Andrew Marcaccio
Senior Counsel

November 12, 2021

VIA ELECTRONIC MAIL

Luly E. Massaro, Commission Clerk
Rhode Island Public Utilities Commission
89 Jefferson Boulevard
Warwick, RI 02888

RE: Docket 5189 – 2022 Annual Energy Efficiency Program Plan
Responses to Division Data Requests - Set 3 (Complete Set)

Dear Ms. Massaro:

On behalf of The Narragansett Electric Company d/b/a National Grid ("National Grid" or the "Company"), attached please find the electronic version of the Company's complete set of responses to the Division of Public Utilities and Carriers' ("Division") Third Set of Data Requests in the above referenced docket.[1] Bates stamp has been applied to the attached electronic version.

Please be advised that the Company has supplemented its response to Division 3-8, and the response has been included in this complete set.

Thank you for your attention to this filing. If you have any questions or concerns, please do not hesitate to contact me at 401-784-4263.

Sincerely,

Andrew S. Marcaccio

Enclosures

cc: Docket 5189 Service List
John Bell, Division
Margaret Hogan, Esq.
Jon Hagopian, Esq.

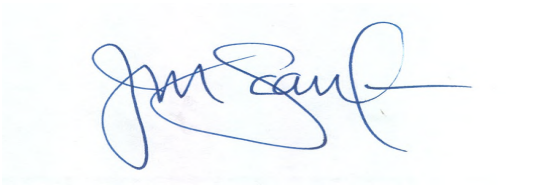
[1] Per the Commission's request, the Company is providing one copy of this transmittal for the Commission's file in this docket and six (6) copies, 3-hole punched for the Commission.

280 Melrose Street, Providence, RI 02907
T: 401-784-4263 ■ andrew.marcaccio@nationalgrid.com ■ www.nationalgrid.com

Certificate of Service

I hereby certify that a copy of the cover letter and any materials accompanying this certificate was electronically transmitted to the individuals listed below.

The paper copies of this filing are being hand delivered to the Rhode Island Public Utilities Commission and to the Rhode Island Division of Public Utilities and Carriers.



_____ November 15, 2021

Joanne M. Scanlon Date

Docket No. 5189 - National Grid – 2022 Annual Energy Efficiency Program
Service list updated 10/27/2021

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Division 3-1
EnergyWise Single-Family

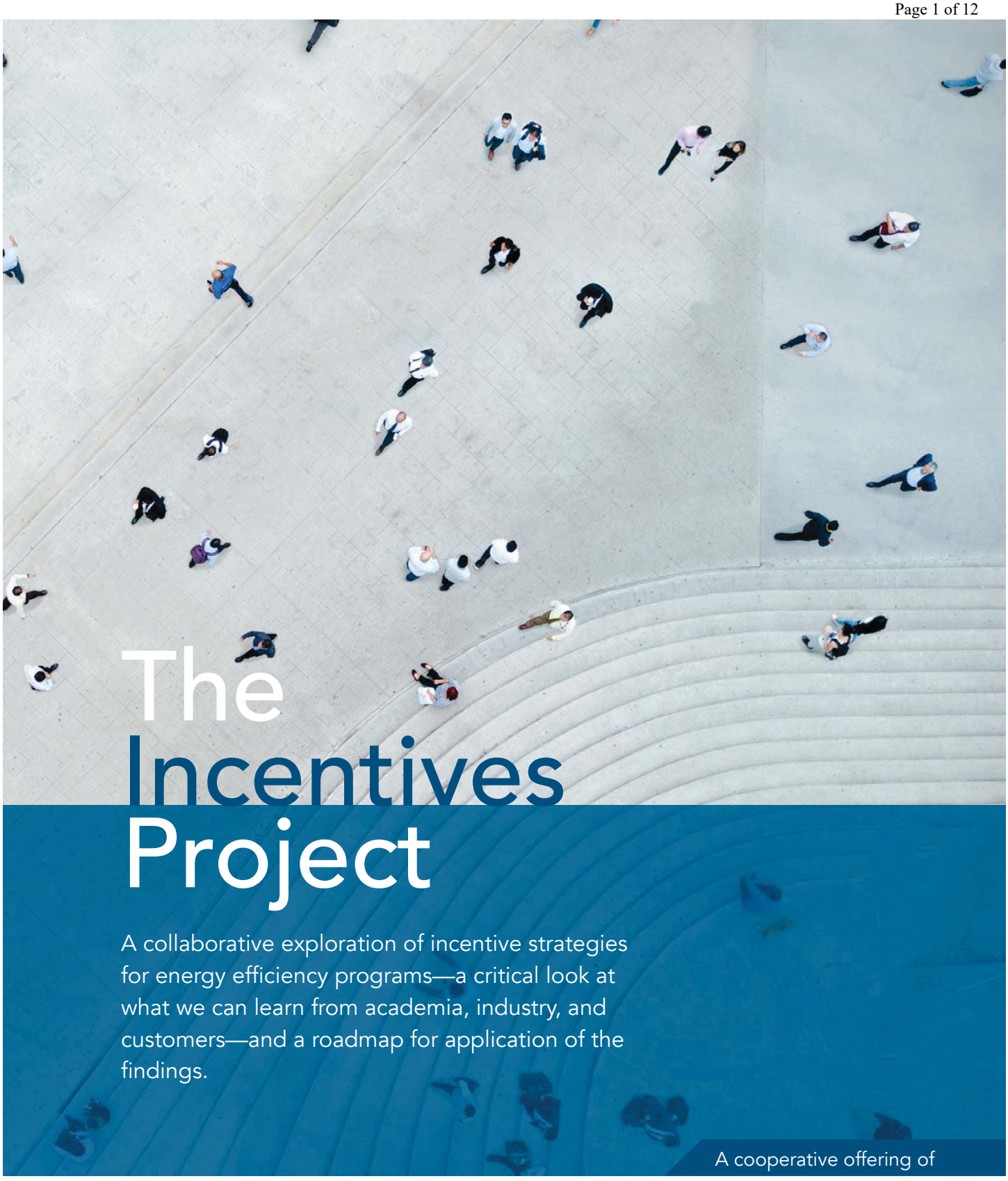
Request:

