostat Savings Inputs

Input	Assumption	Source
ΔkWh	429	Cadmus 2015 report (single-family findings)
Indianapolis $EFLH_{COOL}$	487	Indiana TRM (v2.2)
Evansville $EFLH_{COOL}$	600	Indiana TRM (v2.2)

Where the tracking data indicated that a programmable thermostat was replaced, IPL claimed a more conservative 146 kWh. The evaluation team accepted this number as *ex post*.

To cite page 123 of the Indiana TRM (v2.2), which aligns with the Illinois TRM (v8), "There is no expected peak demand reduction associated with this measure."

Dehumidifiers

The evaluation team applied two equations from the Indiana TRM (v2.2) to calculate energy savings and demand reduction for dehumidifiers:

$$\Delta kWh = C * 0.473 / 24 * \text{Hours} / L/kWh$$

$$\Delta kW = \Delta kWh / \text{Hours} * \text{CF}$$

Where:

C = Average capacity of dehumidifier in pints per day

0.473 = Constant to convert pints to liters

24	=	Hours in a day
Hours	=	Run hours per year (= 1,620)[73]
L/kWh	=	Liters of water consumed per kilowatt-hour
CF	=	Summer peak coincidence factor (= 0.37)[74]

The evaluation team accepted IPL's *ex ante* claim of 269.6 kWh and 0.0618 kW per unit as appropriate for *ex post* savings based the Indiana TRM (v2.2) values shown in Table H-7 and Table H-8.

Table H-7. 2020 Lighting and Appliance Program Annual Dehumidifier Savings by Capacity

Capacity Range	Pints Used Per Day	ENERGY STAR	Federal Standard	Savings (kWh)
≤25	22.4	596	650	54
>25 to ≤35	30	684	798	114
>35 to ≤45	40	851	1,064	213
>45 to ≤54	49.5	988	1,285	297
>54 to ≤75	64.5	1,144	1,329	185
>75 to ≤185	92.8	1,185	1559	374

Table H-8. 2020 Lighting and Appliance Program Summer Peak Coincident Demand Reduction by Capacity

Capacity Range	Pints Used Per Day	ENERGY STAR	Federal Standard	Savings (kWh)
≤25	22.4	0.136	0.148	0.012
>25 to ≤35	30	0.156	0.182	0.027
>35 to ≤45	40	0.194	0.242	0.048
>45 to ≤54	49.5	0.225	0.293	0.068
>54 to ≤75	64.5	0.261	0.303	0.042
>75 to ≤185	92.8	0.270	0.355	0.085

Air Purifiers

The Indiana TRM (v2.2) does not have an entry for air purifiers. Therefore, the evaluation team relied on two equations from the Illinois TRM (v8) to determine deemed energy savings values for air purifiers based on clean air deliver rate:

$$\Delta kWh = kWh_{base} - kWh_{ESTAR}$$

$$\Delta kW = \Delta kWh \ / \ Hours * CF$$

[73] "ENERGY STAR Dehumidifier Calculator." https://www.energystar.gov/ia/partners/promotions/cool_change/downloads/CalculatorConsumerDehumidifier.xls

[74] This value is based on usage being evenly distributed day versus night and weekend versus weekday, and dehumidifiers being used from April through September (for 4,392 possible hours). The ENERGY STAR Dehumidifier Calculator lists 1,620 operating hours, therefore the summer peak coincidence is 36.9% (1,620 / 4,392).

Where:

kWh_{base} = Baseline kilowatt-hour consumption per year[75]

kWh_{ESTAR} = Constant to convert pints to liters

Hours = Run hours per year (= 5,844)[76]

CF = Summer peak coincidence factor (= 0.667)[77]

The evaluation team accepted IPL's *ex ante* claim of 568.2 kWh and 0.0813 kW per unit as appropriate for *ex post* savings based the Illinois TRM (v8) values shown in Table H-9 and Table H-10. Most units had a clean air delivery rate between of 101 and 200.

Table H-9. 2020 Lighting and Appliance Program Annual Air Purifier Energy Savings by Clean Air Delivery Rate

Clean Air Delivery Rate		Unit Energy Consumption (kWh/year)		ΔkWh
Range	Used in Calculation (midpoint)	Baseline	ENERGY STAR	
51-100	75	441	148	293
101-150	**125**	**733**	**245**	**488**
151-200	**175**	**1,025**	**342**	**683**
201-250	225	1,317	440	877
Over 250	300	1,755	586	1,169

Table H-10. 2020 Lighting and Appliance Program Annual Air Purifier Demand Reduction by Clean Air Delivery Rate

Clean Air Delivery Rate	ΔkW
51-100	0.033
101-150	**0.056**
151-200	**0.078**
201-250	0.100
Over 250	0.133

75 "ENERGY STAR Qualified Room Air Cleaner Calculator." https://www.sfwmd.gov/sites/default/files/documents/calculator_energy_star_res_appliance_savings.xlsx

76 This value is consistent with the ENERGY STAR Qualified Room Air Cleaner Calculator assumption of 16 hours per day (16 * 365.25 = 5,844).

77 This value assumes that the purifier usage is evenly spread throughout the year; therefore, coincident peak is calculated as 66.7% (5,844 / 8,766).

Smart Power Strips

While the Indiana TRM (v2.2) has a section for smart power strips, the evaluation team chose to use two equations from the Illinois TRM (v8) because it includes Tier 2 smart power strips, which are specifically designed for residential audio-visual applications. The Illinois TRM (v8) also provides deemed energy-savings values based on several energy reduction percentage ranges:

$$\Delta kWh = ERP * BaselineEnergy_{AV} * ISR$$

$$\Delta kW = \Delta kWh / Hours * CF$$

Where:

ERP	=	Energy reduction percentage of qualifying Tier 2 audio-visual smart power strip product range (as provided in Table H-11 and Table H-12)
$BaselineEnergy_{AV}$	=	Baseline energy usage (= 432 kWh)[78]
ISR	=	In-service rate (= 100% based on surveys)
Hours	=	Annual number of hours during which smart power strips provide savings (= 4,380)[79]
CF	=	Summer peak coincidence factor (= 0.8)[80]

The evaluation team accepted IPL's *ex ante* claim of 150 kWh and 0.027 kW per unit as appropriate for *ex post* savings based on similarity to the Illinois TRM (v8) values shown in Table H-11 and Table H-12, which indicate an assumed Class E power strip scenario.

78 Alternative Energy Systems Consulting (AESC, Inc.). "Energy Savings of Tier 2 Advanced Power Strips in Residential AV Systems." p. 28.
This load represents the average of controlled audio-visual devices only and will likely be lower than total audio-visual usage.

79 This estimate is based on the assumption that approximately half of savings are during active hours (supported by the AESC study), assumed to be 5.3 hours per day, for 1,936 hours per year (New York State Energy Research and Development Authority. 2011. *Advanced Power Strip Research Report.*), and half of savings are during standby hours (8,760 - 1,936 = 6,824 hours). The weighted average is 4,380 hours.

80 In the absence of empirical evaluation data, the team based this value on assumptions of the typical run pattern for televisions and computers in homes. This appears to be supported by the "Average Weekday AV Demand Profile and Reduction" charts in the AESC study (pages 33 and 34), which show that average demand reduction is relatively flat across the year.

Table H-11. 2020 Lighting and Appliance Program Smart Power Strip Energy Savings by Product Class

Product Class	Field Trial Energy Reduction Percentage Range	Energy Reduction Percentage Used	Baseline Energy Usage (kWh)
A	55% to 60%	55%	238
B	50% to 54%	50%	216
C	45% to 49%	45%	194
D	40% to 44%	40%	173
E	**35% to 39%**	**35%**	**151**
F	30% to 34%	30%	130
G	25% to 29%	25%	108
H	20% to 24%	20%	86

Table H-12. 2020 Lighting and Appliance Program Smart Power Strip Demand Reduction by Product Class

Product Class	Energy Reduction Percentage Used	ΔkW
A	55%	0.043
B	50%	0.039
C	45%	0.035
D	40%	0.032
E	**35%**	**0.028**
F	30%	0.024
G	25%	0.020
H	20%	0.016

Clothes Washers

The Indiana TRM (v2.2) provides the deemed savings values for clothes washers shown in Table H-13. Clothes washers in the tracking data are consistent with the ENERGY STAR product class that saves 202 kWh and 0.028 kW per unit. The evaluation team accepted IPL's *ex ante* claims as appropriate for *ex post* savings.

Table H-13. Clothes Washer Deemed Measure Savings

Product Class	Average Annual Savings Per Unit (kWh)	Average Summer Peak Coincident Savings Per Unit (kW)
ENERGY STAR	202	0.028
CEE Tier 2	233	0.033

Clothes Dryers

The Indiana TRM (v2.2) does not have an entry for clothes dryers. Therefore, the evaluation team relied on savings from the Illinois TRM (v8) to determine if *ex ante* savings were appropriate. Clothes dryers in the tracking data are consistent with the example calculations in the Illinois TRM (v8) for a standard, vented, electric clothes dryer that saves 160 kWh and 0.0215 kW. The evaluation team accepted IPL's *ex ante* claims as appropriate for *ex post* savings.

Pool Pumps

The Indiana TRM (v2.2) provides the deemed savings values for pool pumps shown in Table H-14. Pool pumps in the tracking data are consistent with either the two-speed or variable speed deemed savings values; however, all pool pumps in the tracking data are labeled as two speed. Where the tracking data indicated a two-speed pool pump, the evaluation team accepted IPL's *ex ante* claims as appropriate for *ex post* savings. For two-speed units in the tracking data that report savings for variable speed units, the evaluation team adjusted *ex post* savings to the two-speed level.

Table H-14. Pool Pump Deemed Measure Savings

Product Class	Average Annual Savings Per Unit (kWh)	Average Summer Peak Coincident Savings Per Unit (kW)
Two-Speed	436	1.113
Variable Speed	1,137	1.716

Ceiling Fans

The Indiana TRM (v2.2) provides the deemed savings values for ceiling fans shown in Table H-15. Ceiling fans in the tracking data reported savings of 82 kWh and 0.156 kW. These values are similar enough to the Indiana TRM (v2.2) deemed savings numbers that the evaluation team accepted IPL's *ex ante* claims as appropriate for *ex post* savings.

Table H-15. Ceiling Fan Deemed Measure Savings

Product Class	Average Annual Savings Per Unit (kWh)	Average Summer Peak Coincident Savings Per Unit (kW)
Ceiling Fan with Light Fixture	108	0.013

Refrigerators

The Indiana TRM (v2.2) provides the deemed savings values for ENERGY STAR refrigerators shown in Table H-16. Refrigerators in the tracking data reported savings of 130 kWh and 0.020 kW. These values are consistent with the Indiana TRM (v2.2) deemed savings numbers for bottom freezer units, so the evaluation team accepted IPL's *ex ante* claims as appropriate for *ex post* savings.

Table H-16. Refrigerator Deemed Measure Savings

Product Class	Average Annual Savings Per Unit (kWh)	Average Summer Peak Coincident Savings Per Unit (kW)
Bottom Freezer	130	0.020
Top Freezer	83	0.013
Side-by-Side	146	0.023

Room Air Conditioners

The Indiana TRM (v2.2) provides the deemed savings values for room ACs shown in Table H-17. Room ACs in the tracking data reported savings of 227 kWh and 0.205 kW. These values are consistent with the Indiana TRM (v2.2) deemed savings numbers for early retirement. The evaluation team applied the deemed time of sale values of 12 kWh and 0.011 kW to determine *ex post* savings.

Table H-17. Room Air Conditioner Deemed Measure Savings

Product Class	Average Annual Savings Per Unit (kWh)	Average Summer Peak Coincident Savings Per Unit (kW)
Time of Sale	12	0.011
Early Retirement	227	0.205

Televisions

Neither the Indiana TRM (v2.2) nor the Illinois TRM (v8) have an entry for televisions. The evaluation team referenced the Mid-Atlantic TRM (v10),[81] which shows that savings can reach up to 158 kWh and 0.002 kW for televisions that are 65 inches or larger. Since the 146 kWh and 0.002 kW claimed in the tracking data are similar, the evaluation team accepted IPL's *ex ante* claims as appropriate for *ex post* savings.

81 Shelter Analytics. March 2020. *Maryland/Mid-Atlantic Technical Reference Manual Version 10*. https://neep.org/sites/default/files/media-files/trmv10.pdf

Appendix I. Multifamily Direct Install Program Measures, Assumptions, and Algorithms

This appendix presents information—including algorithms, variable assumptions and sources, and differences between *ex ante* and *ex post* per-measure savings—for several MFDI measures:

- LEDs (9-watt, 16-watt, 5-watt globe, 5-watt candelabra, 9-watt exterior, and R30)
- Bathroom and kitchen aerators
- Low-flow showerheads
- Pipe wrap insulation
- Water heater setbacks
- Programmable thermostats
- Smart strips
- Duct sealing
- Air sealing
- LED night-lights
- Filter whistles

Unless otherwise specified, these algorithms, variable assumptions, and measure savings apply to direct install and energy-savings kit measures installed in both multifamily and manufactured homes. For measures where CLEAResult claimed 2019 installation numbers in the 2020 evaluation, the 2019 and 2020 per-measure *ex ante* savings are presented.

LEDs

Algorithms and Variable Assumptions

The evaluation team used equations from the Indiana TRM (v2.2) to calculate *ex post* per-measure energy savings and demand reduction for LEDs:

$$kWh\ savings = \frac{(W_{base} - W_{LED}) * (Hrs/day * 365) * \ (1 + WHFe)}{1{,}000}$$

$$kW\ reduction = \frac{(W_{base} - W_{LED}) * \ CF * \ (1 + WHFd)}{1{,}000}$$

Where:

W_{base} = Baseline wattage of existing bulb being replaced with LED (= varies by measure; see Table I-1)

Table I-1. 2020 MFDI Program LED Baseline Wattages

Measure	*Ex Ante*		*Ex Post*
	2019	2020	
9-Watt LED	30.42	20.00	43.00
16-Watt LED	54.56	46.00	65.00
5-Watt Globe LED	40.00	20.00	40.00
5-Watt Candelabra LED	40.00	9.00	40.00
9-Watt Exterior LED	30.42	20.00	43.00
R30 LED	65.00	24.00	65.00

W_{LED} = Actual installed LED wattage

Hrs/day = Average number of hours per day the light is in use

WHF_e = Waste heat factor for energy use; this accounts for the effects of more efficient lighting on cooling energy use

CF = Coincidence factor; a number between 0 and 1 indicating the ratio of LEDs expected to be in use and saving energy during the peak summer demand period

WHF_d = Waste heat factor for demand; this accounts for the effects of more efficient lighting on cooling energy demand

Table I-2 summarizes the *ex post* assumptions and source for the installed LEDs.

Table I-2. 2020 MFDI Program *Ex Post* Variable Assumptions for LEDs

Variable	Value	Source
Baseline Wattage (W_{base})	As shown in Table I-1	Lumens compared with ENERGY STAR and EISA halogen baseline equivalent wattages applied
LED Wattage (W_{LED})	As shown in Table I-1	Wattages of installed LED
Hours per Day (Hrs/day, interior lights)	902	Indiana TRM (v2.2)
Hours per Day (Hrs/day, 9-watt exterior)	1,607	Indiana TRM (v2.2)
Hours per Day (Hrs/day, interior lights)	902 for direct install 1,135 for kits	Indiana TRM (v2.2)
Weighted Average Waste Heat Factor for Energy (WHFe)	-0.061 for interior 0 for exterior	Indiana TRM (v2.2) for Indianapolis
Coincidence factor (CF)	0.11	Indiana TRM (v2.2)
Weighted Average Waste Heat Factor for Demand (WHFd)	0.055 for interior 0 for exterior	Indiana TRM (v2.2) for Indianapolis

Savings Summary for LEDs

Table I-3 shows the *ex ante* savings and the resulting *ex post* per-measure savings for LEDs.

Table I-3. 2020 MFDI Program *Ex Ante* and *Ex Post* Per-Measure Savings for LEDs

Measure	*Ex Ante* Savings				*Ex Post* Savings	
	2019		2020			
	kWh	kW	kWh	kW	kWh	kW
Direct Install						
9-Watt LED	18.14	0.002	8.57	0.001	28.80	0.004
16-Watt LED	32.66	0.004	23.38	0.003	41.50	0.006
5-Watt Globe LED	18.13	0.004	12.60	0.002	29.64	0.004
5-Watt Candelabra LED	18.39	0.004	4.72	0.001	29.64	0.004
9-Watt Exterior LED	-	-	16.26	-	54.64	0.000
R30 LED	-	-	12.60	0.002	46.58	0.006
Kits						
9-Watt LED [a]	-	-	8.19	0.001	36.24	0.004
11-Watt LED	N/A	N/A	12.67	0.002	44.76	0.005
16-Watt LED	N/A	N/A	22.34	0.003	52.22	0.006

[a] The 2019 ex ante kit savings were not provided by measure type.

The differences between *ex ante* and *ex post* savings are due to differences in baseline wattage calculations for LEDs. To calculate *ex ante* savings, CLEAResult applied the lower baseline wattages for LED bulbs from the post-EISA backstop and included embedded ISRs. The evaluation team did not reduce the baseline wattages because the EISA backstop was not enforced, and we did not include an embedded ISR. Additionally, the 2020 *ex ante* savings calculations include embedded ISRs but the *ex post* savings calculations do not. Lastly, the evaluation team applied 1,135 AOH for kits rather than 902 AOH which the Indiana TRM (v2.2) specifies for direct install.

Bathroom and Kitchen Faucet Aerators

Algorithms and Variable Assumptions

The evaluation team used equations from the Indiana TRM (v2.2) to calculate *ex post* per-measure energy savings and demand reduction for bathroom and kitchen faucet aerators installed in homes with an electric water heater:

$$kWh\ savings_{aerator} = (gpm_{base} - gpm_{low})\ x\ MPD * \frac{PH}{FH} * \text{DRF} * \text{S} * (T_{mix} - T_{Inlet}) * \frac{365}{RE * 3{,}412} * WHS$$

$$kW\ reduction_{aerator} = (gpm_{base} - gpm_{low}) * 60 * \text{DRF} * S * \frac{(T_{mix} - T_{Inlet})}{RE * 3{,}412} * CF * WHS$$

Where:

gpm_{base} = Baseline flow rate of existing faucet in gallons per minute

gpm_{low} = Low-flow rate of aerator in gallons per minute

MPD = Average minutes per day per person of faucet use

PH = Average number of people per household

FH	=	Average number of faucets per household
DRF	=	Drain recovery factor that represents the percentage of water that flows down the drain
S	=	Constant used to convert the weight of water from gallons to pounds (8.3 lbs/gallon)
T_{mix}	=	Temperature of water leaving the aerator (°F)
T_{inlet}	=	Temperature of water entering the water heater (°F)
RE	=	Recovery efficiency of electric water heater in operation
CF	=	Coincidence factor; a number between 0 and 1 indicating the ratio of aerators expected to be in use and saving energy during the peak summer demand period

Table I-4 summarizes the *ex post* assumptions and sources for installed faucet aerators.

Table I-4. 2020 MFDI Program *Ex Post* Variable Assumptions for Faucet Aerators

Variable	Value		Source
	Bathroom	Kitchen	
Baseline Flow Rate (gpm_{base})	1.9	2.44	Indiana TRM (v2.2)
Low-Flow Rate (gpm_{low})	1	1.5	Program data
Minutes per Person per Day (MPD)	1.6	4.5	Indiana TRM (v2.2)
People per Household (PH)	1.83	1.83	Indiana TRM (v2.2)
Faucets per Household (FH)	1.43	1	Indiana TRM (v2.2)
Drain Recovery Factor (DRF)	0.7	0.5	Indiana TRM (v2.2)
Conversion Factor (S)	8.3	8.3	Engineering constant in units of Btu/(gal°F)
Mixed Temperature (T_{mix})	86°F	93°F	Indiana TRM (v2.2)
Inlet Temperature (T_{inlet})	58.1°F	58.1°F	Indiana TRM (v2.2)
Recovery Efficiency (RE)	0.98	0.98	Indiana TRM (v2.2) for Indianapolis
Coincidence Factor (CF)	0.0012	0.0033	Indiana TRM (v2.2)

Savings Summary for Faucet Aerators

Table I-5 shows the *ex ante* deemed savings and the resulting *ex post* per-measure savings for faucet aerators. The team calculated savings for aerators installed through the MFDI program using equipment information and the Indiana TRM (v2.2).

Table I-5. 2020 MFDI Program *Ex Ante* and *Ex Post* Per-Measure Savings for Faucet Aerators

Measure	*Ex Ante* Savings				*Ex Post* Savings	
	2019		2020			
	kWh	kW	kWh	kW	kWh	kW
Bathroom Aerators	30.98	0.003	32.61	0.003	32.61	0.003
Kitchen Aerators	116.26	0.008	122.38	0.008	122.38	0.008

The differences between *ex ante* and *ex post* bathroom aerator savings are due to deemed versus Indiana TRM (v2.2) calculated savings for 2019 installations: CLEAResult cited a deemed savings value while the evaluation team referenced the Indiana TRM (v2.2).

As shown in the table, there are no differences between *ex ante* and *ex post* savings for 2020 bathroom aerators and kitchen aerators.

Low-Flow Showerheads

Algorithms and Variable Assumptions

The evaluation team used equations from the Indiana TRM (v2.2) to calculate *ex post* per-measure energy savings and demand reduction for low-flow showerheads installed in homes with an electric water heater:

$$kWh\ savings_{Showerhead} = (gpm_{base} - gpm_{low}) * \text{MS} * \text{SPD} * \frac{PH}{SH} * S * (T_{mix} - T_{Inlet}) * \frac{365}{RE * 3{,}412} * WHS$$

$$kW\ reduction_{Showerhead} = (gpm_{base} - gpm_{low}) * 60 * S * \frac{(T_{mix} - T_{Inlet})}{RE * 3{,}412} * CF * WHS$$

Where:

gpm_{base}	=	Baseline flow rate of existing showerhead in gallons per minute
gpm_{low}	=	Low-flow rate of showerhead in gallons per minute
MS	=	Average minutes per shower per person per day
SPD	=	Average number of showers per person per day
PH	=	Average number of people per household
SH	=	Average number of showerheads per household
S	=	Constant used to convert the weight of water from gallons to pounds (8.3 lbs/gallon)
T_{mix}	=	Temperature of water leaving the showerhead (°F)
T_{inlet}	=	Temperature of water entering the water heater (°F)
RE	=	Recovery efficiency of electric water heater in operation
CF	=	Coincidence factor; a number between 0 and 1 indicating the ratio of showerheads expected to be in use and saving energy during the peak summer demand period

The low-flow showerhead measure replaces an existing, less efficient showerhead. Table I-6 summarizes the *ex post* assumptions and sources for the installed low-flow showerheads. The team calculated savings using equipment information and the Indiana TRM (v2.2).

Table I-6. 2020 MFDI Program *Ex Post* Variable Assumptions for Low-Flow Showerheads

Variable	Value	Source
Baseline Flow Rate (gpm_{base})	2.63	Indiana TRM (v2.2)
Low-Flow Rate (gpm_{low})	1.5	Program data
Minutes per Shower per Person per Day (MS)	7.8	Indiana TRM (v2.2)
Showers per Person per Day (SPD)	0.6	Indiana TRM (v2.2)
People per Household (PH)	1.83	Indiana TRM (v2.2)
Showerheads per Household (SH)	1.2	Indiana TRM (v2.2)
Conversion Factor (S)	8.3	Engineering constant in units of Btu/(gal°F)
Mixed Temperature (T_{mix})	101°F	Indiana TRM (v2.2)
Inlet Temperature (T_{inlet})	58.1°F	Indiana TRM (v2.2)
Recovery Efficiency (RE)	0.98	Indiana TRM (v2.2)
Coincidence Factor (CF)	0.0023	Indiana TRM (v2.2)

Savings Summary for Low-Flow Showerheads

Table I-7 shows the *ex ante* deemed savings and the resulting *ex post* per-measure savings for low-flow showerheads.