At Bates 151, the Company indicated that it was excited to participate in the "Incentives Project" research project. Please provide a detailed description of this project.

Response:

Please see Attachment PUC 3-1 for detailed information about The Incentives Project.

Prepared by or under the supervision of: Angela Li



The Incentives Project

A collaborative exploration of incentive strategies for energy efficiency programs—a critical look at what we can learn from academia, industry, and customers—and a roadmap for application of the findings.

A cooperative offering of

ICF | E Source

icf.com/energy


The Incentives Project
New developments in incentive strategy design may enable program administrators to increase the yield on their expenditures by 10-20%.
ICF
E Source
2

Executive summary

North American energy efficiency program sponsors spend approximately $7B a year on energy efficiency programs. And while the approximately 30% of that figure that goes toward implementation and administration receives a great deal of examination, the almost $5B spent on customer incentives could benefit from new, more sophisticated, approaches to incentive design. Across the country, incentives for the same products vary greatly and do not always take advantage of lessons learned by retailers and manufacturers regarding the channel, form, and timing of incentives. **We estimate that many program sponsors could increase the future yield on their incentive budgets by as much as 10-20% through the use of advanced incentive strategies.**

This groundbreaking study will comprehensively explore what we can learn from academic research into consumer behavior and pricing/discounting theory.

We will:

- Conduct detailed interviews with key actors in the supply chain to discover how they incent their energy efficient products.
- Identify where in the customer purchase journey incentives will be most influential.
- Conduct original market research to determine customer tradeoffs between product attributes.
- Finally, we will take the industry beyond applications of payback acceptance curves and develop technology-specific price elasticities that reveal customers' true willingness-to-pay for efficiency.

Questions we will help you address include:

- How might my incentives strategies be improved going forward?
- What will happen to participation if I change my incentive strategy?
- How can I demonstrate the prudence of my incentive strategy to stakeholders and regulators?
- How do I apply these learnings to my programs today?

The study will also promote cooperation between manufacturers, distributors, retailers, and program administrators—providing a platform for understanding of regulatory restrictions or other constraints faced by stakeholders.

The broadly applicable results make this study ideally suited to sponsorship by multiple organizations that can share the cost. We anticipate that approximately 10 sponsors will participate. In its first 12 months, the study will focus on a group of technologies of greatest interest to sponsors (currently anticipated to be residential HVAC systems and heat pumps). Future cohorts will address additional technologies based on sponsor interest. In addition to the project deliverables, two workshops will be held each year to facilitate the discussion of findings and exchange of experience.

Targeted at utilities of all kinds (gas/electric/combination, investor- and publicly-owned), at third-party program administrators, and at major manufacturers, the study is anticipated to begin in Q3 2020. A limited number of sponsorships will be made available at $49,500 per year each.

The Team of ICF and E Source is uniquely qualified to perform this research. With over 7,000 employees worldwide, ICF's team of Ph.D. economists and statisticians have extensive experience designing incentives and estimating willingness-to-pay and price elasticity for utilities, industry, and government. Coupled with ICF's experience designing and delivering more than 200 individual energy efficiency programs for utilities across North America, along with our marketing work for major brands such as Johnson Controls, BMW, Delta, Eaton, Coors, Kraft, and Bissell, ICF provides unparalleled access to insights from within and beyond the utility industry. E Source is a leading solver of problems facing electric, gas, and water utilities and municipalities. With deep expertise in customer experience and journey mapping, as well as extensive data on energy efficiency program design and performance, they are uniquely qualified to contribute to this study.

Background

The pressure on energy efficiency program administrators to improve the cost-effectiveness of their programs and achieve greater savings with smaller budgets has never been greater. Stricter codes and standards, rising baselines, declining avoided costs, and even faltering regulatory and legislative support have all created an environment where program planners are asked to do more with less. And with a COVID-19 induced economic recession looming, both a declining customer willingness to make discretionary investments and a heightened regulatory scrutiny of utility program costs seem likely. Typically, such pressure has led to reduced program delivery and marketing budgets, cancellation of expensive technologies or "full service" programs, and a move to midstream offerings. Often overlooked, however, is redesigning the incentive strategy.

Such redesign may involve changing the incentive level ($), the eligibility criteria (using tiered incentives or multiple measure bonuses), the format (cash rebate versus price buydown), the recipient (end-user versus contractor or distributor), seasonal or special promotion availability, or even the way the incentive is articulated (as a "% off" or as a "$ off"). It may also include low interest financing in lieu of a rebate, buy-one get-one offers, or even the provision of extended warranties on efficient equipment. And incentives for some customers may, taking a page from pricing methodologies of the airline industry, vary based on how the project came to the program (through a trade ally or direct from the customer), how close the program is to meeting goal, the kWh savings yield per incentive dollar, or the statistical probability that projects with greater yield will become available. Redesigns may also include better alignment with incentives and promotions offered by manufacturers and other trade allies–who often complain that "blunt instrument" utility incentives conflict with their pricing, marketing, and stocking strategies.

But sorting through these alternatives raises some complex questions, such as:

- How much will the various strategies affect participation?
- What is the impact on net-to-gross?
- What is the return on investment?
- How will trade allies react?

Further, many regulators have historically opined that "the greater the share of the program budget that ends up as cash incentives the better" and that "all customers should receive the exact same incentive year-round." While well meaning, these perspectives ignore the fact that other program services such as technical support can sometimes be more influential than cash, and that while year-round all-customer standardization is appealing, it may come at a cost that outweighs its benefit.

This study will help sponsors answer these questions, and provide a framework for ensuring that the alternatives have been thoroughly and quantitatively examined, that the chosen incentive strategies have been optimized, and that stakeholders and regulators have bought in.

Our previous work in this area suggests that the typical utility may, in the future, be able to reduce its incentive budget by 10-20% while still achieving the same savings. It is hard to imagine any other area of investigation that could yield such significant results.

Scope of work and deliverables

The study will include:

1. Academic theory and literature review

As a first step, we will conduct a literature review of academic papers, research reports, and case studies regarding customers' equipment buying processes, barriers to participation in energy efficiency (EE) programs, and customer incentive strategies. The literature review will include research and results from both utilities and non-utilities and will help identify strategies that should be prioritized in later stages of the study.

The Team will complete the academic theory and literature review exercise in the first four weeks of the project. The output of this step will be a presentation identifying key insights and factors to be considered while designing the interview questionnaires for utility and non-utility partners, customer purchase journey mapping, and conjoint analysis. This will be shared with stakeholders during the monthly project updates.

2. Industry interviews

Non-utility partners such as manufacturers, distributors, and retailers have gained valuable insight into the benefits and features of equipment, how prices should be set, and how incentives could be designed to better engage and motivate others in the supply chain – most notably end-user customers.

The Team will conduct in-depth phone interviews with approximately 15 manufacturers, distributors, and retailers to identify their approach to pricing, promotions, and discounts. We will also elicit feedback regarding how utilities can better coordinate energy efficiency incentives with those of the market.

In addition, the Team will conduct a series of discussions with participating utilities and their applicable EM&V stakeholders to document the current state of their programs for selected measures and their corresponding incentives structures.

Finally, interview notes will be synthesized and analyzed into a presentation. Findings from these interviews will add perspective and inform other work streams such as the customer purchase and influence mapping and conjoint analysis.

3. Benchmarking

The Team will review all known active utility programs with similar design and incentive structures to those at participating utilities. For every participating utilities' program, we will identify at least three peer programs to benchmark against. We will use E Source's DSMdat database of more than 6,000 DSM programs from across the US and Canada to select peer utilities and underlying data for benchmarking. Once each program cohort is identified, we

will then benchmark the key performance metrics using data from E Source's databases that includes DSM program goals, incentive levels, net to gross levels, spending, and savings from regulatory filings. We will also conduct a non-utility benchmarking exercise across the following dimensions:

- Product pricing
- Financial incentive
- Marketing and promotional strategies used by manufacturers, distributors, and retailers

The outputs of the benchmarking will be integrated into a presentation describing the comparative findings for the measures of interest. The presentation will provide insights into key performance metrics, product pricing, financial and non-financial incentives, frequency and duration of incentives, and other promotional strategies used by non-utility partners. The presentation will highlight differences between utility and non-utility incentive levels and strategies, and opportunities for learning.