Table I-7. 2020 MFDI Program *Ex Ante* and *Ex Post* Per-Measure Savings for Low-Flow Showerheads

Measure	*Ex Ante* Savings				*Ex Post* Savings	
	2019		2020			
	kWh	kW	kWh	kW	kWh	kW
Low-Flow Showerhead	297.79	0.016	313.46	0.017	313.46	0.017

For the *ex ante* analysis, CLEAResult cited a deemed savings value for the 2019 installations, while the evaluation team referenced the Indiana TRM (v2.2). As shown in the table, there are no differences between *ex ante* and *ex post* savings for 2020 low-flow showerheads.

Pipe Wrap Insulation

Algorithms and Variable Assumptions

The evaluation team used equations from the Indiana TRM (v2.2) to calculate *ex post,* per-measure energy savings and demand reduction for pipe wrap insulation installed in homes with an electric water heater:

$$kWh\ savings_{pipe\ insulation} = \frac{\left(\frac{1}{R_{existing}} - \frac{1}{R_{new}}\right) * L * C * (\Delta T) * Hrs/yr}{3{,}412 * EF_{electric\ WH}}$$

$$kW\ reduction_{pipe\ insulaton} = \frac{kWh\ savings_{pipe\ insulation}}{Hrs/yr}$$

Where:

$R_{existing}$ = R-value of uninsulated hot water pipe

R_{new} = R-value after installing new pipe insulation

L = Total linear feet of installed pipe insulation

C = Circumference of hot water pipe in feet (assumed pipe diameter of 0.5 inches): C = $\pi * pipe\ diameter * 0.083$

ΔT = Difference between ambient temperature where water heater is installed and temperature of distributed hot water

Hrs/yr = Total number of hours per year the water heater remains in operation

$EF_{electric\ WH}$ = Energy factor of the electric water heater in operation

Table I-8 summarizes *ex post* assumptions and sources for installed pipe wrap insulation.

Table I-8. 2020 MFDI Program *Ex Post* Variable Assumptions for Pipe Wrap Insulation

Variable	Value	Source
Existing R-Value ($R_{existing}$)	1	Indiana TRM (v2.2)
Post-Installation R-Value (R_{new})	3	Indiana TRM (v2.2)
Pipe Length (L)	1	Per-foot increments
Circumference (C)	0.19635	Assumes 0.75-inch diameter pipe
Temperature Change (ΔT)	65°F	Indiana TRM (v2.2)
Hours per Year (Hrs/yr)	8,760	Indiana TRM (v2.2)
Energy Factor ($EF_{electric\ WH}$)	0.98	Indiana TRM (v2.2)

Savings Summary for Pipe Wrap Insulation

Table I-9 shows *ex ante* deemed savings and resulting *ex post* savings for pipe wrap insulation, per installed foot.

Table I-9. 2020 MFDI Program *Ex Ante* and *Ex Post* Per-Measure Savings for Pipe Wrap Insulation

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Pipe Wrap Insulation (per foot)	22.29	0.003	22.29	0.003

As shown in the table, there are no differences between *ex ante* and *ex post* savings for pipe wrap insulation.

Water Heater Setbacks

Algorithms and Variable Assumptions

The evaluation team used equations from the Illinois TRM (v7) to calculate *ex post,* per-measure energy savings and demand reduction for water heater setback:

$$kWh\ savings_{WH} = \frac{(U * A * (T_{pre} - T_{post}) * AOU * ISR)}{3{,}412 * RE_{elec}}$$

$$kW\ reduction_{WH} = \Delta kWh / AOH * CF$$

Where:

U	=	Overall heat transfer coefficient of tank (Btu/hr-F-ft^2)
A	=	Surface area of tank in square feet
T_{pre}	=	Hot water setpoint prior to adjustment (°F)
T_{post}	=	Hot water setpoint after adjustment (°F)
AOH	=	Hours per year
ISR	=	In-service rate of electric water heater
RE_{elec}	=	Recovery efficiency of electric water heater
CF	=	Coincidence factor

Table I-10 summarizes *ex post* assumptions and sources for water heater setback savings.

Table I-10. 2020 MFDI Program *Ex Post* Variable Assumptions for Water Heater Setback

Variable	Value	Source
Heat Transfer Coefficient (U)	0.083	Illinois TRM (v7)
Surface Area (A)	24.99	Illinois TRM (v7)
Hot Water Setpoint before Adjustment (T_{pre})	135°F	Illinois TRM (v7)
Hot Water Setpoint after Adjustment (T_{post})	120°F	Illinois TRM (v7)
Hours per Year (AOH)	8,766	Illinois TRM (v7)
In-Service Rate (ISR)	1	Illinois TRM (v7)
Recovery Efficiency of Electric Water Heater (RE_{elec})	0.98	Illinois TRM (v7)
Coincidence Factor (CF)	1	Illinois TRM (v7)

Savings Summary for Water Heater Setback

Table I-11 shows *ex ante* deemed savings and the resulting *ex post* savings for water heater setback.

Table I-11. 2020 MFDI Program *Ex Ante* and *Ex Post* Per-Measure Savings for Water Heater Setback

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Water Heater Setback	100.81	0.012	81.56	0.009

The differences between *ex ante* and *ex post* savings resulted because of using actual versus assumed water heater tank size and outlet temperature prior to setback: The evaluation team did not receive the water heater tank size or heater outlet temperature prior to setback, so instead referenced the Illinois TRM (v7) and assumed a tank size of 50 gallons and an initial water temperature of 135°F.

Programmable Thermostats

Algorithms and Variable Assumptions

The evaluation team used equations from the Indiana TRM (v2.2) to calculate *ex post* per-measure energy savings and demand reduction for programmable thermostats:

$$kWh\ savings_{PStat} = kWh\ savings_{AC\ cooling} + kWh\ savings_{Elec\ htg}$$

$$kWh\ savings_{AC\ cooling} = \frac{1}{n_{cool}} * FLH_{cool} * \frac{BTUh_{cool}}{1{,}000} * ESF_{cool}$$

$$kWh\ savings_{Elec\ htg} = FLH_{heat} * \frac{BTUh_{heat}}{n_{heat} * 3{,}412} * ESF_{heat}$$

Where:

n_{cool}	=	Efficiency of existing cooling system controlled by programmable thermostat (in units of SEER)
FLH_{cool}	=	Full-load cooling hours for Indianapolis
$Btuh_{cool}$	=	Capacity of cooling system (Btu/hour)
ESF_{cool}	=	Energy savings factor for cooling
FLH_{heat}	=	Full-load heating hours for Indianapolis
$Btuh_{heat}$	=	Capacity of heating system (Btu/hour)
n_{heat}	=	Efficiency of existing heating system controlled by programmable thermostat (in units of coefficient of performance)
ESF_{heat}	=	Energy savings factor for heating

Table I-12 summarizes the *ex post* assumptions and source for the installed programmable thermostats.

Table I-12. 2020 MFDI Program *Ex Post* Variable Assumptions for Programmable Thermostats

Variable	Value	Source
Efficiency of Existing Cooling System (n_{cool})	11.15	Indiana TRM (v2.2)
Full-Load Cooling Hours (FLH_{cool})	487	Indiana TRM (v2.2) for Indianapolis
Capacity of Cooling System ($Btuh_{cool}$)	28,994	Indiana TRM (v2.2)
Energy Savings Factor for Cooling (ESF_{cool})	0.09	Indiana TRM (v2.2)
Full-Load Heating Hours (FLH_{heat})	1,341	Indiana TRM (v2.2) for Indianapolis
Capacity of Heating System ($Btuh_{heat}$)	32,000	2016 Pennsylvania TRM
Efficiency of Existing Heating System (n_{heat}, electric resistance)	1	Indiana TRM (v2.2)
Efficiency of Existing Heating System (n_{heat}, air-source heat pump)	2.26	Indiana TRM (v2.2)
Energy Savings Factor for Heating (ESF_{heat})	0.068	Indiana TRM (v2.2)

Savings Summary for Programmable Thermostats

Table I-13 shows the *ex ante* deemed savings and resulting *ex post* per-measure savings for programmable thermostats.

Table I-13. 2020 MFDI Program *Ex Ante* and *Ex Post* Per-Measure Savings for Programmable Thermostats

Measure	*Ex Ante* Savings				*Ex Post* Savings	
	2019		2020			
	kWh	kW	kWh	kW	kWh	kW
Programmable Thermostat (Electric Heat + Central AC)	897.56	0	969.20	0	969.20	0
Programmable Thermostat (Electric Heat no Central AC)	-	-	855.22	0	855.22	0

For the *ex ante* analysis, CLEAResult cited a deemed savings value for the 2019 installations, while the evaluation team referenced the Indiana TRM (v2.2). As shown in the table, there are no differences between *ex ante* and *ex post* savings for 2020 programmable thermostats.

Smart Strips

Algorithms and Variable Assumptions

The evaluation teamed used deemed values from the Indiana TRM (v2.2) for energy savings and demand reduction for computer and audio-visual equipment smart strips:

$$kWh\ savings_{Smart\ Strip} = deemed = 150.0$$

$$kW\ reduction_{Smart\ Strip} = deemed = 0.027$$

Savings Summary for Smart Strips

Ex ante deemed savings and resulting *ex post,* per-measure savings for smart strips are shown in Table I-14.

Table I-14. 2020 MFDI Program *Ex Ante* and *Ex Post* Per-Measure Savings for Smart Strips

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Smart Strips	150.0	0.027	150.0	0.027

As shown in the table, there are no differences between *ex ante* and *ex post* savings for smart strips.

Duct Sealing

Algorithms and Variable Assumptions

The evaluation team used equations from the Indiana TRM (v2.2) to calculate *ex post,* per-measure energy savings and demand reduction for duct sealing:

$$kWh\ savings_{PStat} = kWh\ savings_{heat} + kWh\ savings_{cool}$$

$$kWh\ Savings_{heat} = \frac{(DE_{After} - DE_{Before})}{DE_{After}} * \frac{FLH_{heat} * Btuh_{heat}}{n_{heat} * 3{,}412}$$

$$kWh\ Savings_{cool} = \frac{(DE_{After} - DE_{Before})}{DE_{After}} * \frac{FLH_{cool} * Btuh_{cool}}{SEER * 1{,}000}$$

$$kW\ Savings = \frac{(DE_{After} - DE_{Before})}{DE_{After}} * \frac{Btuh_{cool}}{EER * 1{,}000} * CF$$

Where:

DE_{After}	=	Distribution system efficiency after duct sealing
DE_{Before}	=	Distribution system efficiency before duct sealing
FLH_{heat}	=	Full-load heating hours for Indianapolis
$Btuh_{heat}$	=	Capacity of heating system (Btu/hour)
n_{heat}	=	Efficiency of existing heating system controlled by programmable thermostat (in coefficient of performance units)
FLH_{cool}	=	Full-load cooling hours for Indianapolis
$Btuh_{cool}$	=	Capacity of cooling system (Btu/hour)
SEER	=	Seasonal average efficiency of AC equipment
EER	=	Peak efficiency of AC equipment (in EER units); if unknown, EER = SEER * 0.9
CF	=	Coincidence factor

Table I-15 summarizes *ex post* assumptions and sources for duct sealing.

Table I-15. 2020 MFDI Program *Ex Post* Variable Assumptions for Duct Sealing

Variable	Value	Source
Distribution System Efficiency after Duct Sealing (DE_{After}, cool)	0.91	Indiana TRM (v2.2), 8% uninsulated
Distribution System Efficiency after Duct Sealing (DE_{After}, heat)	0.88	Indiana TRM (v2.2), 8% uninsulated
Distribution System Efficiency after Duct Sealing (DE_{After}, peak)	0.90	Indiana TRM (v2.2), 8% uninsulated
Distribution System Efficiency before Duct Sealing (DE_{Before}, cool)	0.86	Indiana TRM (v2.2), 20% uninsulated
Distribution System Efficiency before Duct Sealing (D_{Before}, heat)	0.82	Indiana TRM (v2.2), 20% uninsulated
Distribution System Efficiency before Duct Sealing (D_{Before}, peak)	0.83	Indiana TRM (v2.2), 20% uninsulated
Full-load Heating Hours (FLH_{heat})	1,341	Indiana TRM (v2.2)
Capacity of Heating System ($Btuh_{heat}$) [a]	43,026	Participant data
Efficiency of Existing Electric Heating System (n_{heat})	0.91	Indiana TRM (v2.2)
Full-Load Cooling Hours (FLH_{cool})	487	Indiana TRM (v2.2)
Capacity of Cooling System ($Btuh_{cool}$)	28,994	Indiana TRM (v2.2)
Seasonal Average Equipment Efficiency (SEER)	11.15	Indiana TRM (v2.2)
Peak Equipment Efficiency (EER)	10.035	Indiana TRM (v2.2), = SEER * 0.9
Coincidence Factor (CF)	0.88	Indiana TRM (v2.2)

[a] Average of participant data and is provided as a representative value. Actual values from the tracking data were used to calculate savings.

Savings Summary for Duct Sealing

Table I-16 shows *ex ante* deemed savings and resulting *ex post,* per-measure savings for duct sealing.

Table I-16. 2020 MFDI Program *Ex Ante* and *Ex Post* Per-Measure Savings for Duct Sealing

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Duct Sealing (Electric Heat + Central AC)	1,509.59	0.228	1,679.35	0.198
Duct Sealing (Electric Heat no Central AC)	12,333.90	0	924.24	0

The differences between *ex ante* and *ex post* savings are due to actual versus Indiana TRM (v2.2) duct distribution efficiencies: For the *ex ante* analysis, CLEAResult cited actual duct distribution efficiency values. The evaluation team was not provided with the actual values, so instead leveraged the Indiana TRM (v2.2) and assumed distribution system efficiency leakages and insulation conditions, for both before and after duct sealing.

Air Sealing

Algorithms and Variable Assumptions

The evaluation team used equations from the Indiana TRM (v2.2) to calculate *ex post,* per-measure energy savings and demand reduction for air sealing measures:

$$kWh\ savings_{Air\ Sealing} = (CFM50_{existing} - CFM50_{air\ sealed}) * \frac{\left(\frac{\Delta kWh}{CFM}\right)}{N_{factor}}$$

$$kW\ reduction_{Air\ Sealing} = (CFM50_{existing} - CFM50_{air\ sealed}) * \frac{\left(\frac{\Delta kW}{CFM}\right)}{N_{factor}} * CF$$

Where:

$CFM50_{existing}$ = Initial blower door test results measured in CFM, pressurized at 50 pascal, of the leakage amount in the home prior to air-sealing measures

$CFM50_{air\ sealed}$ = Blower door test results after air sealing measured in CFM, pressurized at 50 pascal, of the leakage amount in the home after installing air-sealing measures

ΔkWh/CFM = Energy savings for each CFM reduction (varies by HVAC equipment)

N_{factor} = Constant used to convert 50-pascal airflow to natural airflow, dependent on exposure levels

ΔkW/CFM = Demand reduction for each CFM reduction (varies by HVAC equipment)

CF = Coincidence factor; a number between 0 and 1 indicating the ratio of cooling equipment expected to be in use and saving energy during the peak summer demand period

Table I-17 summarizes *ex post* assumptions and sources for the air sealing measure.

Table I-17. 2020 MFDI Program *Ex Post* Variable Assumptions for Air Sealing

Variable	Value	Source
Initial Blower Door Test Results ($CFM50_{existing}$)	750	Assumed, 15% reduction
Blower Door Test Results after Air Sealing ($CFM50_{air\ sealed}$)	637.5	
Energy Savings for Each CFM Reduction (ΔkWh/CFM, Electric Heat + Central AC)	50.1	Indiana TRM (v2.2)
Energy Savings for Each CFM Reduction (ΔkWh/CFM, Electric Heat Only)	48.2	
Conversion Factor (N-factor)	16.3	Indiana TRM (v2.2), unknown number of stories and exposure
Demand Reduction for Each CFM Reduction (ΔkW/CFM, Electric Heat + Central AC)	0.006	Indiana TRM (v2.2)
Demand Reduction for Each CFM Reduction (ΔkW/CFM, Electric Heat Only)	0	
Coincidence factor (CF)	0.88	Indiana TRM (v2.2)

Savings Summary for Air Sealing

Table I-18 shows a comparison of average *ex ante* and *ex post* air sealing savings per participant.

Table I-18. 2020 MFDI Program *Ex Ante* and *Ex Post* Per-Measure Savings for Air Sealing

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Air Sealing (Electric Heat with Central AC)	789.36	0.083	345.78	0.036
Air Sealing (Electric Heat Only)	2,680.67	0	332.67	0

The differences between *ex ante* and *ex post* savings are due to actual versus assumed blower door test results: For the *ex ante* analysis, CLEAResult referred to actual blower door test results. The evaluation team was not provided with this information, so instead leveraged the Indiana TRM (v2.2) and assumed a 15% infiltration reduction after improvements.

LED Night-Lights

Algorithms and Variable Assumptions

The evaluation team used an equation from the Indiana TRM (v2.2) to calculate *ex post* per-measure energy savings for LED night-lights included in the kits:

$$kWh\ savings = \frac{\left(W_{base} - W_{Night-light}\right) * (Hrs/day * 365)}{1{,}000}$$

Where:

W_{base} = Baseline wattage of existing night-light being replaced with a LED night-light (= 5 watts)

$W_{Night\text{-}light}$ = Actual wattage of installed LED night-light (= 0.5 watts)

Hrs/day = Average number of hours per day the night-light is in use

Table I-19 summarizes the *ex post* assumptions and source for the LED night-lights.

Table I-19. 2020 MFDI Program *Ex Post* Variable Assumptions for LED Night-Lights

Variable	Value	Source
Baseline Wattage (W_{base})	5	Indiana TRM (v2.2)
LED Night-Light Wattage ($W_{Night\text{-}light}$)	0.33	Indiana TRM (v2.2)
Hours per Day (Hrs/day)	2,920	Indiana TRM (v2.2)

Savings Summary for LED Night-Lights

Table I-20 shows the *ex ante* deemed savings and the resulting *ex post* per-measure savings for LED night-lights.

Table I-20. 2020 MFDI Program *Ex Ante* and *Ex Post* Per-Measure Savings for LED Night-Lights

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
LED Night-Lights	13.64	0	13.64	0

As shown in the table, there are no differences between *ex ante* and *ex post* savings for LED night-lights.

Filter Whistle

Algorithms and Variable Assumptions

The evaluation team used equations from the 2016 Pennsylvania TRM to calculate *ex post* per-measure energy savings and demand reduction for filter whistles included in the kit:

$$kWh\ savings_{Filter\ Whistle} = kWh/yr\ savings_{heat} + kWh/yr\ savings_{cool}$$

$$kWh/yr\ savings_{heat} = \text{kW}_{motor} * FLH_{heat} * EI * ISR$$

$$kWh/yr\ savings_{cool} = \text{kW}_{motor} * FLH_{cool} * EI * ISR$$

$$kW\ reduction_{Filter\ Whistle} = \frac{kWh/yr_{cool}}{FLH_{cool}} * \text{CF}$$

Where:

kW_{motor}	=	Average motor full-load electric demand
FLH_{heat}	=	Full-load heating hours
EI	=	Efficiency improvement
ISR	=	In-service rate
FLH_{cool}	=	Full-load cooling hours
CF	=	Coincidence factor

Table I-21 summarizes the *ex post* assumptions and source for the filter whistles.

Table I-21. 2020 MFDI Program *Ex Post* Variable Assumptions for Filter Whistles

Variable	Value	Source
Average Motor Full-Load Electric Demand (kW_{motor})	0.5	2016 Pennsylvania TRM
Full-Load Heating Hours (FLH_{heat})	1,341	Indiana TRM (v2.2) for Indianapolis
Efficiency Improvement (EI)	0.15	2016 Pennsylvania TRM
In-Service Rate (ISR)	1	Assumed for analysis
Full-Load Cooling Hours (FLH_{cool})	487	Indiana TRM (v2.2) for Indianapolis
Coincidence Factor (CF)	0.647	2016 Pennsylvania TRM

Savings Summary for Filter Whistles

Table I-22 shows the *ex ante* and *ex post* per-measure savings for filter whistles.

Table I-22. 2020 MFDI Program *Ex Ante* and *Ex Post* Per-Measure Savings for Filter Whistles

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Filter Whistle	137.1	0.049	137.1	0.049

As shown in the table, there are no differences between *ex ante* and *ex post* savings for filter whistles.

Appendix J. Peer Comparison Program Impact Evaluation Methodology

To evaluate the Peer Comparison program savings and efficiency uplift, the evaluation team conducted several tasks:

- Data collection, review, and preparation
- Equivalency checks on treatment and control groups
- Billing analysis
- Energy-savings estimates
- Energy efficiency program uplift analysis
- Demand reduction analysis

Data Collection, Review, and Preparation

The evaluation team received monthly electricity bills from Oracle for January 2011 through January 2021 for homes in treatment and control group waves 1 through 10. The data included approximately six to 12 months of pre-program bills and, depending on the wave, one to nine years of monthly bills during program participation. These billing data included energy use during the monthly billing cycle and on the last day of the billing cycle, as well as several fields:

- Assignment to treatment or control group
- First report date[82]
- Opt-out date for customers who choose not to participate
- Account active and inactive dates (if applicable)
- Oracle account numbers for linking to IPL's customer information

The team also collected National Oceanic and Atmospheric Administration daily temperature data from weather stations at the Indianapolis International Airport (in Indiana) and the Terre Haute municipal airport (in Indiana)—the two stations nearest to all program treatment and control homes.

For the uplift analysis, the evaluation team included participation and measure savings data for the 2021 IQW, Appliance Recycling, Whole Home, Lighting and Appliance, and IPL Marketplace programs. These data for each program and measure included customer information, numbers and descriptions of measures installed, measure installation dates, and verified gross savings. The team used this information to estimate program participation and savings' effects on other efficiency programs.

The evaluation team estimated CDDs and HDDs for each home during the billing cycle, using a base temperature of 65°F. Using billing cycle end dates, the team calculated CDDs and HDDs that exactly matched energy use in each customer bill. To fit monthly designations for the billing analysis, the team

[82] Oracle assigned a first report date to control homes (representing when a first energy report would have been mailed).

calendarized the billing data by creating an average daily consumption value for each billing cycling and assigning that value proportionally to the number of days in each month in the cycle.

As all weather data derived from only two stations, the temperatures did not vary significantly among homes. Most weather variations in the data occurred over time rather than across the territory.

Using the number of days in the billing cycle, the evaluation team determined monthly energy use, daily average energy use, and weather data, then merged the billing, weather, and program data, including the approximate delivery date of the first home energy report.

The team performed a billing analysis on the program home population, with a few exceptions. To test for potential issues with program homes, we determined whether they were missing a randomized control trial start date or usage information, among other filters (Table J-1 shows these filters and results). The billing analysis did not include customers with fewer than six pre-program monthly energy bills (note that the overall savings estimate includes these homes).