4. Customer purchase journey/influence mapping

To design an incentive structure that motivates customers, it is helpful to understand the process consumers go through to research, shop, choose, and purchase equipment. To do this, we recommend collecting data from customers who purchased equipment through a utility-sponsored program as well as consumers who were not aware of or chose not to work through an energy efficiency program.

For customers who have participated in utility programs, we'll use multiple sources of existing data—such as customer feedback and stakeholder interviews—to conduct a current state assessment and identify opportunities for improvement in both the incentives and placement of incentives within the purchase journey.

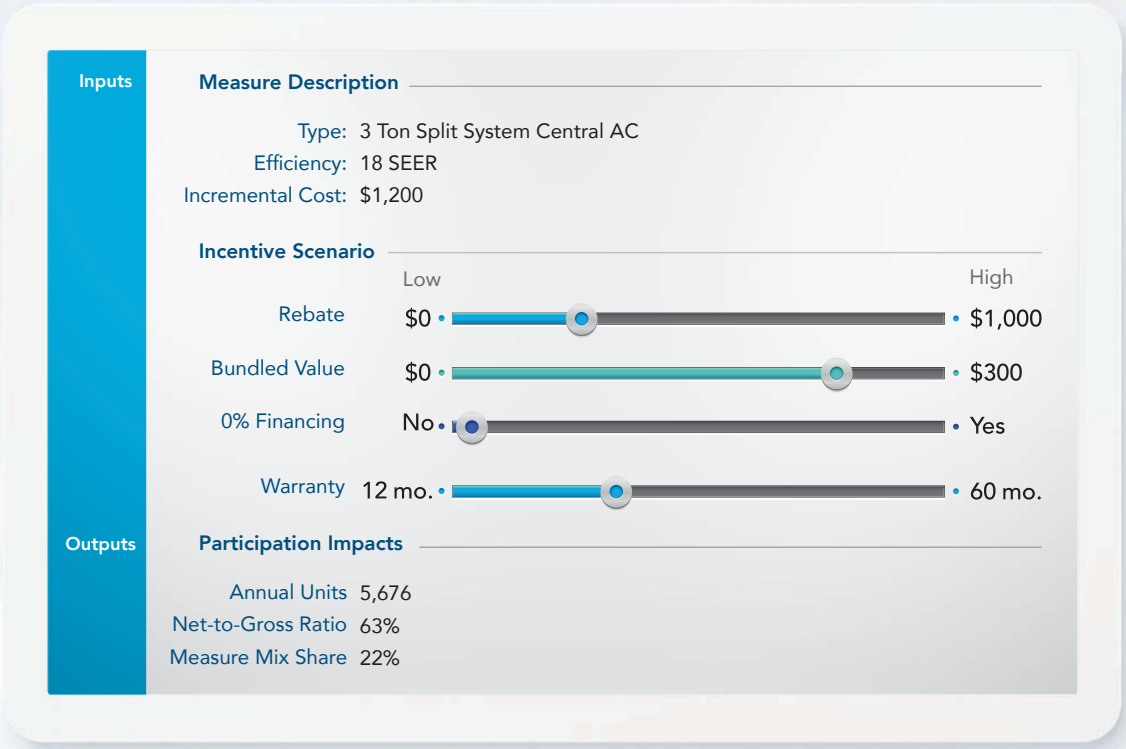
For customers who didn't participate in a utility program, we will conduct research with a national sample of individuals who bought covered measures in the past 3-6 months in order to uncover key moments of truth, frustrations, and delight in the shopping and purchasing process.

The outputs of the customer purchase journey and influence mapping task will include a presentation report that captures survey results, a current state assessment, key observations, relevant customer quotes, customer/trade ally satisfaction levels, a journey map summarizing the experiences of both program and non-program purchasers, and recommendations for where to leverage incentives.

5. Analytics

Quantifying the factors that influence selection of energy efficiency levels is key to designing such programs. Of particular interest is the least expensive incentive that will drive the desired level of participation. An incentive that is higher than necessary may induce participation but could be wasteful or not cost-effective. An incentive that is too low may not induce the necessary participation or may result in excessive free ridership. In both cases, consideration should be given to measure attributes that influence measure adoption, such as warranty, product bundles, lead time, or financing options.

Illustrative Incentive Simulation Model



To understand the impact of different attribute levels on participation, the Team will conduct a choice-based conjoint analysis and market share analysis. This will include multiple analytical steps starting with a scientific approach to questionnaire development that will involve developing comparable combinations of attributes and their levels. Those attributes would be a subset of (for example) the following characteristics:

- Incentive payment
- Price premium over standard equipment

- Efficiency level of the equipment (e.g., SEER)
- Payback period
- Length of warranty
- Financing (e.g., availability of 0% interest financing)
- Package deals (e.g., HVAC and smart thermostat)
- Service / maintenance plan
- Rebate timing (e.g., time from submittal of rebate to getting money back)
- Information delivery (e.g., when/how/what does the potential participant receive to describe the equipment)

The Team will administer the survey and process the results to produce a willingness-to-pay for each attribute and marginal rates of substitution between attributes. These results will be used to do a Market Share Analysis and will provide information on the percent of respondents willing to implement the specific measure at a given incentive level. Further, we will explore differences based on demographics (e.g., age, income, sex, education) and situation (new construction, retrofit, replacement).

Once the market share analysis is completed, we will use program design and optimization tools to vary incentive and participation together to identify an optimized incentive level for a representative program's goals. These program goals may include program budget, and cost effectiveness. The optimization tool targets a minimum or maximum program outcome (e.g., minimum budget or maximum savings) by allowing the incentives and participation for each measure to change within set bounds.

Additional findings will include insights into the other influential measure and offer characteristics and how to best factor them in to program design and implementation activities.

6. Workshops

Two 1 ½-day workshops will be hosted by the Team, and sponsors will receive complimentary registrations for up to 2 individuals. Participants will be responsible for their own travel and lodging expenses. These workshops are designed to be in-person but could be hosted virtually if circumstances require. The first workshop will occur at the midpoint of the study and be designed to present initial findings from the academic theory primer, industry interviews, benchmarking, and journey-mapping. The second workshop will occur at the conclusion of all tasks and focus the results and learning from all elements of the scope of work. In addition, a virtual kick-off meeting and monthly project status meetings will be held where interim deliverables will be presented and discussed. An additional on-site presentation of the study results for each sponsor is also included.

For additional information or to schedule a meeting to learn more, please contact:

David Pickles, Senior Vice President, ICF

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About ICF

ICF is a global consulting services company with over 7,000 specialized experts, but we are not your typical consultants. At ICF, business analysts and policy specialists work together with digital strategists, data scientists and creatives. We combine unmatched industry expertise with cutting-edge engagement capabilities to help organizations solve their most complex challenges.

ICF's energy experts have supported the energy industry for more than 50 years, and have designed and implemented many of the industry's largest and most successful energy efficiency portfolios. Our deep bench of Ph.D. economists and statisticians with experience in incentive design, our relationships with more than 1,500 manufacturers, distributors, and retailers of energy efficiency products, our non-utility marketing work with some of the biggest brands in retail, our in-house market research call center, and our extensive prior work on incentive design all make ICF uniquely qualified to offer this study. Learn more at **icf.com/work/energy**.

About E Source

E Source is a leading solver of problems facing electric, gas, and water utilities and municipalities. We provide predictive analytics, market research, benchmarking data, and consulting services to more than 300 utilities, municipalities, and their partners.

Our guidance helps customers make data-driven decisions to strengthen their customer relationships, plan for tomorrow's infrastructure needs, and further their environmental sustainability goals while becoming more innovative and responsive in the rapidly evolving market.

Division 3-2
Multi-family Programs

Request:

What interactions, if any, has the Company, or its lead vendor undertaken with the Municipal Planners and or Planning Departments of each municipality to educate them on energy efficiency measures that should be encouraged or required, as part of the approval process for multi-family dwellings and/or projects, especially those that are presented as low and moderate income housing projects under comprehensive permit process, under Chapter 53 of Title 45 of the RI Gen Laws, Low and Moderate Income Housing?

Response:

The Multifamily Program's lead vendor regularly interacts throughout the year with Municipal Planners and Planning Departments, such as the Rhode Island Housing Authority, where they provide information on energy efficiency measures within the income eligible multifamily program. The Company's Community Solutions Program Managers also regularly meet with Municipal Planners to discuss energy efficiency opportunities, which include multifamily projects.

Prepared by or under the supervision of: Angela Li and Jennifer Amatore

Division 3-3
Multi-family Programs

Request:

At Bates 159, the Company reported that it had co-branded marketing with its lead vendor according the Company's co-branding guidelines.

a. Please provide a copy of the Company's co-branding guidelines.
b. Please provide examples of all co-branded marketing pieces.
c. Please identify if the co-branding marketing materials are financed through the energy efficiency budget and, if so, please provide the amount for each of the co-branded materials for 2020, and 2021.

Response:

a. Please see the Company's co-branding guidelines, Attachment DIV 3-3-1.
b. Please see examples of the co-branded marketing pieces, attached. This collateral was used in 2020 and 2021 for the Multifamily Program (Attachments DIV 3-3-2 and DIV 3-3-3).
c. The co-branded marketing materials are included in the STAT budget of the Multifamily Program. It is not an itemized expense because the lead vendor includes this service within the program's vendor contract.

Prepared by or under the supervision of: Angela Li and Jennifer Amatore

Co-brand guidelines

Brand basics | September 2018 release

nationalgrid

Co-branding

Entities that enter into a marketing partnership or other agreement with National Grid may use the National Grid logo on advertisements, promotional or educational marketing materials, provided that they adhere to co-branding guidelines set forth in this document.