Table J-1. 2020 Peer Comparison Program Analysis Sample Selection

Wave and Group		Original Randomly Assigned Homes	Filters			Final Estimation Sample
			Missing Billing Data	Sufficient Bills for Post-Only Model	Total Filtered	
Wave 1	Treatment	16,302	392	21	413	15,889
	Control	27,162	600	31	631	26,531
Wave 2	Treatment	19,206	302	490	792	18,414
	Control	64,978	1108	1548	2656	62,322
Wave 3	Treatment	21,000	243	1,744	1,987	19,013
	Control	189,000	2449	15,995	18,444	170,556
Wave 4	Treatment	10,500	34	2,026	2,060	8,440
	Control	11,550	41	2,299	2,340	9,210
Wave 5	Treatment	10,500	31	774	805	9,695
	Control	31,499	88	2349	2437	29,062
Wave 6	Treatment	12,000	27	1,545	1,572	10,428
	Control	34,513	62	4,478	4,540	29,973
Wave 7	Treatment	20,000	17	2,704	2,721	17,279
	Control	58,850	73	7,850	7,923	50,927
Wave 8	Treatment	20,000	13	6,874	6,887	13,113
	Control	35,000	39	12,049	12,088	22,912
Wave 9	Treatment	16,000	11	5,280	5,291	10,709
	Control	42,000	53	13,746	13,799	28,201
Wave 10	Treatment	15,000	6	2,404	2,410	12,590
	Control	25,000	10	4,009	4,019	20,981

Equivalency Checks on Treatment and Control Groups

The evaluation team summarized average daily consumption in the pre-period (for each wave) and used a two-sample *t*-test to assess the statistical significance in the mean consumption for control and treatment group customers. No statistical differences emerged in average daily electric consumption for any of the waves.

Billing Analysis

To estimate the program electricity savings, the evaluation team used regression analyses of monthly billing data. In the past, the team reported savings from a D-in-D model and used a post-only model to test for the robustness of savings. In 2020 (and in past years), both models' estimates were contained within the other model's 90% confidence interval, meaning their results did not statistically differ. The team only reported the post-only model results, conforming our billing analysis to the approach described in Chapter 8 and Chapter 17 of the UMP.[83]

The following sections provide additional details about both modeling approaches.

Post-Only Model

The evaluation team specified the post-only model assuming the average daily consumption of electricity in home 'i' during month 't':

$$ADC_{it} = \beta_1 PART_i * PY_t + \beta_2 Pre\text{–}Usage_i * \tau_t + \beta_3 Pre\text{–}Summer_i * \tau_t + \beta_4 Pre\text{–}Winter_i * \tau_t + W'\gamma + \tau_t + \varepsilon_{it}$$

Where:

β_1	=	Coefficient representing the conditional average treatment effect of the program on electricity use (kilowatt-hours per customer per day)
$PART_i$	=	Indicator variable for program participation (which equals 1 if customer 'i' was in the treatment group and 0 otherwise)
PY_t	=	Indicator variable for each program year (which equals 1 if month 't' was in the program year and 0 otherwise)
β_2	=	Coefficient representing the conditional average effect of pre-treatment electricity use during month 't' on post-treatment average daily consumption (kilowatt-hours per customer per day)
$Pre\text{–}Usage_i$	=	Mean household energy consumption of customer 'i' across all pre-treatment months
τ_t	=	Average energy use in month 't' reflecting unobservable factors specific to the month (the analysis controls for these effects with month-by-year fixed effects)
β_3	=	Coefficient representing the conditional average effect of pre-treatment summer electricity use during month 't' on post-treatment average daily consumption (kilowatt-hours per customer per day)

83 "Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol." http://www1.eere.energy.gov/office_eere/de_ump_protocols.html and "Chapter 17: Residential Behavior Protocol." http://www1.eere.energy.gov/office_eere/de_ump_protocols.html

$Pre\text{–}Summer_i$	=	Mean household energy consumption of customer ‘i’ during June, July, August, and September of the pre-treatment period
β_4	=	Coefficient representing the conditional average effect of pre-treatment winter electricity use during month ‘t’ on post-treatment average daily consumption (kilowatt-hours per customer per day)
$Pre\text{–}Winter_i$	=	Mean household energy consumption of home ‘i’ during December, January, February, and March of the pre-treatment period
W	=	Vector using both CDDs and HDDs to control for weather impacts on energy use
γ	=	Vector of coefficients representing the average impact of weather variables on energy use
ε_{it}	=	Error term for customer ‘i’ in month ‘t’

Difference-in-Differences Fixed-Effects Model

The D-in-D fixed effects model was specified, assuming average daily consumption of electricity of customer ‘i’ in month ‘t’ as given by the following equation:

$$ADC_{it} = \alpha_i + \tau_t + W'\gamma + \beta_1 PART_i \times POST_t + \epsilon_{it}$$

Where:

α_i	=	Average energy use of customer ‘i’ reflecting unobservable, non-weather-sensitive, and time-invariant factors specific to the customer (the analysis controlled for these effects with customer fixed effects)
τ_t	=	Average energy use in month ‘t’ reflecting unobservable factors specific to the month (the analysis controlled for these effects with month-by-year fixed effects)
W	=	Vector using CDDs and HDDs to control for weather impacts on energy use
γ	=	Vector of coefficients representing the average impact of weather variables on energy use
β_1	=	Coefficient representing the program’s conditional average treatment effect on electricity use (kilowatt-hours per customer per day)
$PART_i$	=	Indicator variable for program participation (which equals 1 if customer ‘i’ was in the treatment group and 0 otherwise)
$POST_t$	=	Indicator variable for whether month ‘t’ is pre- or post-treatment (which equals 1 if month ‘t’ was in the post-treatment period and 0 otherwise)
ϵ_{it}	=	Error term for customer ‘i’ in month ‘t’

Energy-Savings Estimates

The team estimated the Peer Comparison program energy savings for each wave in 2020. To illustrate the approach, let i=1, 2, …, N index the number of homes receiving a home energy report, and let D(x) be the number of days in 2020 from January 1 for a given date (such as D [February 1] = 32).

For each home, the gross program savings are equal to the product of the average daily savings, β_1, and the total number of home energy report days in the program:

$$Gross\ Savings = -\beta_1 * \sum_{i=1}^{N} D(x)_i$$

Where:

i	=	Index of the number of homes in the wave (= 1, 2, …, N)
$D(x)_i$	=	Number of days each customer was treated and active in 2020

Energy Efficiency Program Uplift Analysis

The Peer Comparison program could contribute to increased participation in IPL's other residential energy efficiency programs in two ways:

- The home energy reports could educate customers about other IPL programs and encourage them to take advantage of program offerings and incentives.
- The home energy reports could raise customer awareness and knowledge of energy efficiency, which may independently cause them to participate in IPL programs.

We analyzed program uplift for two main reasons:

- IPL sought to learn whether, and to what extent, the Peer Comparison program caused participation in its other programs.
- To the extent the Peer Comparison program caused participation in other efficiency programs, energy savings resulting from this participation would be counted twice: once in the regression estimate of the Peer Comparison program's savings and once in the other programs' savings (thus double-counting savings in the IPL portfolio). Subtracting these double-counted savings from the gross savings estimate is equivalent to net savings.

The uplift analysis yielded estimates of the program effect on participation in other programs and the amount of double-counted savings. However, we limited the analysis to voluntary residential programs that focus on energy savings and that IPL tracked at the customer level.

The evaluation team performed participation and savings uplift analyses for several residential IPL efficiency programs: Appliance Recycling, IQW, Whole Home, and the appliance rebate and IPL Marketplace channels of Lighting and Appliances.

The team did not perform uplift analyses for other residential IPL efficiency programs:

- School Kits (which targets school children and their families, and for which participation is not voluntary)
- CBL (which is an LED giveaway program)
- The Upstream Lighting channel of Lighting and Appliance (for which customer-level data is not available; although the Peer Comparison program may have influenced high-efficiency lighting purchases, such purchases were tracked at the store level and cannot be linked to identifiable customers)

- MFDI (the Peer Comparison program targets residents of single-family and multifamily housing units, while the MFDI program targets property managers who did not receive home energy reports and who do not make decisions about electricity use in multifamily tenant units)
- Demand Response

As with the energy savings analysis, the evaluation team followed the logic of the program's experimental design for the uplift analysis. The team collected efficiency program participation and savings data in 2020, matched the data to treatment and control homes by customer account number, and applied a simple differences analysis to each customer wave. Because customers in the treatment and control groups are expected to be identical (except for having participated in the program), the difference between these groups in their participation in other efficiency IPL programs is the Peer Comparison program uplift. In homes matching the 2020 DSMore program data, we excluded measures installed after an account became inactive, as well as measures installed before 2020.

To calculate uplift, let ρ_m be the 2020 program participation rate (defined as the number of participants divided by the number of potential participants) for group 'm' (as before, m=1 for treatment homes and m=0 for control homes) in period 't' (t in {0,1}), as illustrated in the following equation:

$$\text{Participation Uplift} = \rho_1 - \rho_0$$

The evaluation team used this method to express participation uplift relative to the participation rate of control homes in 2020, which yielded an estimate of the percentage uplift, as illustrated in the following equation:

$$\%\text{Participation Uplift} = \text{Program Uplift}/\rho_0$$

We estimated Peer Comparison program savings from participation in other efficiency programs by replacing the program participation rate with the program net savings per home, as illustrated in the following equation:

$$\text{Net savings per home from participation uplift} = \sigma_1 - \sigma_0$$ [84]

Multiplying net savings per home by the number of program homes yielded an estimate for each wave of Peer Comparison program net savings counted in IPL's other efficiency programs.

Demand Reduction Analysis

The evaluation team estimated the peak coincident demand reduction using Integral Analytics' DSMore software load shape for a typical IPL home and the evaluated net program energy savings as inputs (described below in Step 1). The evaluation team applied the calibrated DSMore load-shape differences approach because IPL did not have enough homes with AMI meters to estimate the demand reduction using electricity use measurements.

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84 The evaluation team obtained net savings by multiplying measure-verified gross savings by the estimated measure NTG.

For this approach, the evaluation team used IPL-specific residential load shapes built into DSMore and calibrated those load shapes to match the verified annual consumption of the treatment group to equal the annual kilowatt-hour savings. We then identified the demand reduction during the coincident peak for the utility. The team followed five specific steps:

1. Conducted a pre-post D-in-D (experimental design with randomized control group) billing analysis to identify the average participant and program-wide energy savings achieved (this is detailed above in the *Billing Analysis* section)
2. Calibrated IPL-specific residential DSMore load shapes to match the kilowatt-hour consumption levels of the treatment group
3. Adjusted the load shape to reflect the annual savings identified in the billing analysis (this maintains the same shape while reducing the amplification of that shape)
4. Recorded the coincident load reduction on the calibrated DSMore load shape for the peak period defined by IPL
5. Multiplied the peak reduction determined in Step 4 by the number of participants to determine the program kilowatt impacts

This approach provided a reasonable estimate of the per-home and program-wide peak demand reduction given the available data.

Appendix K. School Kits Program Measures, Assumptions, and Algorithms

This appendix presents the evaluation team's assumptions for determining the energy savings and demand reduction for each measure within the Take Action Kits, along with our NTG methodology. The evaluation team examined each assumption in the algorithms used to capture savings and compared these against the Indiana TRM (v2.2), as well as against other state and industry approaches, for all School Kits measures for which IPL claimed savings in 2020:

- 9-watt general purpose (A19) LEDs
- 11-watt reflector (BR30) LEDs
- LED night-light
- Kitchen faucet aerator
- Bathroom faucet aerator
- Low-flow showerhead
- Water heater pipe wrap
- Water heater setback
- Furnace filter whistle

Gross Impact Methodology

The following sections address algorithms and assumptions the evaluation team used to calculate *ex post* savings for each kit measure.

LEDs

The evaluation team used two equations to calculate energy savings and demand reduction for LEDs:

$$\Delta kWh = \frac{(W_{baseline} - W_{LED})}{1{,}000} * AOH * (1 + WHF_e) * ISR$$

$$\Delta kW = \frac{(W_{baseline} - W_{LED})}{1{,}000} * CF * (1 + WHF_d) * ISR$$

Where:

$W_{baseline}$ = Weighted average wattage of bulbs being replaced

W_{LED} = Wattage of LED bulbs

1,000 = Constant to convert watts to kilowatts

AOH = Average hours of use per year

WHF_e = Waste heat factor for energy to account for HVAC interactions with lighting, depending on location

ISR = In-service rate (lifetime NPV)

CF = Summer peak coincidence factor

WHF_d = Waste heat factor for demand to account for HVAC interactions with lighting, depending on location

Table K-1 lists input assumptions and sources for the LED savings calculations.

Table K-1. 2020 School Kits Program *Ex Post* Variable Assumptions for LEDs

Input	9-Watt A19 LED	11-Watt BR30 LED	Source
$W_{baseline}$	37.8	65.0	2018 parent survey (9-watt A19 LEDs); Illinois TRM (v8) (11-watt BR30 LEDs)
W_{LED}	9.0	11.0	Actual installed wattage
AOH	1,135	1,135	Indiana TRM (v2.2)
WHF_e	-0.26	-0.26	Indiana TRM (v2.2), weighted using 2018 parent survey results
ISR [a]	96.7%	89.1%	2018 parent survey (9-watt A19 LEDs); Illinois TRM (v8) (11-watt BR30 LEDs)
CF	0.11	0.11	Indiana TRM (v2.2)
WHF_d	0.06	0.06	Indiana TRM (v2.2), weighted using 2018 parent survey results

[a] Lifetime ISRs calculated according to the UMP.

Baseline Wattages

The evaluation team collected self-reported data from the 2018 parent survey to determine the distribution of bulb types the program participants replaced with kit LEDs. The evaluation team used the lumen equivalence method to assign baseline wattages to replaced bulbs that were reported by survey respondents. Table K-2 shows the distribution of baseline bulb types derived from survey responses as well as baseline wattages applied, using the lumen equivalence method to calculate the final weighted average baseline wattages for 9-watt general purpose (A19) LEDs.

Table K-2. 2020 School Kits Program Parent Survey Results for Baseline Light Bulbs

Measure	Incandescent [a]	Halogen	CFL	LED	New/Empty Fixture
9-watt LEDs					
Distribution from survey results	51%	10%	10%	18%	12%
Baseline wattage	60	43	13	9	0
Weighted average baseline					**37.8**

[a] Halogen bulbs are often confused with incandescent bulbs, which can no longer be purchased. To account for this, the evaluation team asked participants if they had incandescent bulbs in storage. If respondents answered yes, the team assumed they replaced or would have installed an incandescent bulb. If they answered no, we assumed they replaced or would have installed a halogen bulb.

For 11-watt reflector (BR30) LEDs, the evaluation team used the default ISR in the Illinois TRM (v8), consistent with EISA guidelines.

Lifetime In-Service Rates

The evaluation team relied on the UMP for calculating lifetime ISRs to account for future installations of bulbs in storage. The methodology assumes that 24% of all bulbs in storage would be installed in each subsequent year. To account for the time sensitivity of these added savings, stemming from increased

ISRs but taking place after 2020, the evaluation team discounted the 2% annual lifetime ISR to determine NPV lifetime ISRs for each LED. Table K-3 shows a comparison of first-year and lifetime ISRs, illustrating how marginal increases to first-year ISRs using the UMP methodology resulted in NPV lifetime ISRs used in measure impact calculations.

Table K-3. 2020 School Kits Program First-Year and Lifetime In-Service Rate Calculations

Measure	First-Year ISR	2021	2022	Lifetime ISR	NPV ISR
9-watt (A19) LED	94.4%	1.4%	1.0%	96.7%	96.7%
11-watt (BR30) LED	81.5%	4.4%	3.4%	89.3%	89.1%

Waste Heat Factors

To determine WHFs, the evaluation team employed a method similar to that used for deriving baseline wattages. The evaluation team collected self-reported heating and cooling data from participants through the 2018 parent survey, then applied Indiana TRM (v2.2) WHF values to the survey results, weighting them according to the survey response distribution shown in Table K-4.

Table K-4. 2020 School Kits Program Indiana TRM (v2.2)
Waste Heat Factors, Weighted by 2018 Parent Survey Results

HVAC Type	WHF_e	WHF_d	Distribution
AC with natural gas heat	0.06	0.07	31%
Heat pump	-0.17	0.03	7%
AC with electric heat	-0.45	0.07	54%
Electric heat only	-0.52	0.00	4%
Natural gas heat only	0.00	0.00	3%
Weighted average	**-0.260**	**0.062**	**100%**

LED Night-Lights

The evaluation team used the following equation to calculate energy savings for LED night-lights:

$$\Delta kWh = \frac{(W_{baseline} - W_{LED})}{1{,}000} * AOU * ISR$$

Where:

$W_{baseline}$ = Wattage of bulb being replaced, depending on bulb type

W_{LED} = Wattage of the LED night-light

1,000 = Constant to convert watts to kilowatts

AOH = Average hours of use per year

ISR = In-service rate (lifetime NPV)

Table K-5 lists input assumptions and sources for the LED night-light savings calculations.

Table K-5. 2020 School Kits Program *Ex Post* Variable Assumptions for LED Night-Lights

Input	Value	Source
$W_{baseline}$ for incandescent replacement	5.0	Indiana TRM (v2.2)
$W_{baseline}$ for LED replacement	0.5	Equal to W_{LED}
$W_{baseline}$ for no replacement	0.0	Measure definition
W_{LED}	0.5	Actual installed wattage
AOH	2,920	Indiana TRM (v2.2)
Percentage of incandescent replacement	37%	2018 parent survey
Percentage of LED replacement	15%	
Percentage of no replacement	48%	
ISR	83%	

Table K-6 shows the weighting of savings calculations by replacement conditions.

Table K-6. 2020 School Kits Program Calculation of LED Night-Light Savings

Baseline Condition	$W_{baseline}$	W_{LED}	Savings (kWh)	Distribution
Incandescent replacement	5.0	0.5	13.14	37%
LED replacement	0.5	0.5	0.00	15%
No replacement	0.0	0.5	-1.46	48%

Kitchen and Bathroom Faucet Aerators

The evaluation team used two equations to calculate energy savings and demand reduction for low-flow kitchen and bathroom faucet aerators:

$$\Delta kWh = (GPM_{base} - GPM_{eff}) * MPD * \frac{PH}{FH} * DR * 8.33 * (T_{mix} - T_{inlet}) * \frac{366}{RE * 3{,}412} * ISR * DHW$$

$$\Delta kW = (GPM_{base} - GPM_{eff}) * DR * 60 * 8.33 * \frac{T_{mix} - T_{inlet}}{RE * 3{,}412} * CF * ISR * DHW$$

Where:

GPM_{base}	=	Gallons per minute of baseline faucet aerator
GPM_{eff}	=	Gallons per minute of low-flow faucet aerator
MPD	=	Average minutes of faucet use per person per day
PH	=	Average number of people per household
FH	=	Average number of faucets per household
DRF	=	Percentage of water flowing down the drain
8.33	=	Specific weight of water in pounds per gallon, multiplied by specific water temperature (1.0 Btu/lb-°F)
T_{mix}	=	Mixed water temperature exiting faucet
T_{inlet}	=	Cold water temperature entering the DHW system
366	=	Number of days in 2020
RE	=	Recovery efficiency of electric hot water heater

3,412	=	Constant to convert British thermal units to kilowatt-hours
ISR	=	In-service rate, first-year
DHW	=	Percentage of households with electric water heaters
60	=	Minutes per hour
CF	=	Summer peak coincidence factor

Table K-7 lists input assumptions and source for the faucet aerator savings calculations.

Table K-7. 2020 School Kits Program *Ex Post* Variable Assumptions for Faucet Aerators

Input	Kitchen Aerator Value	Bathroom Aerator Value	Source
GPM_{base}	2.44	1.90	Indiana TRM (v2.2)
GPM_{eff}	1.5	1.0	Program materials
MPD	4.5	1.6	Indiana TRM (v2.2)
PH	4.63	4.63	2018 parent survey
FH	1.00	2.55	2018 parent survey
DRF	50%	70%	Indiana TRM (v2.2)
T_{mix}	93	86	Indiana TRM (v2.2)
T_{inlet}	58.1	58.1	Indiana TRM (v2.2)
RE	0.98	0.98	Indiana TRM (v2.2)
ISR	62%	53%	2018 parent survey
DHW	54%	54%	2018 parent survey
CF	0.0033	0.0012	Indiana TRM (v2.2)

Low-Flow Showerheads

The evaluation team used two equations to calculate the energy savings and demand reduction for low-flow showerheads:

$$\Delta kWh = \left(GPM_{base} - GPM_{eff}\right) * MS * SPD * \frac{PH}{SH} * 8.33 * (T_{mix} - T_{inlet}) * \frac{366}{RE * 3{,}412} * ISR * DHW$$

$$\Delta kW = \left(GPM_{baseline} - GPM_{efficient}\right) * 60 * 8.33 * \frac{T_{mix} - T_{inlet}}{RE * 3{,}412} * CF * ISR * DHW$$

Where:

GPM_{base}	=	Gallons per minute of baseline showerhead
GPM_{eff}	=	Gallons per minute of low-flow showerhead
MS	=	Average minutes per shower event
SPD	=	Average number of shower events per person per day
PH	=	Average number of people per household
SH	=	Average number of showerheads per household
8.33	=	Specific weight of water in pounds per gallon, multiplied by specific water temperature (1.0 Btu/lb-°F)
T_{mix}	=	Mixed water temperature exiting faucet
T_{inlet}	=	Cold water temperature entering water heater
366	=	Number of days in 2020

RE	=	Recovery efficiency of electric hot water heater
3,412	=	Constant to convert British thermal units to kilowatt-hours
ISR	=	In-service rate, first-year
DHW	=	Percentage of households with electric water heaters
60	=	Minutes per hour
CF	=	Summer peak coincidence factor

Table K-8 lists input assumptions and sources for the low-flow showerhead savings calculations.

Table K-8. 2020 School Kits Program *Ex Post* Variable Assumptions for Low-Flow Showerheads

Input	Value	Source
GPM_{base}	2.35	Indiana TRM (v2.2)
GPM_{eff}	1.5	Program materials
MS	7.8	Indiana TRM (v2.2)
SPD	0.6	Indiana TRM (v2.2)
PH	4.63	2018 parent survey
SH	1.75	2018 parent survey
T_{mix}	101	Indiana TRM (v2.2)
T_{inlet}	58.1	Indiana TRM (v2.2)
RE	0.98	Indiana TRM (v2.2)
ISR	61%	2018 parent survey
DHW	54%	2018 parent survey
CF	0.0023	Indiana TRM (v2.2)

Water Heater Pipe Wrap

For the 2020 program, the evaluation team used the water heater pipe wrap engineering savings algorithms outlined in the Indiana TRM (v2.2):

$$\Delta kWh = \left(\frac{1}{R_{baseline}} - \frac{1}{R_{efficient}}\right) * \frac{L * C * \Delta T * 8{,}784}{RE * 3{,}412} * DHW$$

$$\Delta kW = \frac{\Delta kWh}{8{,}784} * DHW$$

Where:

$R_{baseline}$	=	Pipe heat loss coefficient of uninsulated pipe
$R_{efficient}$	=	Pipe heat loss coefficient of insulated pipe
L	=	Length of pipe (in feet)
C	=	Circumference of pipe (in feet)
ΔT	=	Average difference in temperature between incoming water supply and ambient air (°F)
8,784	=	Number of hours in 2020
RE	=	Recovery efficiency of electric hot water heater
3,412	=	Constant to convert British thermal units to kilowatt-hours
DHW	=	Percentage of households with electric water heaters

Table K-11 lists input assumptions and sources for the pipe wrap savings calculations.