These guidelines prescribe how the National Grid logo can and cannot be used.

The National Grid logo or name may not be used as a part of any organization's name or product name, and may not be associated with any unrelated product or service.

- All partners will be asked to submit all marketing materials to their National Grid contact for review and approval prior to production.
- The National Grid logo may not be used in any company name, product name, service name, domain name or web site title.
- A clear space should surround the National Grid logo at all times.
- There must be a clear space between the National Grid logo and any other trademarks to prevent dilution and confusion.
- The National Grid logo may not be used in any manner that would disparage the National Grid utility.
- The National Grid logo may not be altered, cut apart, separated or otherwise distorted.

Co-branding with National Grid

Partnership overview

Co-branding encompasses a variety of activities at National Grid – everything from energy efficiency partnerships to the sponsorship of community events and activities.

While this guide does not identify every possible co-branding scenario, it does call attention to the most common types of approved partnerships in which the company may take part. Each co-branding scenario should be evaluated to maximize the National Grid brand, and that of its partners.

The most common co-branding scenarios include:

National Grid in a lead position.

Examples:

- Community events
- Named sponsorships
- Marketing vendors under contract to National Grid
- Marketing programs where National Grid is the lead entity

National Grid as a co-sponsor of a program or event.

Examples:

- Community events
- Trade show co-sponsorship
- Sports/arena advertising
- State/county fairs

National Grid in a collaborative position.

Examples:

- Statewide energy efficiency initiatives
- Cross marketing programs with other utilities

National Grid supports and/or works with a lead entity:

Our partners often leverage the National Grid brand to support their own programs. Additionally, there are cases where National Grid can leverage the brand of a partner or other entity in order to gain entry into new markets, for example.

Examples:

- Vendors with a written agreement with National Grid, such as Energy Service Providers and Value Plus Installers.

Please refer to the following pages for the required treatment of the National Grid logo in each of these partnerships.

Sub-brands

In general, National Grid does not allow the creation of sub brand visual elements, i.e. logos. for the company's products, services or programs.

Programs may be referred to in text, however. On first reference, use the company name before the program name, and the program name thereafter.

Example:

- First reference: National Grid's Save Program
  Second reference: The Save Program

Co-branding: lead position

National Grid in a lead position.

This example shows the relationship of the National Grid's logo to that of the partner in situations where National Grid is in the lead position of a program, sponsorship or other activity.

For specific guidance on typography and approved colors, please refer to the complete U.S. brand style guidelines located on **https://nationalgrid.onbrandcloud.com**

Specs:

There is a minimum x-height clear space around the logo. The x-height is the distance between the baseline of the type and the tops of the main body of lower case letters, excluding ascenders and descenders.

No typography, illustration, photography or other graphic device must ever encroach on this area.

- The width of the National Grid logo should never be less than 25 percent of the width of the entire piece.
- The minimum width of the National Grid logo is 30mm.
- The National Grid logo should appear 125 percent larger than the partner's logo.
- The partner logo should be positioned in the lower right-hand of page.

Co-branding: lead position don’ts

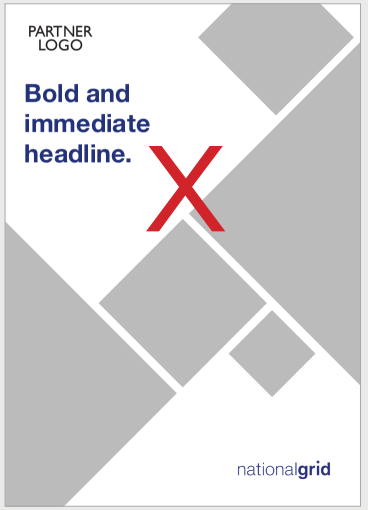
National Grid in a lead position.

Don’ts
The examples on this page are of what **not** to do in the cases where National Grid has the lead position.

Example 1
The partner logo must not exceed the size of the National Grid logo.

Example 2
The secondary position for a partner logo is in the lower right-hand corner.

Example 1



Example 2

Co-branding: co-sponsorship position

National Grid in a co-sponsorship position.

This example shows the relationship of the National Grid logo to that of other another partner(s) in situations where National Grid is an equal sponsor.

For specific guidance on typography and approved colors, please refer to the complete U.S. brand style guidelines located on **https://nationalgrid.onbrandcloud.com**

Both the National Grid logo and the partner logo should be optically equal in size. The National Grid logo is positioned to the left of the partner logo. The partner logo is positioned in a secondary position to the right of the National Grid logo. They are both positioned equally from the top of the page.

Specs:

- National Grid logo should be optically equal in size to the co-sponsoring logo.
- There is a minimum x-height clear space around the National Grid logo.
- Logos should be seperated by .5 point vertical rule equi-distant between them.

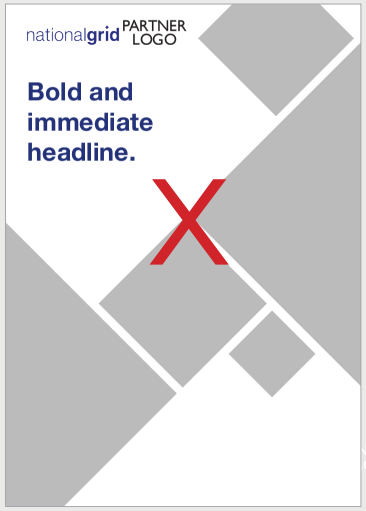
Co-branding: co-sponsorship position don’ts

National Grid in a co-sponsorship position.

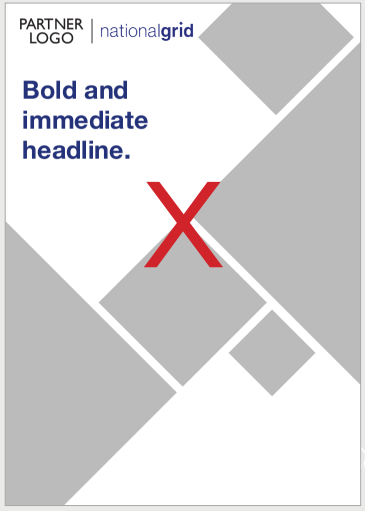
Don’ts
The examples on this page illustrate what not to do in instances of co-sponsorship.

Example 1
The partner logo should not infringe on the space the National Grid logo needs surrounding it.

Example 2
The National Grid logo must always maintain the primary position to the left of the partner logo. The partner logo must be in the secondary position to the right of the National Grid logo.



Example 1



Example 2

Co-branding: collaborative position

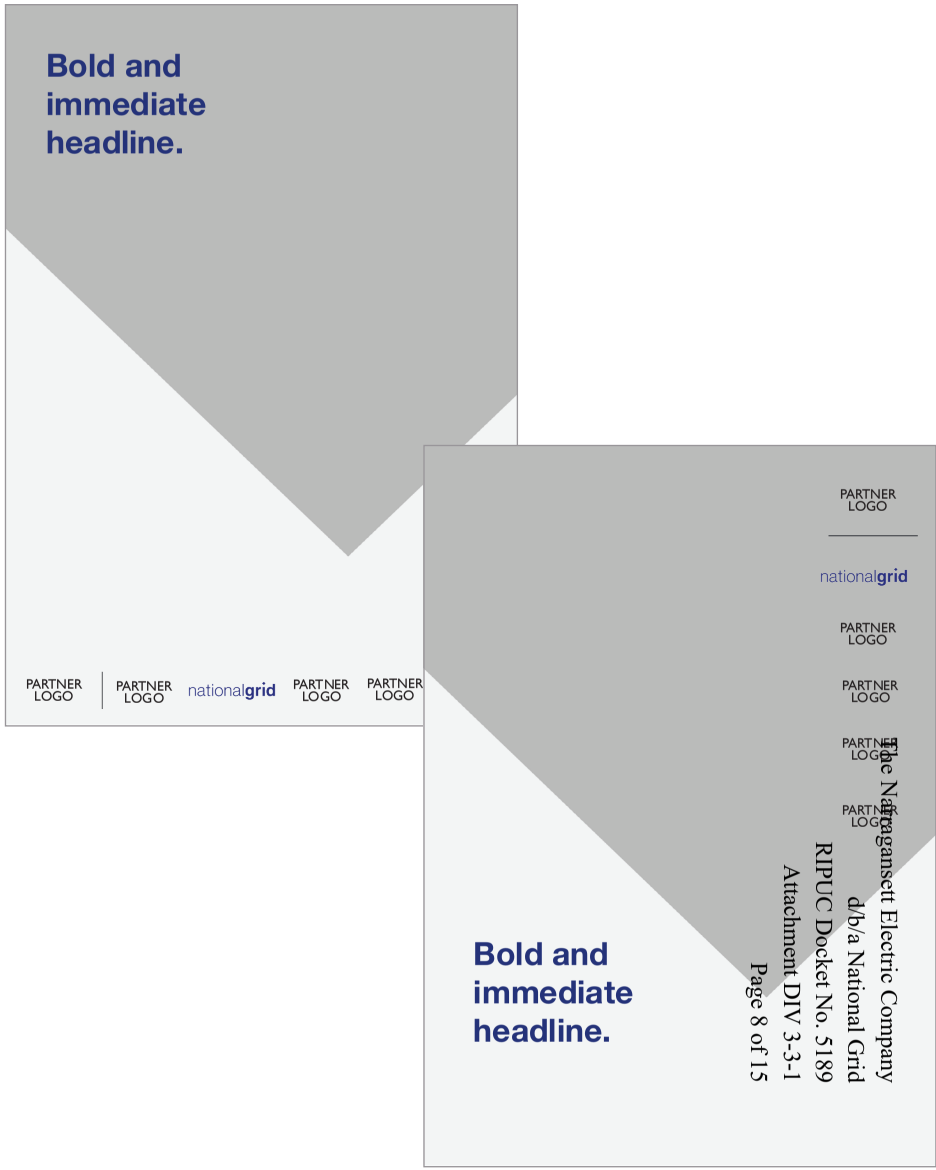
National Grid in a collaborative position.