Table K-9. 2020 School Kits Program *Ex Post* Variable Assumptions for Pipe Wrap

Input	Value	Source
$R_{baseline}$	1.0	Indiana TRM (v2.2)
$R_{efficient}$	4.0	Program materials/IPL *ex ante*
L	3.0	Program materials
C	0.20	Indiana TRM (v2.2)
ΔT	65	Indiana TRM (v2.2)
RE	0.98	Indiana TRM (v2.2)
DHW	54%	2018 parent survey

Water Heater Setback

For the 2020 program, the evaluation team used the water heater setback card engineering savings algorithms outlined in the Illinois TRM (v8):

$$\Delta kWh = \frac{U * A * \left(T_{pre} - T_{post}\right) * 8{,}784 * ISR}{3{,}412 * RE} * DHW$$

$$\Delta kW = \frac{\Delta kWh}{8{,}784} * CF * DHW$$

Where:

U	=	Overall heat transfer coefficient of water heater tank (Btu-HR-°F-ft^2)
A	=	Surface area of storage tank (in square feet)
T_{pre}	=	Hot water setpoint prior to adjustment (°F)
T_{post}	=	Hot water setpoint after adjustment (°F)
8,784	=	Number of hours in 2020
ISR	=	In-service rate, first-year
3,412	=	Constant to convert British thermal units to kilowatt-hours
RE	=	Recovery efficiency of electric hot water heater
DHW	=	Percentage of households with electric water heaters
CF	=	Summer peak coincidence factor

Table K-10 lists input assumptions and sources for the water heater setback card savings calculations.

Table K-10. 2020 School Kits Program *Ex Post* Variable Assumptions for Water Heater Setback Card

Input	Value	Source
U	0.083	Illinois TRM (v8)
A	24.99	Illinois TRM (v8)
T_{pre}	135	Illinois TRM (v8)
T_{post}	120	Illinois TRM (v8)
ISR	13%	Illinois TRM (v8)
RE	0.98	Illinois TRM (v8)
DHW	54%	2018 parent survey
CF	1.00	Illinois TRM (v8)

Furnace Whistles

For the 2020 program, the evaluation team used the furnace whistle engineering savings algorithms outlined in the 2016 Pennsylvania TRM:

$$\Delta kWh = (EFLH_{heat} + EFLH_{cool}) * kW_{motor} * EI * ISR$$

$$\Delta kW = kW_{motor} * EI * CF * ISR$$

Where:

$EFLH_{heat}$ = Equivalent full-load heating hours per year

$EFLH_{cool}$ = Equivalent full-load cooling hours per year

kW_{motor} = Average motor full load electric demand in kilowatts

EI = Efficiency improvement

ISR = Installation rate, first-year

CF = Coincidence factor

Table K-11 lists input assumptions and sources for the furnace whistle savings calculations. The evaluation team derived equivalent full-load hour assumptions from the Indiana TRM (v2.2) to reflect local weather conditions and furnace usage.

Table K-11. 2020 School Kits Program *Ex Post* Variable Assumptions for Furnace Whistle

Input	Value	Source
$EFLH_{heat}$	977	Indiana TRM (v2.2)/IPL *ex ante*
$EFLH_{cool}$	432	Indiana TRM (v2.2)/IPL *ex ante*
kW_{motor}	0.377	Program materials/IPL *ex ante*
EI	10%	Program materials/IPL *ex ante*
ISR	39%	2018 parent survey
CF	0.647	2016 Pennsylvania TRM

Net-to-Gross Methodology

Using responses to the 2018 parent survey, the evaluation team estimated freeridership and spillover, explained below. General purpose LEDs had the highest freeridership rates, while furnace whistles had the lowest.

Freeridership

To determine freeridership, the evaluation team asked participants representing 275 measure-specific freeridership responses about whether, in absence of the School Kits program, they would have installed equipment to the same efficiency level within one year. Based on survey feedback, the evaluation team calculated overall freeridership for the program as 15%, shown in Table K-12.

Table K-12. 2018 School Kits Program Freeridership Results

Measure	Responses (n)	Freeridership [a]	*Ex Post* Gross Population Savings (kWh)
LEDs	71	25%	1,226,958
LED night-light	56	18%	38,313
Showerhead	43	13%	1,352,744
Kitchen faucet aerator	43	9%	1,051,356
Bathroom faucet aerator	37	14%	133,199
Furnace whistle	25	8%	542,563
Overall [b]	**275**	**15%**	**4,345,132**

Note: Values rounded for reporting purposes.

[a] The evaluation team weighted measure freeridership by the survey sample *ex post* gross kilowatt-hour savings, and weighted overall freeridership by the *ex post* gross program population kilowatt-hour savings.

[b] The total freeridership and *ex post* total gross population savings include all measures delivered in kits in 2020, while table rows depict only measures evaluated using the 2018 parent survey. The evaluation team assumed 25% freeridership for 11-watt BR30 LEDs (consistent with 9-watt A19 LEDs) and 0% freeridership for pipe wrap and water heater setback cards.

The evaluation team estimated measure-level freeridership for each participant based on responses to two questions:

- FR1. “If you had not received the kit, would you have purchased a [MEASURE] on your own?”
- FR2. “When would you have purchased the [MEASURE]?”

If a participant answered “no” to FR1, the evaluation team estimated them as a 0% freerider. If a participant said they “already have the measure installed in all available locations” to FR1, the team estimated them as a 100% freerider. If a participant answered “yes” to FR1, the evaluation team based the freeridership estimate on their answer to FR2. Table K-13 shows response options to the freeridership questions, the freeridership score (FR Score) associated with each response, and the response frequency for each measure type.

Table K-13. 2018 School Kits Program Freeridership Responses and Scoring

Freeridership Questions / Response Options	FR Score	Frequency of Responses					
FR1. If you had not received the kit, would you have purchased a [measure] on your own?		9-Watt LED (3)	LED Night-Light	Shower-head	Kitchen Faucet Aerator	Bathroom Faucet Aerator	Furnace Whistle
No	0%	32	44	35	35	33	22
Already have the measure installed in all available locations	100%	2	1	1	2	2	1
Yes							
FR2. When would you have purchased the [measure]?							
Around the same time I received the kit	100%	6	5	3	0	1	0
Later, but within one year	50%	24	1	3	4	1	2
More than one year later	0%	0	1	1	0	0	0
Don't know	25%	7	4	0	2	0	0
Total	**N/A**	**71**	**56**	**43**	**43**	**37**	**25**

Spillover

The evaluation team estimated spillover using specific information about participants (determined through the evaluation) and incorporating the Indiana TRM (v2.2) as a baseline reference. The evaluation team estimated the percentage of program spillover by dividing the sum of additional spillover savings (as reported by survey respondents) by the total gross savings achieved by all program respondents. Table K-14 shows that the spillover estimate for the School Kits program is 7% (when rounded to the nearest whole percentage).

Table K-14. 2018 School Kits Program Spillover

Spillover Savings (kWh)	Survey Respondent Program Savings (kWh)	Spillover
1,990	26,595	7%

Four participants said the program was *very important* in their decision to purchase and install additional energy-efficient equipment. Table K-15 shows these additional spillover measures and the total resulting energy savings.

Table K-15. 2018 School Kits Program Spillover Measures, Quantity, and Savings

Spillover Measures	Quantity	Total Energy Savings (kWh)
ENERGY STAR Clothes Washer	2	404
ENERGY STAR Dishwasher	1	150
ENERGY STAR Refrigerator	1	83
ENERGY STAR Room Air Conditioner	1	16
Programmable Thermostat	1	1,336
Total	**N/A**	**1,990**

Note: Values rounded for reporting purposes.

Appendix L. Whole Home Program Measures, Assumptions, and Algorithms

This appendix presents savings details for several Whole Home program measures, including algorithms, variable assumptions and sources, and differences between *ex ante* and *ex post*:

- LEDs (9-watt, 11-watt, 16 watt, 5-watt globe, 5-watt candelabra, 7-watt track light, R30, and 9-watt exterior)
- Bathroom and kitchen aerators
- Low-flow showerheads
- Heat pump water heaters
- Water heater setback
- Pipe wrap insulation
- Smart strips
- Programmable thermostats
- Smart thermostats
- Duct sealing
- Air sealing
- Duct sealing
- Central ACs
- ASHP
- AC tune-ups
- ASHP tune ups
- Attic insulation
- Mini-split heat pumps
- LED night-lights
- Furnace whistles
- Audit recommendations

Unless otherwise specified, these algorithms, variable assumptions, and measure savings apply to direct install and energy-savings kits measures. For measures where 2019 installations are claimed in the 2020 evaluation, the 2019 and 2020 per-measure *ex ante* savings are presented.

LEDs

Algorithms and Variable Assumptions

The evaluation team used equations from the Indiana TRM (v2.2) to calculate *ex post* per-measure energy savings and demand reduction for LEDs:

$$kWh\ savings = \frac{(W_{base} - W_{LED}) * (Hrs/day * 365) * \ (1 + WHFe)}{1{,}000}$$

$$kW\ reduction = \frac{(W_{base} - W_{LED}) * CF * (1 + WHFd)}{1{,}000}$$

Where:

W_{base} = Baseline wattage of existing bulb replaced with LED (see Table L-1)

Table L-1. 2020 Whole Home Program LED Baseline Wattages

Measure	Baseline Wattage
9-watt LED	43
11-watt LED	53
16-watt LED	65
5-watt globe LED	40
5-watt candelabra LED	40
7-watt track light LED	50
R30, 10-watt LED	65

W_{LED} = Actual installed LED wattage

Hrs/day = Average number of hours per day the light remains in use

WHF_e = Waste heat factor for energy use; this accounts for the effects of more efficient lighting on cooling energy use

CF = Coincidence factor; a number between 0 and 1 indicating the ratio of LEDs expected to be in use and saving energy during the peak summer demand period

WHF_d = Waste heat factor for demand; this accounts for the effects of more efficient lighting on cooling energy demand

Table L-2 shows *ex post* assumptions and sources for the installed LEDs.

Table L-2. 2020 Whole Home Program *Ex Post* Variable Assumptions for LEDs

Variable	Value	Source
Baseline wattage (W_{base})	As shown in Table L-1	Lumens compared with ENERGY STAR and EISA halogen baseline equivalent wattages applied
LED wattage (W_{LED})	As shown in Table L-1	Program information
Hours per day (Hrs/day, interior lights)	902	Indiana TRM (v2.2)
Hours per day (Hrs/day, 9-watt exterior)	1,607	Indiana TRM (v2.2)
Weighted average energy waste heat factor (WHFe)	-0.061 for interior 0 for exterior	Indiana TRM (v2.2) for Indianapolis
Coincidence factor (CF)	0.11	Indiana TRM (v2.2)
Weighted average demand waste heat factor (WHFd)	0.055 for interior 0 for exterior	Indiana TRM (v2.2) for Indianapolis

Savings Summary for LEDs

Table L-3 shows *ex ante* deemed savings and the resulting *ex post* per-measure savings for LEDs.

Table L-3. 2020 Whole Home Program *Ex Ante* and *Ex Post* Per-Measure Savings for LEDs

Measure	*Ex Ante* Savings				*Ex Post* Savings	
	2019		2020			
	kWh	kW	kWh	kW	kWh	kW
9-watt LED	18.61	0.002	9.13	0.001	28.80	0.004
11-watt LED	-	-	12.66	0.002	35.57	0.005
16-watt LED	32.66	0.004	22.75	0.003	41.50	0.005
5-watt Globe LED	19.44	0.004	5.51	0.001	29.64	0.004
5-watt Candelabra LED	19.71	0.004	12.99	0.002	29.64	0.004
7-watt track light LED	12.59	0.002	5.48	0.001	36.42	0.005
R30, 10-watt LED	30.93	0.006	14.41	0.002	46.58	0.006
9-watt exterior LED	32.68	0.000	17.25	0.000	54.64	0.000

The differences between *ex ante* and *ex post* savings are due to differences in baseline wattage calculations for LEDs. For the *ex ante* calculations, CLEAResult applied the lower baseline wattages for LED bulbs from the post-EISA backstop and included embedded ISRs. The evaluation team did not reduce the baseline wattages for *ex post* calculations (because the EISA backstop has not been enforced) and we did not include an embedded ISR.

Carryover Bulbs

To calculate carryover bulbs, the evaluation team referenced the UMP to estimate how many bulbs would be installed each year. The UMP recommends a 2021 sunset, given EISA standard implementation. However, recent changes at the U.S. Department of Energy mean that general service lamps will still have halogen baseline savings until at least 2022. The team used the initial first-year ISR for kit measures, then extrapolated estimated lifetime ISRs for these bulbs using the 24% installation rate estimate plus a discount factor to account for installation delays. The team used the resulting 78% lifetime cumulative ISR for virtual audit LEDs and 87% lifetime cumulative ISR for kit LEDs rather than the original calculated LED ISR, accounting for future installations of bulbs in storage (see Table L-4).

Table L-4. 2020 Whole Home Program Adjusted Lifetime Installation Rates for Lighting Measures by Program Path

Program Path	First Year ISR	Cumulative Year 4 ISR
Virtual Audit	58%	78%
Energy Saving Kits	74%	87%

Bathroom and Kitchen Faucet Aerators

Algorithms and Variable Assumptions

The evaluation team two used equations from the Indiana TRM (v2.2) to calculate *ex post* per-measure energy savings and demand reduction for bathroom and kitchen faucet aerators installed in homes with an electric water heater:

$$kWh\ savings_{aerator} = (gpm_{base} - gpm_{low})\ x\ MPD * \frac{PH}{FH} * \text{DRF} * \text{S} * (T_{mix} - T_{Inlet}) * \frac{365}{RE * 3{,}412}$$

$$kW\ reduction_{aerator} = (gpm_{base} - gpm_{low}) * 60 * \text{DRF} * S * \frac{(T_{mix} - T_{Inlet})}{RE * 3{,}412} * CF$$

Where:

gpm_{base}	=	Baseline flow rate of existing faucet in gallons per minute
gpm_{low}	=	Low-flow rate of aerator in gallons per minute
MPD	=	Average minutes per day and per person of faucet use
PH	=	Average number of people per household
FH	=	Average number of faucets per household
DRF	=	Drain recovery factor, representing the percentage of water flowing down the drain
S	=	Constant used to convert the weight of water from gallons to pounds (8.3 lbs/gallon)
T_{mix}	=	Temperature of the water leaving the aerator (°F)
T_{inlet}	=	Temperature of the water entering the water heater (°F)
RE	=	Recovery efficiency of the electric water heater in operation
CF	=	Coincidence factor; a number between 0 and 1 indicating the ratio of aerators expected to be in use and saving energy during the peak summer demand period

Table L-5 shows *ex post* assumptions and sources for installed faucet aerators.

Table L-5. 2020 Whole Home Program *Ex Post* Variable Assumptions for Faucet Aerators

Variable	Value		Source
	Bathroom	Kitchen	
Baseline flow rate (gpm_{base})	1.9	2.44	Indiana TRM (v2.2)
Low-flow rate (gpm_{low})	1.0	1.5	Program information
Minutes/person/day (MPD)	1.6	4.5	Indiana TRM (v2.2
People per household (PH)	2.64	2.64	Indiana TRM (v2.2)
Faucets per household (FH)	2.04	1	Indiana TRM (v2.2)
Drain recovery factor (DRF)	0.7	0.5	Indiana TRM (v2.2)
Conversion factor (S)	8.3	8.3	Engineering constant in units of Btu/(gal°F)
Mixed temperature (T_{mix}, °F)	86	93	Indiana TRM (v2.2)
Inlet temperature (T_{inlet}, °F)	58.1	58.1	Indiana TRM (v2.2) for Indianapolis
Recovery efficiency (RE)	0.98	0.98	Indiana TRM (v2.2)
Coincidence factor (CF)	0.0012	0.0033	Indiana TRM (v2.2)

Savings Summary for Faucet Aerators

Table L-6 shows *ex ante* deemed savings and resulting *ex post* per-measure savings for faucet aerators.

Table L-6. 2020 Whole Home Program *Ex Ante* and *Ex Post* Per-Measure Savings for Faucet Aerators

Measure	*Ex Ante* Savings				*Ex Post* Savings	
	2019		2020			
	kWh	kW	kWh	kW	kWh	kW
Bathroom Aerators	29.35	0.003	32.97	0.003	32.97	0.003
Kitchen Aerators	157.13	0.007	176.55	0.31	176.55	0.008

The differences between *ex ante* and *ex post* demand reduction for the kitchen aerator are due to deemed versus Indiana TRM (v2.2) calculated savings. CLEAResult cited a deemed savings value for kitchen aerators that is greater than the *ex ante* value from the 2019 program evaluation, while the evaluation team leveraged the Indiana TRM (v2.2). The *ex ante* and *ex post* energy savings for kitchen and bathroom aerators align.

Low-Flow Showerheads

Algorithms and Variable Assumptions

The evaluation team used two equations from the Indiana TRM (v2.2) to calculate *ex post* per-measure energy savings and demand reduction for low-flow showerheads installed in homes with an electric water heater:

$$kWh\ savings_{Showerhead} = (gpm_{base} - gpm_{low}) * \text{MS} * \text{SPD} * \frac{PH}{SH} * S * (T_{mix} - T_{Inlet}) * \frac{365}{RE * 3{,}412}$$

$$kW\ reduction_{Showerhead} = (gpm_{base} - gpm_{low}) * 60 * S * \frac{(T_{mix} - T_{Inlet})}{RE * 3{,}412} * CF$$

Where:

gpm_{base}	=	Baseline flow rate of existing showerhead in gallons per minute
gpm_{low}	=	Low-flow rate of showerhead in gallons per minute
MS	=	Average minutes per shower per person per day
SPD	=	Average number of showers per person per day
PH	=	Average number of people per household
SH	=	Average number of showerheads per household
S	=	Constant used to convert the weight of water from gallons to pounds (8.3 lbs/gallon)
T_{mix}	=	Temperature of water leaving the showerhead (°F)
T_{inlet}	=	Temperature of water entering the water heater (°F)
RE	=	Recovery efficiency of the electric water heater in operation
CF	=	Coincidence factor; a number between 0 and 1 indicating the ratio of showerheads expected to be in use and saving energy during the peak summer demand period

For this measure, an efficient, low-flow showerhead replaces an existing, less-efficient showerhead. Table L-7 shows *ex post* assumptions and sources for low-flow showerheads installed through the Whole Home program.

Table L-7. 2020 Whole Home Program *Ex Post* Variable Assumptions for Low-Flow Showerheads

Variable	Value	Source
Baseline flow rate (gpm_{base})	2.63	Indiana TRM (v2.2)
Low-flow rate (gpm_{low})	1.5	Program information
Minutes per shower per person per day (MS)	7.8	Indiana TRM (v2.2)
Showers per person per day (SPD)	0.6	Indiana TRM (v2.2)
People per household (PH)	2.64	Indiana TRM (v2.2)
Showerheads per household (SH)	1.6	Indiana TRM (v2.2)
Conversion factor (S)	8.3	Engineering constant in units of Btu/(gal°F)
Mixed temperature (T_{mix}, °F)	101	Indiana TRM (v2.2)
Inlet temperature (T_{inlet}, °F)	58.1	Indiana TRM (v2.2)
Recovery efficiency (RE)	0.98	Indiana TRM (v2.2)
Coincidence factor (CF)	0.0023	Indiana TRM (v2.2)

Savings Summary for Low-Flow Showerheads

Table L-8 shows *ex ante* deemed savings and resulting *ex post* per-measure savings for low-flow showerheads. The evaluation team calculated *ex post* savings using installed equipment information and details from the Indiana TRM (v2.2).

Table L-8. 2020 Whole Home Program *Ex Ante* and *Ex Post* Per-Measure Savings for Low-Flow Showerheads

Measure	*Ex Ante* Savings				*Ex Post* Savings	
	2019		2020			
	kWh	kW	kWh	kW	kWh	kW
Low-Flow Showerhead	322.20	0.016	339.16	0.166	339.16	0.017

The difference between *ex ante* and *ex post* demand reduction resulted from the use of deemed versus Indiana TRM (v2.2) calculated savings. For the 2020 *ex ante* analysis, CLEAResult cited a deemed savings value that is greater than the 2019 deemed savings value, while the evaluation team leveraged the Indiana TRM (v2.2) to calculate *ex post* reduction (which aligns with the 2019 *ex ante* savings and with the example calculation in the Indiana TRM (v2.2)).

Heat Pump Water Heater

Algorithms and Variable Assumptions

The evaluation team used two equations from the Indiana TRM (v2.2) to calculate *ex post* per-measure energy savings and demand reduction for heat pump water heaters replacing standard electric water heaters:

$$kWh\ savings_{HPWH} = kWh_{base} * \frac{COP_{new} - COP_{base}}{COP_{new}} + kWh_{cooling} - kWh_{heating}$$

$$kW\ reduction_{HPWH} = \frac{\Delta kWh}{EFLH} * CF$$

Where:

kWh_{base} = Average electric DHW consumption

COP_{new} = Coefficient of performance (efficiency) of heat pump water heater

COP_{base} = Coefficient of performance (efficiency) of standard electric water heater

$kWh_{cooling}$ = Cooling savings from converting space heat to water heat

$kWh_{heating}$ = Heating savings from converting space heat to water heat

EFLH = Equivalent full-load hours of hot water heater

CF = Coincidence factor; a number between 0 and 1 indicating the ratio of showerheads expected to be in use and saving energy during the peak summer demand period

Table L-9 shows *ex post* assumptions and sources for the installed heat pump water heaters.

Table L-9. 2020 Whole Home Program *Ex Post* Variable Assumptions for Heat Pump Water Heaters

Variable	Value	Source
Average hot water consumption (kWh_{base})	3,460	Indiana TRM (v2.2)
Coefficient of performance of heat pump water heater (COP_{new})	Actual	Participant data
Coefficient of performance of standard electric water heater (COP_{base})	0.904	Indiana TRM (v2.2)
Cooling savings ($kWh_{cooling}$)	180	Indiana TRM (v2.2)
Heating savings ($kWh_{heating}$)	Actual	Participant data
Equivalent full load hours (EFLH)	2,533	Indiana TRM (v2.2)
Coincidence factor (CF)	0.346	Indiana TRM (v2.2)

Savings Summary for Heat Pump Water Heaters

Table L-10 shows *ex ante* deemed savings and resulting *ex post* per-measure savings for heat pump water heaters. Note that *ex post* results are specific to the participant.

Table L-10. 2020 Whole Home Program *Ex Ante* and *Ex Post* Per-Measure Savings for Heat Pump Water Heaters

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Heat Pump Water Heater	1,697.1	0.237	1,697.1	0.232

The difference between *ex ante* and *ex post* demand reduction is due to rounding.

Water Heater Setback

Algorithms and Variable Assumptions

The evaluation team used two equations from the Illinois TRM (v8) to calculate *ex post,* per-measure energy savings and demand reduction for water heater setback:

$$kWh\ savings_{WH} = \frac{\left(U * A * \left(T_{pre} - T_{post}\right) * AOH * ISR\right)}{3{,}412 * \ RE_{elec}}$$

$$kW\ reduction_{WH}\ = \Delta kWh/\ AOH\ *\ CF$$

Where:

U = Overall heat transfer coefficient of tank (Btu/hr-F-ft^2)

A = Surface area of tank (square feet)

T_{pre} = Hot water setpoint prior to adjustment (°F)

T_{post} = Hot water setpoint after adjustment (°F)

AOH = Hours per year

ISR = In-service rate of electric water heater

RE_{elec} = Recovery efficiency of electric water heater

CF = Coincidence factor

Table I-11 summarizes *ex post* assumptions and sources for water heater setback savings.

Table L-11. 2020 Whole Home Program *Ex Post* Variable Assumptions for Water Heater Setback

Variable	Value	Source
Overall heat transfer coefficient of tank (U)	0.083	Illinois TRM (v8)
Surface area of tank (A)	Actual	Program tracking data or Illinois TRM (v8) when actual not provided
Hot water setpoint prior to adjustment (T_{pre})	Actual	Program tracking data or Illinois TRM (v8) when actual not provided
Hot water setpoint after adjustment (T_{post})	120	Illinois TRM (v8)
Hours per year (AOH)	8,766	Illinois TRM (v8)
In-service rate (ISR)	1	Illinois TRM (v8)
Recovery efficiency (RE_{elec})	0.98	Illinois TRM (v8)
Coincidence factor (CF)	1.0	Illinois TRM (v8)

Savings Summary for Water Heater Setback

Table L-12 shows *ex ante* deemed savings and the resulting *ex post,* per-measure savings for water heater setbacks.

Table L-12. 2020 Whole Home Program *Ex Ante* and *Ex Post* Per-Measure Savings for Water Heater Setback

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Water Heater Setback	104.60	0.012	83.30	0.010

The difference between *ex ante* and *ex post* savings is due to using actual versus assumed water heater tank size and outlet temperature prior to setback for some projects. CLEAResult provided the evaluation team with water heater tank size and water heater outlet temperature prior to setback for 11 of 37 projects. When actual data were not provided, the evaluation team referenced the Illinois TRM (v8) for deemed water heater size and temperature prior to setback.

Pipe Wrap Insulation

Algorithms and Variable Assumptions

The evaluation team used two equations from the Indiana TRM (v2.2) to calculate *ex post* per-measure energy savings and demand reduction for pipe wrap insulation installed in homes with an electric water heater:

$$kWh\ savings_{pipe\ insulation} = \frac{\left(\frac{1}{R_{existing}} - \frac{1}{R_{new}}\right) * L * C * (\Delta T) * Hrs/yr}{3{,}412 * EF_{electric\ WH}}$$

$$kW\ reduction_{pipe\ insulaton} = \frac{kWh\ savings_{pipe\ insulation}}{Hrs/yr}$$

Where:

$R_{existing}$	=	R-value of uninsulated hot water pipe
R_{new}	=	R-value after installing new pipe insulation
L	=	Total linear feet of installed pipe insulation
C	=	Circumference of hot water pipe in feet (assumed pipe diameter of 0.5 inches): C = $\pi * pipe\ diameter * 0.083$
ΔT	=	Difference between ambient temperature where water heater is installed and temperature of distributed hot water
Hrs/yr	=	Total number of hours per year the water heater remains in operation
$EF_{electric\ WH}$	=	Energy factor of electric water heater in operation

Table L-13 shows *ex post* assumptions and sources for installed pipe wrap insulation.

Table L-13. 2020 Whole Home Program *Ex Post* Variable Assumptions for Pipe Wrap Insulation

Variable	Value	Source
R-value of uninsulated pipe ($R_{existing}$)	1	Indiana TRM (v2.2)
R-value after new pipe insulation (R_{new})	3	Indiana TRM (v2.2)
Pipe length (L)	1	To calculate savings in 1-foot increments
Circumference (C)	0.196	Assumes 0.75-inch diameter pipe
Temperature change (ΔT)	65	Indiana TRM (v2.2)
Hours per year (Hrs/yr)	8,760	Indiana TRM (v2.2)
Energy Factor (EF)	0.98	Indiana TRM (v2.2)

Savings Summary for Pipe Wrap Insulation

Table L-14 shows *ex ante* deemed savings and resulting *ex post* savings for pipe wrap insulation, per installed foot.

Table L-14. 2020 Whole Home Program *Ex Ante* and *Ex Post* Per Installed Foot Savings for Pipe Wrap Insulation

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Pipe Wrap Insulation (per foot)	22.29	0.003	22.29	0.003

As shown in the table, there are no differences between *ex ante* and *ex post* savings for pipe wrap insulation.

Smart Strips

Algorithms and Variable Assumptions

The evaluation teamed used deemed energy savings and demand reduction values deemed for smart strips, which align with the median value for a Class F, Tier 2 Smart Strip in the Illinois TRM v8:

$$kWh\ savings_{Smart\ Strip} = \text{deemed} = 24.3$$

$$kW\ reduction_{Smart\ Strip} = deemed = 0.0044$$

Savings Summary for Smart Strips

Ex ante deemed savings and resulting *ex post* per-measure savings for smart strips are shown in Table L-15.

Table L-15. 2020 Whole Home Program *Ex Ante* and *Ex Post* Per-Measure Savings for Smart Strips

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Smart Strips	150.00	0.027	150.00	0.027

As shown in the table, there are no differences between *ex ante* and *ex post* savings for smart strips.

Programmable Thermostats

Algorithms and Variable Assumptions

The evaluation team used three equations from the Indiana TRM (v2.2) to calculate *ex post* per-measure energy savings for programmable thermostats:

$$kWh\ savings_{PStat} = kWh\ savings_{AC\ cooling} + kWh\ savings_{Elec\ htg}$$

$$kWh\ savings_{AC\ cooling} = \frac{1}{n_{cool}} * FLH_{cool} * \frac{BTUh_{cool}}{1000} * ESF_{cool}$$

$$kWh\ savings_{Elec\ htg} = FLH_{heat} * \frac{BTUh_{heat}}{n_{heat} * 3{,}412} * ESF_{heat}$$

Where:

n_{cool} = Efficiency of existing cooling system controlled by programmable thermostat (in units of SEER)

FLH_{cool} = Full-load cooling hours for Indianapolis

$BTUh_{cool}$ = Capacity of cooling system (Btu/hour)

ESF_{cool} = Energy savings factor for cooling

FLH_{heat} = Full-load heating hours for Indianapolis

$BTUh_{heat}$ = Capacity of heating system (Btu/hour)

n_{heat} = Efficiency of existing heating system controlled by programmable thermostat (in units of coefficient of performance)

ESF_{heat} = Energy savings factor for heating

Table L-16 shows *ex post* assumptions and sources for installed programmable thermostats.

Table L-16. 2020 Whole Home Program *Ex Post* Variable Assumptions for Programmable Thermostats

Variable	Value	Source
Efficiency of existing cooling system (n_{cool})	11.15	Indiana TRM (v2.2)
Full-load cooling hours (FLH_{cool})	487	Indiana TRM (v2.2) for Indianapolis
Capacity of cooling system ($BTUh_{cool}$)	28,994	Indiana TRM (v2.2)
Energy savings factor for cooling (ESF_{cool})	0.09	Indiana TRM (v2.2)
Full-load heating hours (FLH_{heat})	1,341	Indiana TRM (v2.2) for Indianapolis
Capacity of heating system ($BTUh_{heat}$)	32,000	2016 Pennsylvania TRM
Efficiency of existing heating system (n_{heat})	1	Indiana TRM (v2.2)
Energy savings factor for heating (ESF_{heat})	0.068	Indiana TRM (v2.2)

Savings Summary for Programmable Thermostats

Table L-17 shows *ex ante* deemed savings and resulting *ex post* per-measure savings for programmable thermostats.

Table L-17. 2020 Whole Home Program *Ex Ante* and *Ex Post* Per-Measure Savings for Programmable Thermostats

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Programmable Thermostat (Natural Gas Heat + Central AC)	113.97	0	113.97	0

As shown in the table, there are no differences between *ex ante* and *ex post* savings for programmable thermostats.

Smart Thermostats

Algorithms and Variable Assumptions

The evaluation team used three equations from the Indiana TRM (v2.2) to calculate *ex post* per-measure energy savings for smart thermostats:

$$kWh\ savings_{PStat} = kWh\ savings_{AC\ cooling} + kWh\ savings_{Elec\ htg}$$

$$kWh\ savings_{AC\ cooling} = \frac{1}{n_{cool}} * FLH_{cool} * \frac{BTUh_{cool}}{1000} * ESF_{cool}$$

$$kWh\ savings_{Elec\ htg} = FLH_{heat} * \frac{BTUh_{heat}}{n_{heat} * 3{,}412} * ESF_{heat}$$

Where:

n_{cool} = Efficiency of existing cooling system controlled by programmable thermostat (in SEER units)

FLH_{cool} = Full-load cooling hours for Indianapolis

$BTUh_{cool}$ = Capacity of cooling system (Btu/hour)

ESF_{cool} = Energy savings factor for cooling

FLH_{heat} = Full-load heating hours for Indianapolis

$BTUh_{heat}$ = Capacity of heating system (Btu/hour)

n_{heat} = Efficiency of existing heating system controlled by programmable thermostat (in coefficient of performance units)

ESF_{heat} = Energy savings factor for heating

Table L-18 shows *ex post* assumptions and sources for installed smart thermostat savings.

Table L-18. 2020 Whole Home Program *Ex Post* Variable Assumptions for Smart Thermostats

Variable	Value	Source
Efficiency of existing cooling system (n_{cool})	11.15	Indiana TRM (v2.2)
Full-load cooling hours (FLH_{cool})	487	Indiana TRM (v2.2) for Indianapolis
Capacity of cooling system ($BTUh_{cool}$)	28,994	Indiana TRM (v2.2)
Energy savings factor for cooling (ESF_{cool})	0.049 if replacing programmable in use, else 0.139	Vectren 2015 report [a]
Full-load heating hours (FLH_{heat})	1,341	Indiana TRM (v2.2) for Indianapolis
Capacity of heating system ($BTUh_{heat}$)	32,000	2016 Pennsylvania TRM
Efficiency of existing heating system (n_{heat} for electric resistance)	1	Indiana TRM (v2.2)
Efficiency of existing heating system (n_{heat} for heat pump)	2.26	Indiana TRM (v2.2)
Energy savings factor for heating (ESF_{heat})	0.057 if replacing programmable in use, else 0.125	Vectren 2015 report [a]

[a] Cadmus. January 29, 2015. *Evaluation of the 2013-2014 Programmable and Smart Thermostat Program.* Prepared for Northern Indiana Public Service Company and Vectren Corporation.

Savings Summary for Smart Thermostats

Table L-19 shows *ex ante* deemed savings and resulting average *ex post* per-measure savings for smart thermostats.

Table L-19. 2020 Whole Home Program *Ex Ante* and *Ex Post* Per-Measure Savings for Smart Thermostats

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Smart Thermostat with Enrollment (Electric Heat + Central AC)	1,123.83	0	1,341.30	0
Smart Thermostat with Enrollment (ASHP)	533.89	0	625.03	0
Smart Thermostat with Enrollment (Natural Gas Heat + Central AC)	118.79	0	118.79	0
Smart Thermostat without Enrollment (ASHP)	706.57	0	871.64	0
Smart Thermostat without Enrollment (Natural Gas Heat + Central AC)	62.05	0	62.05	0

The differences between *ex ante* and *ex post* savings are due to using a different energy savings factor for manual thermostats: CLEAResult applied an undocumented energy savings factor while the evaluation team applied the savings factor from the Cadmus 2015 report, *Evaluation of the 2013-2014 Programmable and Smart Thermostat Program*.

Duct Sealing

Algorithms and Variable Assumptions

The evaluation team used four equations from the Indiana TRM (v2.2) to calculate *ex post* per-measure energy savings and demand reduction for duct sealing.

$$kWh\ savings_{PStat} = kWh\ savings_{heat} + kWh\ savings_{cool}$$

$$kWh\ Savings_{heat} = \frac{(DE_{After} - DE_{Before})}{DE_{fter}} * \frac{FLH_{heat} * Btuh_{heat}}{n_{heat} * 3{,}412}$$

$$kWh\ Savings_{cool} = \frac{(DE_{After} - DE_{Before})}{DE_{After}} * \frac{FLH_{cool} * Btuh_{cool}}{SEER * 1{,}000}$$

$$kW\ Savings = \frac{(DE_{After} - DE_{Before})}{DE_{After}} * \frac{Btuh_{cool}}{EER * 1{,}000} * CF$$

Where:

DE_{After}	=	Distribution system efficiency after duct sealing
DE_{Before}	=	Distribution system efficiency before duct sealing
FLH_{heat}	=	Full-load heating hours for Indianapolis
$Btuh_{heat}$	=	Capacity of heating system (Btu/hour)
n_{heat}	=	Efficiency of existing heating system controlled by programmable thermostat (in coefficient of performance units)
FLH_{cool}	=	Full-load cooling hours for Indianapolis
$Btuh_{cool}$	=	Capacity of cooling system (Btu/hour)
SEER	=	Seasonal average efficiency of AC equipment
EER	=	Peak efficiency of AC equipment (in EER units); if unknown, EER = SEER * 0.9
CF	=	Coincidence factor

Table L-20 shows *ex post* assumptions and sources for duct sealing.

Table L-20. 2020 Whole Home Program *Ex Post* Variable Assumptions for Duct Sealing

Variable	Value	Source
Distribution system efficiency after duct sealing (DE_{After} for cool)	Actual	Participant data
Distribution system efficiency after duct sealing (DE_{After} for heat)	Actual	Participant data
Distribution system efficiency after duct sealing (DE_{Before} for cool)	Actual	Participant data
Distribution system efficiency after duct sealing (DE_{Before} for heat)	Actual	Participant data
Full-load heating hours (FLH_{heat})	1,341	Indiana TRM (v2.2)
Capacity of heating system ($Btuh_{heat}$)	Actual	Participant data
Efficiency of existing heating system (n_{heat} for heat pump after 2006)	2.26	Indiana TRM (v2.2)
Efficiency of existing heating system (n_{heat} for electric resistance)	1	Indiana TRM (v2.2)
Full-load cooling hours (FLH_{cool})	487	Indiana TRM (v2.2)
Capacity of cooling system ($Btuh_{cool}$)	Actual	Participant data
Seasonal average efficiency (SEER)	11.15	Indiana TRM (v2.2)
Peak efficiency (EER)	10.035	Indiana TRM (v2.2), EER = SEER * 0.9
Coincidence factor (CF)	0.88	Indiana TRM (v2.2)

Savings Summary for Duct Sealing

Table L-21 shows *ex ante* deemed savings and resulting *ex post* per-measure savings for duct sealing.

Table L-21. 2020 Whole Home Program *Ex Ante* and *Ex Post* Per-Measure Savings for Duct Sealing

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Duct Sealing (Heat Pump)	298.68	0.138	298.62	0.138
Duct Sealing (Electric Heat and Central AC)	429.24	0.084	429.40	0.084

As shown in the table, there are only very slight differences between *ex ante* and *ex post* savings for duct sealing, due to rounding.

Air Sealing

Algorithms and Variable Assumptions

The evaluation team used two equations from the Indiana TRM (v2.2) to calculate *ex post* per-measure energy savings and demand reduction for air sealing measures.

$$kWh\ savings_{Air\ Sealing} = (CFM50_{existing} - CFM50_{air\ sealed}) * \frac{\left(\frac{\Delta kWh}{CFM}\right)}{N_{factor}}$$

$$kW\ reduction_{Air\ Sealing} = (CFM50_{existing} - CFM50_{air\ sealed}) * \frac{\left(\frac{\Delta kW}{CFM}\right)}{N_{factor}} * CF$$

Where:

$CFM50_{existing}$ = Initial blower door test results measured in CFM, pressurized at 50 pascal, of the home air leakage amount prior to air-sealing measures

$CFM50_{air\ sealed}$ = Blower door test results measured in CFM, pressurized at 50 pascal, of the home air leakage amount after installing air-sealing measures

$\Delta kWh/CFM$ = Energy savings for each CFM reduction (varies by HVAC equipment)

N_{factor} = Constant used to convert 50-pascal airflow to natural airflow, dependent on exposure levels

$\Delta kW/CFM$ = Demand reduction for each CFM reduction (varies by HVAC equipment)

CF = Coincidence factor; a number between 0 and 1 indicating the ratio of cooling equipment expected to be in use and saving energy during the peak summer demand period

Table L-22 shows *ex post* assumptions and sources for the air sealing measure.

Table L-22. 2020 Whole Home Program *Ex Post* Variable Assumptions for Air Sealing

Variable	Value	Source
Initial blower door test results ($CFM50_{existing}$)	Actual	Program data
Blower door test results after air sealing ($CFM50_{air\ sealed}$)	Actual	
Energy savings (ΔkWh/CFM for electric heat and central AC)	50.1	Indiana TRM (v2.2)
Energy savings (ΔkWh/CFM for ASHP)	30.9	
Energy savings (ΔkWh/CFM for electric heat only)	48.2	
Airflow conversion constant (N_{factor})	16.3	Indiana TRM (v2.2) for unknown number of stories and exposure
Demand reduction (ΔkW/CFM for electric heat and central AC)	0.006	Indiana TRM (v2.2)
Demand reduction (ΔkW/CFM for ASHP)	0.003	
Demand reduction (ΔkW/CFM for electric heat only)	0	
Coincidence factor (CF)	0.88	Indiana TRM (v2.2)

Savings Summary for Air Sealing

CLEAResult and the evaluation team calculated savings using similar approaches, leveraging project-specific information where available (such as pre- and post-installation CFM). Table L-23 shows a comparison of average savings per participant for *ex ante* and *ex post*.

Table L-23. 2020 Whole Home Program *Ex Ante* and *Ex Post* Per-Measure Savings for Air Sealing

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Air Sealing (Electric Heat with Central AC)	1,547.63	0.163	1,547.63	0.163
Air Sealing (Heat Pump)	517.41	0.044	517.41	0.044

As shown in the table, there are no differences between *ex ante* and *ex post* savings for air sealing.

Central Air Conditioning

Algorithms and Variable Assumptions

The evaluation team used two equations from the Indiana TRM (v2.2) to calculate *ex post* per-measure energy savings and demand reduction for replacing an existing, inefficient central AC unit with an ENERGY STAR unit.

$$kWh\ savings\ = EFLH_{cool} * Btuh * \frac{\left(\frac{1}{SEER_{existing}} - \frac{1}{SEER_{ee}}\right)}{1{,}000}$$

$$kW\ savings\ = EFLH_{cool} * Btuh * \frac{\left(\frac{1}{EER_{existing}} - \frac{1}{EER_{ee}}\right)}{1{,}000} * CF$$

Where:

$EFLH_{cool}$	=	Full-load cooling hours for Indianapolis
Btuh	=	Size of equipment in Btuh
$SEER_{existing}$	=	Seasonal average efficiency of existing unit
$SEER_{ee}$	=	Seasonal average efficiency of ENERGY STAR unit
$EER_{existing}$	=	Energy efficiency of existing unit
EER_{ee}	=	Energy efficiency of ENERGY STAR unit
CF	=	Summer peak coincident factor

Table L-24 shows *ex post* assumptions and sources for the central AC measure.

Table L-24. 2020 Whole Home Program *Ex Post* Variable Assumptions for Central Air Conditioning

Variable	Value	Source
Full-load cooling hours ($EFLH_{cool}$)	487	Indiana TRM (v2.2) for Indianapolis
Size of equipment (Btuh)	28,994	Indiana TRM (v2.2)
Seasonal average efficiency of existing unit ($SEER_{existing}$)	Actual or 11.15	Participant data or Indiana TRM (v2.2)
Seasonal average efficiency of ENERGY STAR unit ($SEER_{ee}$)	16, 17, or 18	Program data
Energy efficiency of existing unit ($EER_{existing}$)	10.035	EER = SEER * 0.9
Energy efficiency of ENERGY STAR unit (EER_{ee})	SEER * 0.9	Indiana TRM (v2.2)
Coincidence factor (CF)	0.88	Indiana TRM (v2.2)

Savings Summary for Central Air Conditioning

Table L-25 shows *ex ante* deemed savings and resulting *ex post* per-measure savings for the central AC measure.

Table L-25. 2020 Whole Home Program *Ex Ante* and *Ex Post* Per-Measure Savings for Central Air Conditioning

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Central AC 16 SEER	294.57	0.707	393.72	0.791
Central AC 17 SEER	371.00	0.859	494.43	0.993
Central AC 18 SEER	518.70	1.154	615.92	1.237

The differences between *ex ante* and *ex post* savings resulted for two reasons:

- ***SEER values:*** There were several outlier baseline SEER values in the participant tracking data that appeared to be cooling capacity rather than SEER. In these cases, the evaluation team used the Indiana TRM (v2.2) deemed value for SEER.
- ***Cooling capacity:*** Actual cooling capacity was not provided in the tracking data, so the evaluation team referred to the Indiana TRM (v2.2). CLEAResult used actual cooling capacity to calculate *ex ante* savings.

Air-Source Heat Pump

Algorithms and Variable Assumptions

The evaluation team used two equations from the Indiana TRM (v2.2) to calculate *ex post* per-measure energy savings and demand reduction for replacing an existing, inefficient central heat pump with an ENERGY STAR unit:

$$kWh\ savings = EFLH_{cool} * Btuh_{cool} * \frac{\left(\frac{1}{SEER_{existing}} - \frac{1}{SEER_{ee}}\right)}{1{,}000} + EFLH_{heat} * Btuh_{heat} * \frac{\left(\frac{1}{HSPF_{existing}} - \frac{1}{HSPF_{ee}}\right)}{1{,}000}$$

$$kW\ savings = EFLH_{cool} * Btuh_{cool} * \frac{\left(\frac{1}{EER_{existing}} - \frac{1}{EER_{ee}}\right)}{1{,}000} * CF$$

Where:

$EFLH_{cool}$	=	Full-load cooling hours for Indianapolis
$Btuh_{cool}$	=	Size of cooling equipment in Btuh
$SEER_{existing}$	=	Seasonal energy efficiency of existing unit
$SEER_{ee}$	=	Seasonal energy efficiency of ENERGY STAR unit
$EFLH_{heat}$	=	Full-load heating hours, Indianapolis
$Btuh_{heat}$	=	Size of heating equipment in Btuh
$HSPF_{existing}$	=	Heating seasonal performance factor of existing ASHP
$HSPF_{ee}$	=	Heating seasonal performance factor of efficient ASHP

$EER_{existing}$ = Energy efficiency of existing unit

EER_{ee} = Energy efficiency of ENERGY STAR unit

CF = Summer peak coincident factor

Table L-26 shows *ex post* assumptions and sources for the central ASHP measure.

Table L-26. 2020 Whole Home Program *Ex Post* Variable Assumptions for Air-Source Heat Pumps

Variable	Value	Source
Full-load cooling hours ($EFLH_{cool}$)	487	Indiana TRM (v2.2) for Indianapolis
Size of cooling equipment ($Btuh_{cool}$)	28,994	Indiana TRM (v2.2)
Seasonal energy efficiency of existing unit ($SEER_{existing}$)	Actual or 11.15	Participant data or Indiana TRM (v2.2) where actual was not provided
Seasonal energy efficiency of ENERGY STAR unit ($SEER_{ee}$)	16, 17, or 18	Program data
Full-load heating hours ($EFLH_{heat}$)	1,341	Indiana TRM (v2.2)
Size of heating equipment ($Btuh_{heat}$)	36,000	Indiana TRM (v2.2)
Heating seasonal performance factor of existing ASHP ($HSPF_{existing}$)	7.7	Indiana TRM (v2.2), baseline SEER
Heating seasonal performance factor of efficient pump ($HSPF_{ee}$)	9.5	ENERGY STAR database
Energy efficiency of existing unit ($EER_{existing}$)	11.7	Indiana TRM (v2.2)
Energy efficiency of ENERGY STAR unit (EER_{ee})	SEER * 0.9	Indiana TRM (v2.2)
Coincident factor (CF)	0.88	Indiana TRM (v2.2)

Savings Summary for Heat Pumps

Table L-27 shows *ex ante* deemed savings and resulting *ex post* per-measure savings for the central ASHP measure.

Table L-27. 2020 Whole Home Program *Ex Ante* and *Ex Post* Per-Measure Savings for Air-Source Heat Pumps

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Heat Pump 16 SEER	1,120.73	0.719	1,063.73	0.878
Heat Pump 17 SEER	1,548.20	0.858	1,072.58	0.895
Heat Pump 18+ SEER	1,817.81	0.977	1,180.50	1.111

The differences between *ex ante* and *ex post* savings are due to different equipment heating and cooling capacity or heating seasonal performance factors for the efficient equipment. The evaluation team did not receive information about the existing or replacement heating and cooling equipment, so we used equipment capacity and HSPF assumptions from the Indiana TRM (v2.2). The team also referred to the Indiana TRM (v2.2) when baseline SEER was not included in the tracking data.

Air Conditioner Tune-Ups

Algorithms and Variable Assumptions

The evaluation team used two equations from the Indiana TRM (v2.2) to calculate *ex post* per-measure energy savings and demand reduction for correcting any problems with the refrigerant charge levels and airflow over the cooling unit:

$$kWh\ savings = EFLH_{cool} * Btuh_{cool} * \frac{1}{SEER_{CAC} * 1{,}000} * MF_E$$

$$kW\ savings = Btuh_{cool} * \frac{1}{EER * 1{,}000} * MF_D * CF$$

Where:

$EFLH_{cool}$	=	Full-load cooling hours for Indianapolis
$Btuh_{cool}$	=	Size of cooling equipment in Btuh
$SEER_{CAC}$	=	Seasonal energy efficiency of existing unit
MF_E	=	Maintenance energy savings factor
EER	=	EER efficiency of existing unit
MF_D	=	Maintenance demand reduction factor
CF	=	Summer peak coincident factor

Table L-28 shows *ex post* assumptions and sources for the AC tune-up measure.

Table L-28. 2020 Whole Home Program *Ex Post* Variable Assumptions for Air Conditioner Tune-Ups

Variable	Value	Source
Full-load cooling hours ($EFLH_{cool}$)	487	Indiana TRM (v2.2) for Indianapolis
Size of cooling equipment ($Btuh_{cool}$)	28,994	Indiana TRM (v2.2)
Seasonal energy efficiency of existing central AC ($SEER_{CAC}$)	Actual or 11.15	Participant data or Indiana TRM (v2.2) where actual was not provided
Maintenance energy savings factor (MF_E)	0.05	Indiana TRM (v2.2)
Energy efficiency of existing unit (EER)	SEER*0.9	Indiana TRM (v2.2)
Maintenance demand reduction factor (MF_D)	0.05	Indiana TRM (v2.2)
Coincident factor (CF)	0.88	Indiana TRM (v2.2)

Savings Summary for Air Conditioner Tune-Ups

Table L-29 shows *ex ante* deemed savings and resulting *ex post* per-measure savings for the AC tune-up measure.

Table L-29. 2020 Whole Home Program *Ex Ante* and *Ex Post* Per-Measure Savings for Air-Conditioner Tune-Ups

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Air Conditioner Tune-Up	59.66	0.146	57.46	0.115

The differences between *ex ante* and *ex post* savings are due to different equipment capacity and SEER values. Actual equipment capacity information was not provided for the participants, and SEER values were not included for 47 of the 191 participants. The evaluation team referred to the Indiana TRM (v2.2) where actual data were not available.

Air-Source Heat Pump Tune-Ups

Algorithms and Variable Assumptions

The evaluation team used two equations from the Indiana TRM (v2.2) to calculate *ex post* per-measure energy savings and demand reduction for correcting any issues with refrigerant charge levels and airflow over the cooling unit:

$$kWh\ savings = (EFLH_{cool} * Btuh_{cool} * \frac{1}{SEER_{ASHP}} + EFLH_{heat} * Btuh_{heat} * \frac{1}{HSPF_{ASHP}}) * \frac{MF_E}{1{,}000}$$

$$kW\ savings = Btuh_{cool} * \frac{1}{EER * 1{,}000} * MF_D * CF$$

Where:

$EFLH_{cool}$	=	Full-load cooling hours for Indianapolis
$Btuh_{cool}$	=	Size of cooling equipment in Btuh
$SEER_{ASHP}$	=	Seasonal energy efficiency of existing unit
$EFLH_{heat}$	=	Full-load heating hours for Indianapolis
$Btuh_{heat}$	=	Size of heating equipment in Btuh
$HSPF_{ASHP}$	=	Heating season performance factor of ASHP
MF_E	=	Maintenance energy savings factor
EER	=	EER efficiency of existing unit
MF_D	=	Maintenance demand reduction factor
CF	=	Summer peak coincident factor

Table L-30 shows *ex post* assumptions and sources for ASHP tune-ups.

Table L-30. 2020 Whole Home Program *Ex Post* Variable Assumptions for Air-Source Heat Pump Tune-Ups

Variable	Value	Source
Full-load cooling hours ($EFLH_{cool}$)	487	Indiana TRM (v2.2) for Indianapolis
Size of cooling equipment ($Btuh_{cool}$)	28,994	Indiana TRM (v2.2)
Seasonal energy efficiency of existing unit ($SEER_{ASHP}$)	Actual or 11.15	Participant data or Indiana TRM (v2.2) where actual was not provided
Full-load heating hours ($EFLH_{heat}$)	1,341	Indiana TRM (v2.2) for Indianapolis
Size of heating equipment ($Btuh_{heat}$)	28,994	Indiana TRM (v2.2)
Heating season performance factor ($HSPF_{ASHP}$)	6.8	Indiana TRM (v2.2)
Maintenance energy savings factor (MF_E)	0.05	Indiana TRM (v2.2)
Energy efficiency of existing unit (EER)	SEER*0.9	Indiana TRM (v2.2)
Maintenance demand reduction factor (MF_D)	0.05	Indiana TRM (v2.2)
Coincident factor (CF)	0.88	Indiana TRM (v2.2)

Savings Summary for ASHP Tune-Ups

Table L-31 shows *ex ante* deemed savings and resulting *ex post* per-measure savings for the ASHP tune-up measure.

Table L-31. 2020 Whole Home Program *Ex Ante* and *Ex Post* Per-Measure Savings for Air-Source Heat Pump Tune-Ups

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
ASHP Tune-Up	251.89	0.145	340.25	0.109

The differences between *ex ante* and *ex post* savings are due to different equipment capacity and SEER values. Actual equipment capacity information was not provided and SEER values were not included for 47 of the 191 participants. The evaluation team referred to the Indiana TRM (v2.2) where actual data were not available.

Attic Insulation

Algorithms and Variable Assumptions

The evaluation team used two equations from the Indiana TRM (v2.2) to calculate *ex post,* per-measure energy savings and demand reduction for attic insulation:

$$kWh\ savings_{Insulation} = kSF * \left(\frac{\Delta kWh}{kSF}\right)$$

$$kW\ reduction_{Insulation} = kSF * \left(\frac{\Delta kW}{kSF}\right) * CF$$

Where:

kSF	=	Total area (in 1,000 square feet) of installed insulation
ΔkWh/kSF	=	Energy savings for every 1,000 square feet of installed insulation, accounting for pre- and post-installation R-value conditions (varies by HVAC equipment)
ΔkW/kSF	=	Demand reduction for every 1,000 square feet of installed insulation, accounting for pre- and post-installation R-value conditions (varies by HVAC equipment)
CF	=	Coincidence factor; a number between 0 and 1 indicating the ratio of cooling equipment expected to be in use and saving energy during the peak summer demand period

The Indiana TRM (v2.2) provides lookup tables that include expected energy savings and demand reduction (per 1,000 square feet of installed insulation) for different pre- and post-insulation R-values. The evaluation team calculated these R-values using a three-step process:

1. Determine variables for insulation compression, R-value ratios, and void factors
2. Calculate the adjusted R-values
3. Interpolate within Indiana TRM (v2.2) tables[85] using the adjusted R-values and obtain savings per 1,000 square feet of insulation (ΔkWh/kSF and ΔkW/kSF)

Step 1: Determine Variables for Insulation Compression, R-Value Ratios, and Void Factors

Insulation Compression

Insulation compressed during installation results in reduced R-values. Therefore, it is important to account for compression when calculating insulation savings. There was no information for this evaluation that supports adjusting R-values due to compression, so the team assumed 0% compression.

R-Value Ratio

The void factor varies based on the ratio between the full assembly R-value and the nominal R-value with the inclusion of compression effects. The evaluation team used this ratio to identify the void factor in lookup tables provided in the Indiana TRM (v2.2). The team calculated pre- and post-installation R-value ratios using an equation from Indiana TRM (v2.2):

$$R_{ratio} = (R_{nominal} * F_{compression})/(R_{nominal} + R_{frame\,\&\,air})$$

Where:

$R_{nominal}$	=	Pre- or post-installation R-value provided in program database
$F_{compression}$	=	Compression factor dependent on the percentage of insulation compression (= 1, assuming 0% compression)

85 "Appendix C – Insulation Measures in Single Family Buildings."

$R_{frame \& air}$ = R-value for materials, framing, and air space for the area where insulation is installed (= R-5 per the Indiana TRM (v2.2))

Void Factor

Table L-32 outlines the void factor, based on the calculated R-value ratio. The evaluation team assumed a 2% void for pre- and post-insulation installation, as this information remained unknown.

Table L-32. 2020 Whole Home Program Insulation Void Factors

R-Value Ratio	Void Factor	
	2% Void (Grade II) [a]	5% Void (Grade III)
0.50	0.96	0.90
0.55	0.96	0.90
0.60	0.95	0.88
0.65	0.94	0.87
0.70	0.94	0.85
0.75	0.92	0.83
0.80	0.91	0.79
0.85	0.88	0.74
0.90	0.83	0.66
0.95	0.71	0.49
0.99	0.33	0.16

Source: Indiana TRM (v2.2).

[a] The evaluation team assumed a 2% void.

Step 2: Calculate the Adjusted R-Values

The evaluation team used R-values from the 2020 program tracking database to calculate adjusted R-values that accounted for factors such as compression, void factors, and installation grade levels via the following formula:

$$Rvalue_{Adjusted} = R_{nominal} * F_{compression} * F_{void}$$

Where:

$R_{nominal}$ = Pre- or post-installation R-value provided in program database

$F_{compression}$ = Compression factor dependent on the percentage of insulation compression (= 1, assuming 0% compression)

F_{void} = Void factor dependent on the insulation installation grade level and percentage of coverage

Step 3: Interpolate within Indiana TRM (v2.2) Tables

The evaluation team interpolated per-measure energy savings and demand reduction values found in the Indiana TRM (v2.2) to determine savings per 1,000 square feet for the adjusted pre- and post-installation R-values (calculated in Step 2).

Savings Summary for Attic Insulation

The evaluation team calculated *ex ante* and *ex post* savings using a custom approach that leveraged project-specific information where available (such as pre- and post-installation R-values), therefore developing unique savings per participant. Rather than display all unique savings values, Table L-33 shows average savings per participant.

Table L-33. 2020 Whole Home Program *Ex Ante* and *Ex Post* Per-Participant Savings for Attic Insulation

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Attic Insulation R≤11 to R-49 (ASHP)	5,073.17	1.0882	5,184.70	0.9260
Attic Insulation R≤11 to R-49 (Electric Furnace + Central AC)	10,155.44	1.0025	8,841.32	0.8450
Attic Insulation R≤11 to R-49 (Natural Gas Furnace + Central AC)	949.71	0.7191	845.32	0.5470
Attic Insulation R-12 to R-49 (ASHP)	2,528.05	0.5424	2,295.76	0.4020
Attic Insulation R-12 to R-49 (Natural Gas Furnace + Central AC)	431.55	0.3268	345.22	0.2460

The differences between *ex ante* and *ex post* savings are due to different per-thousand-square-feet savings values. The evaluation team determined that CLEAResult applied the Indiana TRM (v2.2) deemed kilowatts and kilowatt-hours per thousand square feet values that most closely resembled the pre-determined R-value bins, whereas the evaluation team interpolated within the Indiana TRM (v2.2) deemed savings values for those that reflect actual pre- and post-installation conditions.

Mini Split Heat Pumps

Algorithms and Variable Assumptions

The evaluation team used two equations from the Indiana TRM (v2.2) to calculate *ex post* per-measure energy savings and demand reduction for installing mini-split heat pumps:

$$kWh\ savings = \frac{CAPY_{heat}}{1{,}000} * \left(\frac{OF * DLF}{HSPF_{base}} - \frac{1}{HSPF_{ee}}\right) * EFLH_{heat} + \frac{CAPY_{cool}}{1{,}000} * \left(\frac{OF * DLF}{SEER_{base}} - \frac{1}{SEER_{ee}}\right) * EFLH_{cool}$$

$$kW\ savings = \frac{CAPY_{cool}}{1{,}000} * \left(\frac{OF * DLF}{EER_{base}} - \frac{1}{EER_{ee}}\right) * CF$$

Where:

$CAPY_{heat}$ = Heating capacity of the ductless heat pump unit

OF = Oversize factor to account for baseline unit oversizing

DLF = Duct leakage factor

$HSPF_{base}$ = Heating seasonal performance factor of baseline unit

$HSPF_{ee}$ = Heating seasonal performance factor of efficient unit

$EFLH_{heat}$ = Equivalent full-load heating hours

$CAPY_{cool}$ = Cooling capacity of ductless heat pump unit

$SEER_{base}$ = Seasonal energy efficiency of baseline unit

$SEER_{ee}$ = Seasonal energy efficiency of efficient unit

$EFLH_{cool}$ = Equivalent full-load cooling hours

EER_{base} = Energy efficiency ratio of baseline unit

EER_{ee} = Energy efficiency ratio of efficient unit

CF = Summer peak coincident factor

Table L-34 shows *ex post* assumptions and sources for the mini-split heat pump measure.

Table L-34. 2020 Whole Home Program *Ex Post* Variable Assumptions for Mini Split Heat Pumps

Variable	Value	Source
Heating capacity of the ductless heat pump unit ($CAPY_{heat}$)	18,000	Program information
Oversize factor to account for baseline unit oversizing (OF, ASHP)	1.4	Pennsylvania TRM (2016)
Oversize factor to account for baseline unit oversizing (OF, electric furnace)	1.5	Pennsylvania TRM (2016)
Oversize factor to account for baseline unit oversizing (OF, electric baseboard)	1.4	Pennsylvania TRM (2016)
Oversize factor to account for baseline unit oversizing (OF, room AC)	1	Pennsylvania TRM (2016)
Duct leakage factor (DLF, ASHP)	1.15	Pennsylvania TRM (2016)
Duct leakage factor (DLF, electric furnace)	1.15	Pennsylvania TRM (2016)
Duct leakage factor (DLF, electric baseboard)	1	Pennsylvania TRM (2016)
Duct leakage factor (DLF, room AC)	1	Pennsylvania TRM (2016)
Heating seasonal performance factor of baseline unit ($HSPF_{base}$, ASHP)	8.2	Pennsylvania TRM (2016)
Heating seasonal performance factor of baseline unit ($HSPF_{base}$, electric furnace)	3.242	Pennsylvania TRM (2016)
Heating seasonal performance factor of baseline unit ($HSPF_{base}$, electric baseboard)	3.412	Pennsylvania TRM (2016)
Heating seasonal performance factor of baseline unit ($HSPF_{base}$, room AC)	8.2	Pennsylvania TRM (2016)
Heating seasonal performance factor of efficient unit ($HSPF_{ee}$)	Actual	Pennsylvania TRM (2016)
Equivalent full-load heating hours ($EFLH_{heat}$)	1,341	Indiana TRM (v2.2)
Cooling capacity of ductless heat pump unit ($CAPY_{cool}$)	18,000	Program information
Seasonal energy efficiency of baseline unit ($SEER_{base}$)	Actual or 11.15	Participant data
Seasonal energy efficiency of efficient unit ($SEER_{ee}$)	Actual or 11.15	Participant data
Equivalent full-load cooling hours ($EFLH_{cool}$)	487	Indiana TRM (v2.2)
Energy efficiency ratio of baseline unit (EER_{base})	$SEER_{base}$ * 0.9	Indiana TRM (v2.2)
Energy efficiency ratio of efficient unit (EER_{ee})	$SEER_{ee}$ * 0.9	Indiana TRM (v2.2)
Summer peak coincident factor (CF)	0.647	Pennsylvania TRM (2016)

Savings Summary for Mini Split Heat Pumps

Table L-35 shows *ex ante* deemed savings and resulting *ex post* per-measure savings for the mini split heat pump measure.

Table L-35. 2020 Whole Home Program *Ex Ante* and *Ex Post* Per-Measure Savings for Mini Split Heat Pumps

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Mini Splits 19 SEER. 9.5 HSPF - Replacing ASHP	3,131.85	1.0446	2,760.55	0.8297
Mini Splits 19 SEER, 9.5 HSPF - Replacing electric furnace (with or without Central AC)	27,106.25	1.8125	11,022.30	1.0626
Mini Splits 19 SEER, 9.5 HSPF - Replacing Room AC or None	779.98	0.3232	642.68	0.3541
Mini Splits 21 SEER, 10 HSPF - Replacing ASHP	3,881.63	1.3375	2,930.07	0.8924
Mini Splits 21 SEER, 10 HSPF - Replacing electric furnace (with or without Central AC)	19,563.01	1.7305	11,185.46	1.1159
Mini Splits 21 SEER, 10 HSPF - Replacing Electric Baseboard	8,429.03	0.8147	8,026.73	0.7917
Mini Splits 21 SEER, 10 HSPF - Replacing Room AC or None	833.86	0.3496	816.41	0.4230
Mini Splits 23+ SEER, 10 HSPF - Replacing ASHP	4,682.78	1.4561	2,981.00	0.9676
Mini Splits 23+ SEER, 10 HSPF - Replacing electric furnace (with or without Central AC)	37,037.12	2.3925	11,284.11	1.2615
Mini Splits 23+ SEER, 10 HSPF - Replacing Electric Baseboard	5,608.96	0.6177	8,098.59	0.8978
Mini Splits 23+ SEER, 10 HSPF - Replacing Room AC or None	1,354.75	0.5431	888.00	0.5287

The differences between *ex ante* and *ex post* savings resulted from differences in equipment capacity and SEER values. The evaluation team assumed equipment capacity of 18,000 Btuh, as shown in the program information, because actual capacity was not provided, while CLEAResult used actual capacity values. The evaluation team referred to the Indiana TRM (v2.2) when actual SEER was not provided in the participant tracking data, and CLEAResult used actual conditions.

LED Night-Lights

Algorithms and Variable Assumptions

The evaluation team used an equation from the Indiana TRM (v2.2) to calculate *ex post* per-measure energy savings for LED night-lights:

$$kWh\ savings = \frac{\left(W_{base} - W_{Night-light}\right) * (Hrs/day * 365)}{1{,}000}$$

Where:

W_{base} = Baseline wattage of existing night-light (= 5 watts)

$W_{Night\text{-}light}$ = Actual wattage of installed LED night-light (= 0.33 watts)

Hrs/day = Average number of hours per day the night-light remains in use

Table L-36 shows *ex post* assumptions and sources for LED night-lights.

Table L-36. 2020 Whole Home Program *Ex Post* Variable Assumptions for LED Night-Lights

Variable	Value	Source
Baseline wattage (W_{base})	5	Indiana TRM (v2.2)
LED night-light wattage ($W_{Night\text{-}light}$)	0.33	Indiana TRM (v2.2)
Hours per day (Hrs/day)	8	Indiana TRM (v2.2)

Savings Summary for LED Night-Lights

Table L-37 shows *ex ante* deemed savings and the resulting *ex post* per-measure savings for LED night-lights provided in the kits.

Table L-37. 2020 Whole Home Program *Ex Ante* and *Ex Post* Per-Measure Savings for LED Night-Lights

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
LED Night-Lights	13.64	0	13.64	0

As shown in the table, there is no difference between the *ex ante* and *ex post* savings values for LED night-lights.

Filter Whistle

Algorithms and Variable Assumptions

The evaluation team used four equations from the 2016 Pennsylvania TRM to calculate *ex post* per-measure energy savings and demand reduction for filter whistles:

$$kWh\ savings_{Filter\ Whistle} = \Delta \mathrm{kWh}/yr_{heat} + \Delta \mathrm{kWh}/yr_{cool}$$

$$\Delta \mathrm{kWh}/yr_{heat} = \mathrm{kW}_{motor} * FLH_{heat} * EI * ISR$$

$$\Delta \mathrm{kWh}/yr_{cool} = \mathrm{kW}_{motor} * FLH_{cool} * EI * ISR$$

$$kW\ reduction_{Filter\ Whistle} = \frac{\Delta \mathrm{kWh}/yr_{cool}}{FLH_{cool}} * \mathrm{CF}$$

Where:

kW_{motor} = Average motor full load electric demand

FLH_{heat} = Full-load heating hours

EI = Efficiency improvement

ISR = In-service rate

FLH_{cool} = Full-load cooling hours

CF = Coincidence factor

Table L-38 shows *ex post* assumptions and sources for the filter whistles.

Table L-38. 2020 Whole Home Program *Ex Post* Variable Assumptions for Filter Whistles

Variable	Value	Source
Average motor full load electric demand (kW_{motor})	0.5	2016 Pennsylvania TRM
Full-load heating hours (FLH_{heat})	1,341	Indiana TRM (v2.2) for Indianapolis
Efficiency improvement (EI)	0.15	2016 Pennsylvania TRM
In-service rate (ISR)	1	Assumed for *ex post* analysis
Full-load cooling hours (FLH_{cool})	487	Indiana TRM (v2.2) for Indianapolis
Coincidence factor (CF)	0.647	2016 Pennsylvania TRM

Savings Summary for Filter Whistles

Table L-39 shows *ex ante* deemed savings and resulting *ex post* per-measure savings for filter whistles provided in the kits.

Table L-39. 2020 Whole Home Program *Ex Ante* and *Ex Post* Per-Measure Savings for Filter Whistles

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Filter Whistle	137.05	0.049	137.05	0.049

As shown in the table, there is no difference between the *ex ante* and *ex post* savings values for filter whistles.

After calculating the filter whistle energy savings and demand reduction, the evaluation team applied the weighting factors shown in Table L-40 to account for the distribution of heating and cooling systems among the kit recipients. The resulting savings by fuel type are provided in the report tables.

Table L-40. 2020 Whole Home Program *Ex Post* Variable Assumptions for Filter Whistles

Variable	Value	Source
Percentage of homes with natural gas heat + central AC	63%	Indiana TRM (v2.2)
Percentage of homes with electric heat + central AC	18%	Indiana TRM (v2.2)
Percentage of homes with electric heat only	2%	Indiana TRM (v2.2)
Percentage of homes with natural gas heat only	13%	Indiana TRM (v2.2)

Audit Recommendations

Algorithms and Variable Assumptions

The evaluation team applied an *ex post* audit recommendation value for energy savings from the 2014 *Energizing Indiana Statewide Core Program Report*, cited as CLEAResult's approach.

Savings Summary for Audit Recommendations

Table L-41 shows a comparison of *ex ante* and *ex post* per-measure savings for the audit recommendations.

Table L-41. 2020 Whole Home Program *Ex Ante* and *Ex Post* Per-Measure Savings for Audit Recommendations

Measure	*Ex Ante* Savings		*Ex Post* Savings	
	kWh	kW	kWh	kW
Audit Recommendations	187.5	0	187.5	0

As shown in the table, there is no difference between the *ex ante* and *ex post* savings values for audit recommendations.

Appendix M. Commercial and Industrial Measures, Assumptions, and Algorithms

Gross Impact Methodology

The evaluation team used several algorithms, outlined in this appendix, to determine *ex post* savings for measures where primary on-site data, metered trends, or custom *ex ante* calculations were unavailable. In general, these algorithms aligned with *ex ante* methodologies, though we updated some site-specific inputs in our *ex post* calculations based on evaluation findings.

Lighting Retrofit Algorithms

The evaluation team used two algorithms sourced from the Indiana TRM (v2.2), page 283, to calculate energy savings and demand reduction for lighting retrofit measures:

$$\Delta kWh = (Watts_{base} - Watts_{ee}) * AOH * \frac{1 + WHF_e}{1{,}000}$$

$$\Delta kW_{peak\ coincident} = (Watts_{base} - Watts_{ee}) * CF * \frac{1 + WHF_d}{1{,}000}$$

Where:

$Watts_{base}$	=	Wattage of existing fixture[86]
$Watts_{ee}$	=	Wattage of new energy-efficient fixture (= from application)
AOH	=	Annual operating hours (= from application)
WHF_e	=	Energy waste heat factor (= varies by building type and HVAC technology, see Table M-1)
1/1,000	=	Constant to convert watts to kilowatts or watt-hours to kilowatt-hours
CF	=	Summer peak coincidence factor (= varies by building type, see Table M-2)
WHF_d	=	Demand waste heat factor (= varies by building type and HVAC technology, see Table M-1)

The evaluation team used assumed fixture wattages where *ex ante* baselines or efficient wattages were nominal (that is, they had not accounted for the ballast factor). Table M-1 lists WHFs for energy savings and demand reduction by building type and HVAC technology.

[86] The evaluation team sourced inputs from program applications or used claimed algorithm assumptions if the bulb was EISA-exempt; otherwise, the team referenced Table M-3 through Table M-12.

Table M-1. Waste Heat Factor Assumptions by Building Type and HVAC Technology for Indianapolis

Building Type	Air Conditioning with Natural Gas Heat		Heat Pump		Air Conditioning with Electric Heat		Electric Heat Only		Natural Gas Heat Only or Exterior Space	
	WHFe	WHFd	WHFe	WHFd	WHFe	WHFd	WHFe	WHFd	WHFe	WHFd
Assembly	0.155	0.2	-0.174	0.2	-0.434	0.200	-0.591	0	0	0
Big Box	0.146	0.2	-0.086	0.2	-0.193	0.200	-0.318	0	0	0
Elementary School	0.096	0.2	-0.278	0.2	-0.605	0.200	-0.743	0	0	0
Fast Food	0.109	0.2	-0.023	0.2	-0.53	0.200	-0.661	0	0	0
Full Service Restaurant	0.108	0.2	-0.023	0.2	-0.556	0.000	-0.872	0	0	0
Grocery	0.146	0.2	-0.086	0.2	-0.193	0.200	-0.318	0	0	0
Light Industrial	0.096	0.2	-0.145	0.2	-0.332	0.200	-0.433	0	0	0
Small Office	0.119	0.2	-0.027	0.2	-0.182	0.200	-0.182	0	0	0
Small Retail	0.124	0.2	-0.083	0.2	-0.315	0.200	-0.437	0	0	0
Warehouse	0.096	0.2	-0.145	0.2	-0.332	0.200	-0.433	0	0	0
Other	0.115	0.2	-0.150	0.2	-0.357	0.185	-0.487	0	0	0

Table M-2 lists the coincidence factors associated with various C&I building types.

Table M-2. Coincidence Factors by Building Type

Building Type	Coincidence Factors
Food Sales	0.92
Food Service	0.83
Health Care	0.78
Hotel/Motel	0.37
Office	0.76
Public Assembly	0.65
Public Services (non-food)	0.64
Retail	0.84
Warehouse	0.79
School	0.50
College	0.68
Industrial	0.76
Garage	1.00 [a]
Exterior	0.00 [b]
Other	0.65

[a] This assumption is consistent with 8,760 operating hours.

[b] This value assumes that no exterior lighting is operating during the summer on-peak demand period.

Table M-3 lists baseline wattage assumptions for generic, screw-base light bulbs, distinguished by lumen range, application, and shape.

Table M-3. Baseline Wattage for General Service Medium Screw-Base Lamps

Efficient Bulb Lumen Range			Baseline Wattage
General Service Bulb	Decorative Shape Bulb	Globe Shape Bulb	
--	70-89	--	10
--	90-149	--	15
310-449	150-299	250-349	25
450-799	300-499	350-499	29
800-1,099	500-699	500-574	43
1,100-1,599	--	575-649	53
1,600-2,600	--	650-1,300	72

Source: UMP. “Chapter 21: Residential Lighting Evaluation Protocol.” https://www.energy.gov/sites/prod/files/2015/02/f19/UMPChapter21-residential-lighting-evaluation-protocol.pdf

Table M-4 lists baseline wattage assumptions for EISA-exempt bulb types (such as three-way lights and post lamps), categorized by lumen range.

Table M-4. EISA-Exempt Lumen Bins

Lumen Range	Baseline Wattage
0-309	25
310-449	25
450-799	40
800-1,099	60
1,100-1,599	75
1,600-1,999	100
2,000-2,600	150
2,601-3,300	150
3,301-4,815	200

Table M-5 lists baseline wattage assumptions for reflector lamp types with diameters less than 2.5 inches, categorized by lumen range.

Table M-5. Baseline Wattage Assumptions by Lumen Range for Reflectors with Diameter Less than 2.5 Inches

Lumen Range	Baseline Wattage
200-299	20
300-639	30
640-739	40
740-849	45
850-1,179	50
1,180-1,419	65
1,420-1,789	75
1,790-2,049	90
2,050-2,579	100
2,580-3,429	120
3,430-4,270	150

See Table M-6 and Table M-7 for baseline wattage assumptions for BR30, BR40, ER30, and ER40 lamp types.

Table M-6 lists baseline wattage assumptions for BR30, BR40, and ER40 lamp types, categorized by lumen range.

Table M-6. Baseline Wattage Assumptions by Lumen Range for BR30, BR40, and ER40 Lamps

Lumen Range	Baseline Wattage
200-299	20
300-399	30
400-449	40
450-499	45
500-649	50
650-1,179	65
1,180-1,419	65
1,420-1,789	75
1,790-2,049	90
2,050-2,579	100
2,580-3,429	120
3,430-4,270	150

Table M-7 lists baseline wattage assumptions for ER30 lamp types, categorized by lumen range.

Table M-7. Baseline Wattage Assumptions by Lumen Range for ER30 Lamps

Lumen Range	Baseline Wattage
200-299	20
300-399	30
400-449	40
450-499	45
500-639	50
640-739	40
740-849	45
850-1,179	50
1,180-1,419	65
1,420-1,789	75
1,790-2,049	90
2,050-2,579	100
2,580-3,429	120
3,430-4,270	150

Table M-8 lists baseline wattage assumptions for reflector lamp types with diameters between 2.25 and 2.5 inches, categorized by lumen ranges.

Table M-8. Baseline Wattage Assumptions by Lumen Range for Reflectors with Diameter between 2.25 and 2.5 Inches

Lumen Range	Baseline Wattage
200-299	20
300-539	30
540-629	40
630-719	45
720-999	50
1,000-1,199	65
1,200-1,519	75
1,520-1,729	90
1,730-2,189	100
2,190-2,899	120
2,900-3,850	150

See Table M-9 for baseline wattage assumptions for R20 lamp types.

Table M-9 lists baseline wattage assumptions for R20 lamp types, categorized by lumen range.

Table M-9. Baseline Wattage Assumptions by Lumen Range for R20 Lamps

Lumen Range	Baseline Wattage
200-299	20
300-399	30
400-449	40
450-719	45
720-999	50
1,000-1,199	65
1,200-1,519	75
1,520-1,729	90
1,730-2,189	100
2,190-2,899	120
2,900-3,850	150

Table M-10 lists baseline wattage assumptions for reflector lamp types with diameters under 2.25 inches, categorized by lumen range.

Table M-10. Baseline Wattage Assumptions by Lumen Range for Reflectors with Diameter Equal to or Smaller than 2.25 Inches

Lumen Range	Baseline Wattage
200-299	20
300-399	30
400-449	40
450-499	45
500-649	50
650-1,199	65

Table M-11 lists baseline wattage assumptions for exterior wall packs and flood lamps, categorized by lumen range.

Table M-11. Baseline Wattage Assumptions by Lumen Range for Exterior Wall Pack and Flood Lamps

Bulb Type	Baseline Wattage
Small (≤50 Watts)	139.3
Medium (50< Watts ≤80)	245.9
Large (80< Watts ≤165)	444.4

Table M-12 lists baseline efficacy assumptions for T8 lamps, categorized by bulb type and lumen range.

Table M-12. Baseline Wattage Assumptions by Lumen Range for T8 Lamps

Bulb Type	Minimum Efficacy
4-Foot Medium Bi-Pin ≤4,500 K Lumens	0.89
4-Foot Medium Bi-Pin 4500 K< Lumens ≤7,500 K	0.88
2-Foot U-Shaped ≤4,500 K Lumens	0.84
2-Foot U-Shaped 4,500 K< Lumens ≤7,500 K	0.81

Lighting Controls Algorithms

The evaluation team used algorithms from the Indiana TRM (v2.2), page 267, to calculate energy savings and demand reduction for lighting control measures:

$$\Delta kWh = kW_{controlled} * AOH * (1 + WHF_e) * ESF$$

$$\Delta kW_{peak\ coincident} = kW_{controlled} * (1 + WHF_d) * CF$$

Where:

$kW_{controlled}$ = Total lighting load connected to the control in kilowatts (= from application or Table M-13)

AOH = Annual operating hours (= from application)

WHF_e = Energy waste heat factor (= varies by lighting control type; see Table M-1)

ESF = Energy savings factor (= varies by lighting control type; see Table M-13)

WHF_d = Demand waste heat factor (= varies by lighting control type; see Table M-1)

CF = Summer peak coincidence factor (= varies by lighting control type; see Table M-13)

Table M-13 lists the energy savings factors and coincidence factors for various control types.

Table M-13. Energy Savings Factors and Coincidence Factors by Control Type

Lighting Control Type	Energy-Savings Factor	Coincidence Factor
Wall- or Ceiling-Mounted Occupancy Sensors	0.30	0.15
Fixture-Mounted Occupancy Sensors	0.30	0.15
Remote-Mounted Daylight Dimming Sensors	0.30	0.90
Fixture-Mounted Daylight Dimming Sensors	0.30	0.90
Switching Controls for Multi-Level Lighting	0.30	0.77
Central Lighting Controls (Time Clocks)	0.10	0.00

Variable Frequency Drives Algorithms for HVAC Supply and Return Fans

The evaluation team used several algorithms from the Illinois TRM (v8), Section 4.4.26, to calculate energy savings and demand reduction associated with installations of VFDs on supply and return HVAC fans.

Electric Energy Savings

$$\Delta kWh_{fan} = kWh_{Base} - kWh_{Retrofit}$$

$$kWh_{Base} = \left(0.746 \times HP \times \frac{LF}{\eta_{motor}}\right) \times RHRS_{Base} \times \sum_{0\%}^{100\%} (\%FF \times PLR_{Base})$$

$$kWh_{Retrofit} = \left(0.746 \times HP \times \frac{LF}{\eta_{motor}}\right) \times RHRS_{Base} \times \sum_{0\%}^{100\%} (\%FF \times PLR_{Retrofit})$$

$$\Delta kWh_{total} = \Delta kWh_{fan} \times \left(1 + IE_{energy}\right)$$

Summer Coincident Peak Demand Reduction

$$\Delta kW_{fan} = kW_{Base} - kW_{Retrofit}$$

$$kW_{Base} = \left(0.746 \times HP \times \frac{LF}{\eta_{motor}}\right) \times PLR_{Base,FFpeak}$$

$$kW_{Retrofit} = \left(0.746 \times HP \times \frac{LF}{\eta_{motor}}\right) \times PLR_{Retrofit,FFpeak}$$

$$\Delta kW_{total} = \Delta kW_{fan} \times (1 + IE_{demand})$$

Where:

ΔkWh_{fan} = Fan-only annual energy savings (in kilowatt-hours per year)

kWh_{base} = Baseline annual energy consumption (in kilowatt-hours per year)

$kWh_{Retrofit}$ = Retrofit annual energy consumption (in kilowatt-hours per year)

0.746 = Conversion factor from horsepower to kilowatt-hours

HP	=	Nominal horsepower of controlled motor
LF	=	Load factor; motor load at fan design CFM (default = 65%)
η_{motor}	=	Installed nominal/nameplate motor efficiency (= varies; see Table M-14)[87]
$RHRS_{base}$	=	Annual operating hours for fan motor (= based on building type; see Table M-15)
%FF	=	Percentage of run-time spent within a given flow fraction range
PLR_{Base}	=	Part-load ratio for a given flow fraction range based on the baseline flow control type
$PLR_{Retrofit}$	=	Part-load ratio for a given flow fraction range based on the retrofit flow control type
ΔkWh_{total}	=	Total project annual energy savings (in kilowatt-hours per year)
IE_{energy}	=	HVAC interactive effects factor for energy (default = 15.7%)
ΔkW_{fan}	=	Fan-only summer coincident peak demand impact (in kilowatts)
kW_{Base}	=	Baseline summer coincident peak demand (in kilowatts)
$kW_{Retrofit}$	=	Retrofit summer coincident peak demand (in kilowatts)
$PLR_{Base,FFpeak}$	=	Part-load ratio for the average flow fraction between the peak daytime hours during the weekday peak time period based on the baseline flow control type (default average flow fraction during peak period = 90%)
$PLR_{Retrofit,FFpeak}$	=	Part-load ratio for the average flow fraction between the peak daytime hours during the weekday peak time period based on the retrofit flow control type (default average flow fraction during peak period = 90%)
ΔkW_{total}	=	Total project summer coincident peak demand impact (in kilowatts)
IE_{demand}	=	HVAC interactive effects factor for summer coincident peak demand (default = 15.7%)

Table M-14 lists National Electrical Manufacturers Association premium default motor efficiencies, categorized by horsepower, motor type, number of poles, and operational rpms.

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87 The default motor is a National Electrical Manufacturers Association premium efficiency, open drop proof, 4-pole, 1,800 rpm fan motor.

Table M-14. National Electrical Manufacturers Association Premium Default Motor Efficiency

Size (Horsepower)	Open Drip Proof (# of Poles / Speed in rpm)			Totally Enclosed Fan-Cooled (# of Poles / Speed in rpm)		
	6 / 1,200	4 / 1,800 (Default)	2 / 3,600	6 / 1,200	4 / 1,800 (Default)	2 / 3,600
1	0.825	0.855	0.770	0.825	0.855	0.770
1.5	0.865	0.865	0.840	0.875	0.865	0.840
2	0.875	0.865	0.855	0.885	0.865	0.855
3	0.885	0.895	0.855	0.895	0.895	0.865
5	0.895	0.895	0.865	0.895	0.895	0.885
7.5	0.902	0.910	0.885	0.910	0.917	0.895
10	0.917	0.917	0.895	0.910	0.917	0.902
15	0.917	0.930	0.902	0.917	0.924	0.910
20	0.924	0.930	0.910	0.917	0.930	0.910
25	0.930	0.936	0.917	0.930	0.936	0.917
30	0.936	0.941	0.917	0.930	0.936	0.917
40	0.941	0.941	0.924	0.941	0.941	0.924
50	0.941	0.945	0.930	0.941	0.945	0.930
60	0.945	0.950	0.936	0.945	0.950	0.936
75	0.945	0.950	0.936	0.945	0.954	0.936
100	0.950	0.954	0.936	0.950	0.954	0.941
125	0.950	0.954	0.941	0.950	0.954	0.950
150	0.954	0.958	0.941	0.958	0.958	0.950
200	0.954	0.958	0.950	0.958	0.962	0.954
250	0.954	0.958	0.950	0.958	0.962	0.958
300	0.954	0.958	0.954	0.958	0.962	0.958
350	0.954	0.958	0.954	0.958	0.962	0.958
400	0.958	0.958	0.958	0.958	0.962	0.958
450	0.962	0.962	0.958	0.958	0.962	0.958
500	0.962	0.962	0.958	0.958	0.962	0.958

Table M-15 lists annual HVAC fan run-time hours, categorized by building type.

Table M-15. Annual HVAC Fan Run Hours by Building Type

Building Type	Total Fan Run Hours
Assembly	7,235
Assisted Living	8,760
Auto Dealership	7,451
College	6,103
Convenience Store	7,004
Drug Store	7,156
Elementary School	3,765
Garage	7,357
Grocery	8,453
Healthcare Clinic	4,314
High School	3,460
Hospital - Variable Air Volume Economizer	4,666
Hospital - Continuous Air Volume Economizer	8,021
Hospital - Continuous Air Volume No Economizer	7,924
Hospital - Fan Coil Unit	4,055
Manufacturing Facility	8,706
Multifamily - High Rise	8,760
Multifamily - Mid Rise	8,760
Hotel/Motel - Guest	2,409
Hotel/Motel - Common	8,683
Movie Theater	7,505
Office - High Rise - Variable Air Volume Economizer	2,369
Office - High Rise - Continuous Air Volume Economizer	2,279
Office - High Rise - Continuous Air Volume No Economizer	5,303
Office - High Rise - Fan Coil Unit	1,648
Office - Low Rise	6,345
Office - Mid Rise	3,440
Religious Building	7,380
Restaurant	7,302
Retail - Department Store	7,155
Retail - Strip Mall	6,921
Warehouse	6,832
Unknown	6,241

Table M-16 lists default fan duty cycles, categorized by flow fraction.

Table M-16. Default Fan Duty Cycle

Flow Fraction (Percentage of Design CFM)	Percentage of Time at Flow Fraction
0% to 10%	0.0%
10% to 20%	1.0%
20% to 30%	5.5%
30% to 40%	15.5%
40% to 50%	22.0%
50% to 60%	25.0%
60% to 70%	19.0%
70% to 80%	8.5%
80% to 90%	3.0%
90% to 100%	0.5%

Table M-17 lists part-load ratios of VFDs for various control types.

Table M-17. Part-Load Ratios for Variable Frequency Drives for Given Control Types

Control Type	Flow Fraction									
	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
No Control or Bypass Damper	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Discharge Dampers	0.46	0.55	0.63	0.70	0.77	0.83	0.88	0.93	0.97	1.00
Outlet Damper, Bi and Airfoil Fans	0.53	0.53	0.57	0.64	0.72	0.80	0.89	0.96	1.02	1.05
Inlet Damper Box	0.56	0.60	0.62	0.64	0.66	0.69	0.74	0.81	0.92	1.07
Inlet Guide Vane, Bi and Airfoil Fans	0.53	0.56	0.57	0.59	0.60	0.62	0.67	0.74	0.85	1.00
Inlet Vane Dampers	0.38	0.40	0.42	0.44	0.48	0.53	0.60	0.70	0.83	0.99
Outlet Damper, Forward Curved Fans	0.22	0.26	0.30	0.37	0.45	0.54	0.65	0.77	0.91	1.06
Eddy Current Drives	0.17	0.20	0.25	0.32	0.41	0.51	0.63	0.76	0.90	1.04
Inlet Guide Vane, Forward Curved Fans	0.21	0.22	0.23	0.26	0.31	0.39	0.49	0.63	0.81	1.04
VFD with Duct Static Pressure Controls	0.09	0.10	0.11	0.15	0.20	0.29	0.41	0.57	0.76	1.01
VFD with Low/No Duct Static Pressure	0.05	0.06	0.09	0.12	0.18	0.27	0.39	0.55	0.75	1.00

Table M-18 lists resultant values for the final terms of the algorithms, calculating the baseline and retrofit kilowatt-hours based on flow fraction and the part-load ratio for various control types.

Table M-18. Resultant Values of Flow Fraction and Part-Load Ratios for Given Control Types

Control Type	$\sum_{0\%}^{100\%}(\%FF \times PLR)$
No Control or Bypass Damper	1.00
Discharge Dampers	0.80
Outlet Damper, Bi and Airfoil Fans	0.78
Inlet Damper Box	0.69
Inlet Guide Vane, Bi and Airfoil Fans	0.63
Inlet Vane Dampers	0.53
Outlet Damper, Forward Curved Fans	0.53
Eddy Current Drives	0.49
Inlet Guide Vane, Forward Curved Fans	0.39
VFD with Duct Static Pressure Controls	0.30
VFD with Low/No Duct Static Pressure	0.27

Variable Frequency Drive Algorithms for HVAC Pumps and Cooling Tower Fans

The evaluation team used algorithms from the Illinois TRM (v8), Section 4.4.17, to calculate energy savings and demand reduction associated with VFD installations on HVAC pumps and cooling tower fans:

$$\Delta kWh = \left(\frac{BHP}{EFF_i}\right) \times Hours \times ESF$$

$$\Delta kW = \left(\frac{BHP}{EFF_i}\right) \times DSF$$

Where:

ΔkWh	=	Annual electric energy savings (in kilowatt-hours per year)
BHP	=	Brake horsepower (= nominal motor horsepower multiplied by motor load factor)[88]
EFF_i	=	Currently installed motor efficiency (= actual percentage)[89]
Hours	=	Hours of use (= actual hours, which vary by HVAC application and building type; see Table M-19)[90]
ESF	=	Energy savings factor (in kilowatts per horsepower)[91]

88 Motors are assumed to have a load factor of 65% for calculating kilowatts (if actual values cannot be determined). Custom load factors may be applied if known.

89 If unknown, please reference Table M-14. Actual motor efficiency should be used to calculate kilowatts.

90 When available, actual hours should be used.

91 See Table M-21 for default energy savings factors.

ΔkW = Summer coincident peak demand reduction (in kilowatts

DSF = Demand reduction factor (in kilowatts per horsepower)[92]

Table M-19 lists heating and cooling annual run hours for HVAC equipment, categorized by building type.

Table M-19. Building Type Annual Hours of Use for Heating and Cooling for HVAC Equipment

Building Type	Heating Run Hours	Cooling Run Hours
Assembly	4,888	2,150
Assisted Living	4,711	4,373
College	7,005	4,065
Convenience Store	4,136	2,084
Elementary School	6,028	2,649
Garage	4,849	2,102
Grocery	7,452	5,470
Healthcare Clinic	8,760	6,364
High School	5,480	3,141
Hospital - Variable Air Volume Economizer	8,107	8,707
Hospital - Continuous Air Volume Economizer	3,045	2,336
Hospital - Continuous Air Volume No Economizer	2,927	4,948
Hospital - Fan Coil Unit	4,371	8,760
Manufacturing Facility	3,821	2,805
Multifamily - High Rise	5,168	6,823
Multifamily - Mid Rise	6,011	4,996
Hotel/Motel - Guest	5,632	4,155
Hotel/Motel - Common	6,340	6,227
Movie Theater	5,063	2,120
Office - High Rise - Variable Air Volume Economizer	5,646	3,414
Office - High Rise - Continuous Air Volume Economizer	5,361	4,849
Office - High Rise - Continuous Air Volume No Economizer	4,202	6,049
Office - High Rise - Fan Coil Unit	4,600	5,341
Office - Low Rise	3,834	3,835
Office - Mid Rise	6,119	3,040
Religious Building	5,199	2,830
Restaurant	3,476	2,305
Retail - Department Store	4,249	2,528
Retail - Strip Mall	4,475	2,266
Warehouse	4,606	770
Unknown	5,038	2,987

Table M-20 lists the conditioning type (heating or cooling) associated with three primary VFD applications relevant to algorithms in this appendix.

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[92] See Table M-22 for default demand reduction factor values. Values are based on typical peak loads for the listed application.

Table M-20. Heating and Cooling Hour Type Reference for Variable Frequency Drive Application

Application	Hours Type
Hot Water Pump	Heating
Chilled Water Pump	Cooling
Cooling Tower Fan	Cooling

Table M-21 lists the energy savings factors for VFDs by application relevant to algorithms in this appendix.

Table M-21. Energy Savings Factors for Various Variable Frequency Drive Applications

Application	Energy Savings Factor
Hot Water Pump	0.249
Chilled Water Pump	0.081
Cooling Tower Fan	0.502

Table M-22 lists the demand reduction factors for VFDs by application relevant to algorithms in this appendix.

Table M-22. Demand Reduction Factors for Various Variable Frequency Drive Applications

Application	Demand Reduction Factor
Hot Water Pump	0
Chilled Water Pump	0
Cooling Tower Fan	0.407

Single-Package and Split System Unitary Air Conditioners Algorithm

The evaluation team used algorithms from the Indiana TRM (v2.2), page 224, and from ASHRAE 90.1-2013, Section 6: Heating, Ventilating, and Air Conditioning, to calculate energy savings and demand reduction for unitary HVAC measures:

$$\Delta kWh = Capacity * EFLH * \left(\frac{1}{SEER_{base}} - \frac{1}{SEER_{EE}}\right)$$

$$\Delta kW_{peak\ coincident} = Capacity * \left(\frac{1}{SEER_{base}} - \frac{1}{SEER_{EE}}\right) * CF$$

Where:

Capacity	=	Cooling capacity (in kBtu per hour; = from application)
EFLH	=	Equivalent full-load hours (= varies by building type and location; see Table M-23)
$SEER_{base}$	=	Baseline SEER rating (= varies by AC type and capacity; see Table M-24)

$SEER_{EE}$	=	Installed SEER rating (= from application or equipment documentation)
CF	=	Summer peak coincidence factor[93]

Table M-23 lists the equivalent full-load hours, by building type and location, for use with AC equipment.

Table M-23. Equivalent Full-Load Hours by Building Type and Location

Building Type	Location				
	Indianapolis	South Bend	Evansville	Fort Wayne	Terre Haute
Assembly	810	721	1,047	716	955
Auto Repair	538	484	721	431	675
Big-Box Retail	1,123	1,006	1,422	1,056	1,251
Fast Food Restaurant	798	738	1,066	694	905
Full Service Restaurant	729	641	967	633	837
Grocery	1,123	1,006	1,422	1,056	1,251
Light Industrial	690	598	842	642	760
Primary School	514	456	573	454	503
Religious Worship	401	360	516	357	444
Small Office	1,096	1,015	1,299	1,035	1,151
Small Retail	1,032	906	1,294	977	1,142
Warehouse	690	598	842	642	760
Other	795	711	1,001	725	886

Table M-24 lists baseline SEER ratings for various types of AC equipment and capacity ranges.

Table M-24. Baseline SEER Rating for Air-Cooled Air Conditioners by Size and Capacity

Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency
<65,000 Btu/h	All	Split system	13.0 SEER
		Single package	13.0 SEER
≥65,000 Btu/h and <135,000 Btu/h	Electric resistance (or none)	Split system and single package	11.2 EER
	All other	Split system and single package	11.0 EER
≥135,000 Btu/h and <240,000 Btu/h	Electric resistance (or none)	Split system and single package	11.0 EER
	All other	Split system and single package	10.8 EER
≥240,000 Btu/h and <760,000 Btu/h	Electric resistance (or none)	Split system and single package	10.0 EER
	All other	Split system and single package	9.8 EER

Source: Government Publishing Office. April 27, 2021. *Electronic Code of Federal Regulations.* "Title 10, Chapter II, Subchapter D, Part 431–Energy Efficiency Program for Certain Commercial and Industrial Equipment." https://www.ecfr.gov/cgi-bin/text-idx?SID=f6cc1be4ece3f2b179c0d8ea7ee09d7d&mc=true&node=pt10.3.431&rgn=div5#sp10.3.431.f

93 The evaluation team used the implementer assumption of 0.74.

Pre-Rinse Spray Valve Algorithms

The evaluation team used algorithms from the Indiana TRM (v2.2), page 190, to calculate energy savings and demand reduction for pre-rinse spray valves:

$$\Delta kWh = \Delta Water * HOT_{\%} * 8.33 * (T_{OUT} - T_{IN}) * \left(\frac{1}{EFF_E * 3{,}412}\right)$$

$$\Delta MMBtu = \Delta Water * HOT_{\%} * 8.33 * (T_{OUT} - T_{IN}) * \frac{1}{EFF_G} * 10^{-6}$$

$$\Delta Water = (FLO_{BASE} - FLO_{EFF}) * 60 * \mathrm{H} * 365$$

Where:

ΔWater	=	Water savings (gallons)
$HOT_{\%}$	=	Retrofit annual energy consumption (in kilowatt-hours per year)
8.33	=	Specific weight of water (8.33 lbs/gal) multiplied by the specific heat of water (1.0 Btu/(lb∗°F))
T_{OUT}	=	Water heater setpoint (= actual water heater setpoint, or assume 130°F)
T_{IN}	=	Cold water temperature entering the DHW system (= varies by city; see Table M-25)
EFF_E	=	Electric water heater thermal efficiency (= actual thermal efficiency, or assume 97%)
1/3,412	=	Conversion factor (from kilowatt-hours to Btu)
EFF_G	=	Natural gas water heater thermal efficiency (= actual thermal efficiency, or assume 58%)[94]
10^{-6}	=	Conversion factor (from Btu to MMBtu)
FLO_{BASE}	=	Flow rate of baseline spray nozzle (= assume 3 gallons per minute)
FLO_{EFF}	=	Flow rate of efficient equipment (= assume 1.6 gallons per minute)
60	=	Minutes per hour
H	=	Usage hours per day (= varies by facility type; see Table M-26)
365	=	Days per year

Table M-25 lists groundwater temperature assumptions (T_{IN}) by location.

[94] This 58% is the baseline natural gas water heater thermal efficiency submitted to the Ohio Public Utility Commission (case no. 09-512-GE-UNC) in the natural gas utilities' 2009 proposed predetermined values and protocols.

Table M-25. Groundwater Temperature (T_{IN}) by Location

City	Groundwater Temperature (°F)
Indianapolis	58.1
South Bend	57.4
Terre Haute	60.5
Evansville	62.8
Fort Wayne	55.6

Table M-26 lists estimates for number of hours per day for using pre-rinse spray valves, based on facility type.

Table M-26. Pre-Rinse Spray Valve Hours Per Use by Facility Type

Facility Type	Hours of Pre-Rinse Spray Valve Use per Day
Full Service Restaurant	4
Other	2
Limited Service (Fast Food) Restaurant	1

Evaluation Summary

The evaluation team made savings adjustments based on results from on-site M&V and engineering desk reviews in each program's evaluation sample. The sections below include all analyses for measures that received a realization rate greater than 105% or less than 95%.

Custom Incentives Program

Table M-27 outlines energy-savings analysis results for measures in the Custom Incentives program evaluation sample receiving realization rates greater than 105% or less than 95%.

Table M-27. 2020 Custom Incentives Program Analysis Sample Adjustment Summary for Energy Savings

Measure Type	Energy Savings (kWh)		Realization Rate	Reasons for Discrepancy
	Ex Ante	*Ex Post*		
Building Automation System	90,170	81,000	89.8%	The team verified that the installed condition did not match the reported documentation related to the exclusion of outside air during unoccupied hours.
Lighting	60,421	43,158	71.4%	The team adjusted the AOH based on a virtual site visit and interview with the site contact.
	374,323	322,177	86.1%	The team adjusted the baseline fixture wattage to match the installed fixtures using the lumen equivalence method.
	65,666	35,204	53.6%	The team excluded savings from occupancy sensors by verifying that the fixture-mounted occupancy sensors were not included in the rebated lighting fixtures.
Lighting Controls	478,772	524,623	109.6%	The team adjusted savings to include a WHF and the installed wattage based on fixture specifications.

Process	155,890	72,453	46.5%	The team adjusted the energy model provided with the reported documentation to match the installed condition.
Retro-Commissioning	23,065	25,252	109.5%	The team updated modifications that had been made to assumptions within the refrigerant float calculations.
	75,216	41,148	54.7%	This project claimed savings from occupied temperature setpoint modifications: the team removed these savings. The evaluation team also modified assumptions within the refrigerant float calculations that resulted in 10% higher savings for the measure. The team modified the lighting measure savings calculation to account for a full 168-hour week in the programming logic of the lighting sequence, resulting in a 50% realization rate for the measure.
	372,927	348,734	93.5%	The team modified the occupied schedule of all air-handling units upon viewing the building automation system settings with the customer on a virtual site visit. The proposed schedule resulted in interior temperatures that were too cold (or too warm) in the morning to meet occupant satisfaction, particularly on Monday mornings after the units had been set back for the weekend. The participant modified the units to start up several hours earlier than proposed.
Whole-Building New Construction	384,591	418,779	108.9%	The team included district central plan cooling energy savings achieved through the new construction efficiency improvements.

Table M-28 outlines demand reduction analysis results for measures in the Custom Incentives program evaluation sample that received realization rates greater than 105% or less than 95%.

Table M-28. 2020 Custom Incentives Program Analysis Sample Adjustment Summary for Demand Reduction

Measure Type	Demand Reduction (kW)		Realization Rate	Reasons for Discrepancy
	Ex Ante	*Ex Post*		
Lighting	3	2	93.1%	The team adjusted the parking garage lighting occupancy dimming sensor savings to match expected performance
	54	47	86.1%	The team adjusted the baseline fixture wattage to match the installed fixtures using the lumen equivalence method.
	8	7	85.6%	The team excluded savings from occupancy sensors by verifying that fixture-mounted occupancy sensors were not included in the rebated lighting fixtures.
Lighting Controls	41	63	152.7%	The team adjusted savings to include WHFs and installed wattage based on fixture specifications.
Refrigeration	0	15	20,888.5%	The team adjusted savings to be per linear foot of lighting multiplied by the total linear lighting installed. *Ex ante* savings were based on one foot of lighting.
Retro-Commissioning	8	0	0.0%	The *ex ante* value was not supported in the final M&V report; it appears that the demand reduction from the initial study report was entered for the *ex ante* value, which is incorrect. This project did not achieve or claim any demand reduction that was supported with documentation.
	1	1	120.0%	The team adjusted the *ex post* savings to match the reported documentation.
Whole-Building New Construction	44	39	87.0%	The team included district central plan cooling energy savings achieved through the new construction efficiency improvements.
	323	145	44.9%	The team adjusted the energy model provided with the reported documentation to match the installed condition.
	204	81	39.9%	
	42	0	0.0%	
	14	10	68.8%	

Prescriptive Rebates Program

Table M-29 outlines energy-savings analysis results for measures in the Prescriptive Rebates program evaluation sample receiving realization rates greater than 105% or less than 95%.

Table M-29. 2020 Prescriptive Rebates Program Analysis Sample Adjustment Summary for Energy Savings

Measure Type	Energy Savings (kWh)		Realization Rate	Primary Reasons for Discrepancy
	Ex Ante	Ex Post		
Non-Midstream Delivery Channel				
Exterior LED	174,965	249,950	142.9%	The team adjusted the baseline and installed fixture wattages based on installed fixture specifications.
	11,730	10,079	85.9%	The team adjusted the AOH based on the business scheduled occupancy hours (plus one hour per day).
	320,357	71,451	22.3%	The team adjusted the installed fixture wattage based on fixture specifications and adjusted the AOH based on data collected during a virtual site visit.
High Bay LED	117,988	105,432	89.4%	The team adjusted WHFs based on lack of HVAC cooling for the business verified through a virtual site visit.
	410,574	175,530	42.8%	The team adjusted the AOH based on data collected during a virtual site visit.
	276,917	217,629	78.6%	The team adjusted installed fixture wattage and WHF due to lack of HVAC cooling for the business verified through a virtual site visit.
	29,524	24,598	83.3%	The team adjusted the AOH based on the business scheduled occupancy hours (plus one hour per day).
	28,415	18,559	65.3%	
	8,786	2,778	31.6%	The team adjusted installed fixture wattage and WHF due to lack of HVAC cooling for the business verified through a virtual site visit.
	129,143	151,933	117.7%	The team adjusted the AOH based on the business scheduled occupancy hours (plus one hour per day).
LED Downlight	5,276	3,100	58.8%	
Linear LED	576,666	496,159	86.0%	The team adjusted the AOH based on data collected during a virtual site visit.
	250,773	231,051	92.1%	The team adjusted the WHF and ISR based on building type and verified bulbs that were in storage during the virtual site visit.
	142,735	61,022	42.8%	The team adjusted the AOH based on data collected during a virtual site visit.
	48,698	31,683	65.0%	The team adjusted installed fixture wattage based on fixture specifications and adjusted the AOH based on data collected during a virtual site visit.
	10,399	20,756	199.6%	The team adjusted the AOH based on the business scheduled occupancy hours (plus one hour per day).
	80,642	52,606	65.2%	
	365,077	17,471	4.8%	The team adjusted the baseline and installed fixture wattages based on installed fixture specifications.
Low Bay LED	368,955	394,366	106.9%	The team adjusted the AOH based on the business scheduled occupancy hours (plus one hour per day).
Occupancy Sensor	38,088	34,780	91.3%	The team adjusted the installed fixture wattage and WHF due to lack of HVAC cooling for the business verified through a virtual site visit.

Measure Type	Energy Savings (kWh)		Realization Rate	Primary Reasons for Discrepancy
	Ex Ante	*Ex Post*		
Midstream Delivery Channel – Lighting				
Candle/Decorative	54,898	43,953	80.0%	The team adjusted the baseline and installed fixture wattages based on installed fixture specifications.
High Bay LED	63,815	23,582	37.0%	The team adjusted installed fixture wattage based on fixture specifications and adjusted the AOH based on data collected during the virtual site visit.
	44,956	19,984	44.5%	The team adjusted the WHF and AOH based on building type and adjusted the ISR based to bulbs in storage during the virtual site visit.
	458,454	258,006	56.3%	The team adjusted the AOH based on the business scheduled occupancy hours (plus one hour per day).
	277,051	130,828	47.2%	
LED General Service	5,671	7,184	126.7%	The team adjusted the baseline and installed fixture wattages based on installed fixture specifications.
	15,207	18,022	118.5%	The team adjusted installed fixture wattage based on fixture specifications and adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
	22,583	28,929	128.1%	The team adjusted the baseline and installed fixture wattages based on installed fixture specifications.
	59,697	52,853	88.5%	The team adjusted installed fixture wattage based on fixture specifications and adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
	32,731	28,796	88.0%	
	147,463	132,991	90.2%	The team adjusted the baseline and installed fixture wattages based on installed fixture specifications.
	8,732	22,104	253.1%	The team adjusted installed fixture wattage based on fixture specifications, adjusted installed fixture quantity based on invoices, and adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
	33,262	7,685	23.1%	The team adjusted the ISR and AOH based on data collected during the virtual site visit.
	591,331	531,347	89.9%	The team adjusted the baseline and installed fixture wattages based on installed fixture specifications.
	175,789	314,933	179.2%	
	150,461	135,198	89.9%	
	14,855	4,670	31.4%	The team adjusted the WHF and AOH based on building type and adjusted the ISR based on bulbs in storage during the virtual site visit.
	243,924	219,180	89.9%	The team adjusted the baseline and installed fixture wattages based on installed fixture specifications.
Linear LED	66,744	42,684	64.0%	The team adjusted installed fixture wattage based on fixture specifications and adjusted the AOH based on virtual site visit collected data.
	26,683	13,833	51.8%	The team adjusted installed fixture wattage based on fixture specifications and adjusted the AOH based on the

Measure Type	Energy Savings (kWh)		Realization Rate	Primary Reasons for Discrepancy
	Ex Ante	*Ex Post*		
				business' scheduled occupancy hours (plus one hour per day).
	91,293	59,586	65.3%	The team adjusted the AOH based on the business scheduled occupancy hours (plus one hour per day).
	1,729	1,411	81.6%	The team adjusted the baseline and installed fixture wattages based on virtual site visit data.
	32,351	4,272	13.2%	The team adjusted installed fixture wattage based on fixture specifications and adjusted the AOH based on data collected during the virtual site visit.
	8,802	6,613	75.1%	The team adjusted the AOH based on the business scheduled occupancy hours (plus one hour per day).
	101,465	88,220	87.0%	The team adjusted installed fixture wattage based on fixture specifications and adjusted the AOH based on data collected during the virtual site visit.
	120,133	98,120	81.7%	The team adjusted installed fixture wattage based on fixture specifications and adjusted the AOH based on data collected during the virtual site visit.

Table M-30 outlines demand reduction analysis results for the measures in the Prescriptive Rebates evaluation sample that received realization rates greater than 105% or less than 95%.

Table M-30. 2020 Prescriptive Rebates Program Analysis Sample Adjustment Summary for Demand Reduction

Measure Type	Demand Reduction (kW)		Realization Rate	Primary Reasons for Discrepancy
	Ex Ante	*Ex Post*		
Non-Midstream Delivery Channel				
High Bay LED	20	17	83.3%	The team adjusted installed fixture wattage based on fixture specifications and adjusted the AOH based on data collected during the virtual site visit.
	50	40	79.0%	The team adjusted installed fixture wattage based on fixture specifications and adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
	48	40	83.3%	The team adjusted installed fixture wattage based on fixture specifications and adjusted the AOH based on data collected during the virtual site visit.
	5	6	121.5%	The team adjusted the AOH and WHF based on data collected during the virtual site visit.
	6	5	80.2%	The team adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
	1	1	83.3%	The team adjusted the AOH and WHF based on data collected during the virtual site visit.

Measure Type	Demand Reduction (kW)		Realization Rate	Primary Reasons for Discrepancy
	Ex Ante	*Ex Post*		
Linear LED	57	53	94.1%	The team adjusted the WHF and AOH based on building type and adjusted the ISR due to bulbs in storage during the virtual site visit.
	17	14	79.0%	The team adjusted installed fixture wattage based on fixture specifications and adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
	2	3	153.9%	The team adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
	20	18	90.4%	
	65	3	5.1%	The team adjusted the baseline and installed fixture wattages based on installed fixture specifications.
Occupancy Sensor	4	4	85.2%	The team adjusted installed fixture wattage based on fixture specifications and adjusted the WHF based on data collected during the virtual site visit.
Midstream Delivery Channel – Lighting				
High Bay LED	8	5	60.4%	The team adjusted installed fixture wattage based on fixture specifications and adjusted the AOH based on data collected during the virtual site visit.
	7	5	76.0%	The team adjusted the WHF and AOH based on data collected during the virtual site visit.
	83	78	94.2%	The team adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
LED General Service	1	1	126.7%	The team adjusted the baseline and installed fixture wattages based on installed fixture specifications.
	4	5	128.6%	The team adjusted installed fixture wattage based on fixture specifications and adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
	9	8	88.9%	
	5	5	90.2%	
	18	16	90.2%	The team adjusted the baseline and installed fixture wattages based on installed fixture specifications.
	2	3	138.7%	The team adjusted installed fixture wattage based on fixture specifications and adjusted the AOH based on data collected during the virtual site visit.
	10	5	46.3%	The team adjusted the WHF and AOH based on building type and adjusted ISRs due to bulbs in storage during the virtual site visit.
	72	59	81.2%	The team adjusted installed fixture wattage based on fixture specifications and adjusted the AOH based on data collected during the virtual site visit.
	19	33	179.8%	The team adjusted installed and baseline fixture wattage based on fixture specifications.
	16	14	90.2%	
	3	1	17.2%	The team adjusted the WHF and AOH based on building type and adjusted the ISR based on bulbs in storage during the virtual site visit.
	30	27	90.2%	The team adjusted installed and baseline fixture wattage based on fixture specifications.

Measure Type	Demand Reduction (kW)		Realization Rate	Primary Reasons for Discrepancy
	Ex Ante	*Ex Post*		
LED Specialty	7	5	72.3%	The team adjusted installed fixture wattage based on fixture specifications and adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
Linear LED	5	5	94.9%	The team adjusted installed fixture wattage to match fixture specifications based on data collected during the virtual site visit.
	12	11	90.7%	The team adjusted installed fixture wattage based on fixture specifications and adjusted the AOH based on data collected during the virtual site visit.
	5	4	89.9%	The team adjusted installed fixture wattage based on fixture specifications and adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
	16	15	90.5%	The team adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
	0	0	81.6%	The team adjusted installed and baseline fixture wattage based on fixture specifications verified during a virtual site visit.
	4	2	61.1%	The team adjusted the WHF and the AOH based on building type and adjusted the ISR based on data collected during the virtual site visit.
	30	28	93.9%	The team adjusted the WHF and AOH based on data collected during the virtual site visit.

Small Business Direct Install Program

Table M-31 outlines energy-savings analysis results for measures in the SBDI program evaluation sample that received realization rates that greater than 105% or less than 95%

Table M-31. 2020 SBDI Program Analysis Sample Adjustment Summary for Energy Savings

Measure Type	Energy Savings (kWh)		Realization Rate	Primary Reasons for Discrepancy
	Ex Ante	*Ex Post*		
4-Foot LED Replacement Lamp	7,496	3,535	47.2%	The team adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
4-Foot LED Replacement Lamp	5,960	1,739	29.2%	The team adjusted the WHF, AOH, and ISR based on data collected during the virtual site visit.
4-Foot LED Replacement Lamp	5,354	3,666	68.5%	The team adjusted the WHF, AOH, and ISR based on data collected during the virtual site visit.
4-Foot LED Replacement Lamp	7,281	5,528	75.9%	The team adjusted the WHF and AOH based on data collected during the virtual site visit.
4-Foot LED Replacement Lamp	6,174	4,148	67.2%	The team adjusted the WHF and AOH based on data collected during the virtual site visit.
4-Foot LED Replacement Lamp	8,524	5,722	67.1%	The team adjusted the WHF and AOH based on data collected during the virtual site visit.
4-Foot LED Replacement Lamp	11,205	14,378	128.3%	The team adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
4-Foot LED Replacement Lamp	1,894	1,113	58.8%	The team adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
4-Foot LED Replacement Lamp	7,893	5,218	66.1%	The team adjusted installed fixture wattage based on fixture specifications and adjusted the AOH based on data collected during the virtual site visit.
4-Foot LED Replacement Lamp	8,924	10,584	118.6%	The team adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
4-Foot LED Replacement Lamp	7,893	9,365	118.7%	The team adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
4-Foot LED Replacement Lamp	11,681	15,363	131.5%	The team adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
4-Foot LED Replacement Lamp	9,866	12,110	122.8%	The team adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
LED A-Line Lamps	24,392	9,540	39.1%	The team adjusted the WHF and AOH based on data collected during the virtual site visit.
LED A-Line Lamps	18,479	8,106	43.9%	The team adjusted the WHF and AOH based on data collected during the virtual site visit.
LED A-Line Lamps	4,305	5,523	128.3%	The team adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
LED A-Line Lamps	7,997	3,384	42.3%	The team adjusted the AOH based on data collected during a virtual site visit.
LED A-Line Lamps	8,183	5,493	67.1%	The team adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
LED A-Line Lamps	2,523	1,349	53.4%	The team adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
LED A-Line Lamps	8,555	3,532	41.3%	The team adjusted the AOH based on the business' scheduled occupancy hours (plus one hour per day).
LED BR30 Lamps	5,611	2,461	43.9%	The team adjusted the WHF, AOH, and ISR based on data collected during the virtual site visit.
LED BR30 Lamps	12,086	6,059	50.1%	The team adjusted the WHF and AOH based on data collected during the virtual site visit.
LED BR30 Lamps	8,471	1,918	22.6%	The team adjusted the WHF and AOH based on data collected during the virtual site visit.
LED BR30 Lamps	652	346	53.1%	The team adjusted the WHF, AOH, and ISR based on data collected during the virtual site visit.
LED MR16 Lamps	5,253	2,752	52.4%	The team adjusted the WHF and AOH based on data collected during the virtual site visit.
LED PAR38 Lamps	35,958	12,146	33.8%	The team adjusted the WHF and AOH based on data collected during the virtual site visit.
LED PAR38 Lamps	10,274	4,506	43.9%	The team adjusted the WHF and AOH based on data collected during the virtual site visit.