This example shows the relationship of the National Grid logo to that of other entities when involved in a collaborative position.

For specific guidance on typography and approved colors, please refer to the visual brand guidelines.

Specs:

- National Grid should appear alphabetically within logo grouping.
- The National Grid logo should be equal optically in size to partner logos.
- There should be a minimum x-height clear space around the National Grid logo.
- The National Grid logo should be equi-distant from other logos. If possible, allow for additional clear space between co-branded logos so that each appears as an impactful and individual element within the application.
- Co-branded logos should always align to a central axis. This axis may be horizontal or vertical, based on the arrangements.
- When multiple partners unite to form one singular brand, the logo depicting that singular brand should appear to the left with a vertical .5 point rule seperating the logo of the collaborative from that of the partners.
- When possible, group partner logos horizontally. In rare instances where logos must be shown vertically, the collaborative logo should appear at the top and partner logos should be listed alphabetically underneath.



Co-branding: collaborative position don’ts

National Grid in a collaborative position.

Don’ts
The examples on this page illustrate what not to do in instances of collaboration.

Example 1
Partner logo(s) should not infringe on the space required surrounding the National Grid logo.

Example 2
The logo grouping should never appear staggered.

Example 3
The National Grid must be equal optically in size than the other partner logos.

Example 1

Example 2

Example 3

Co-branding: with a tall logo

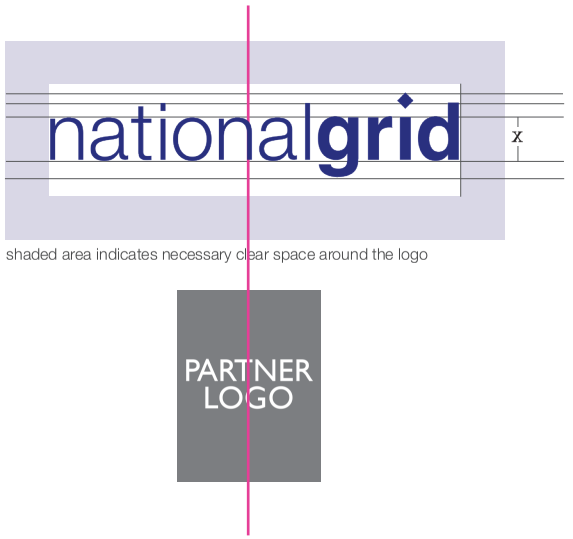
The tall logo in this example demonstrates co-branding with a logo that is vertical in weight or orientation. When the National Grid logo is presented with another mark, please follow the logo clear space recommendations.

Co-brand logos should relate in optical size. The National Grid logo and Partner logos should correspond in density.

Logos should always align along a central axis. The examples to the right shows how the alignment follows a horizontal axis and a vertcal axis.

Note that certain co-branded layouts may benefit from additional clear space.

shaded area indicates necessary clear space around the logo



shaded area indicates necessary clear space around the logo

Co-branding: with a square logo

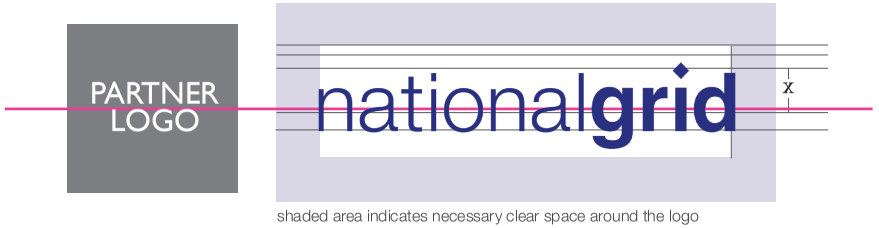
The square logo in this example demonstrates co-branding with a logo that is approximately 1 x 1 in proportion. The partner logo does not need to be a perfect square for these recommendations to apply.

When the National Grid logo is presented with another mark, please follow the logo clear space recommendations.

Co-brand logos should relate in optical size. The National Grid logo and partner logos should correspond in density. This may be done through scale and placement.

Logos should always align along a central axis. The examples to the right shows how the alignment follows a horizontal axis and a vertcal axis.

Note that certain co-branded layouts may benefit from additional clear space.



shaded area indicates necessary clear space around the logo

shaded area indicates necessary clear space around the logo

Co-branding: with a circular logo

The circular logo in this example demonstrates co-branding with a logo that is approximately 1 x 1 in proportion. The partner logo does not need to be a perfect circle for these recommendations to apply.

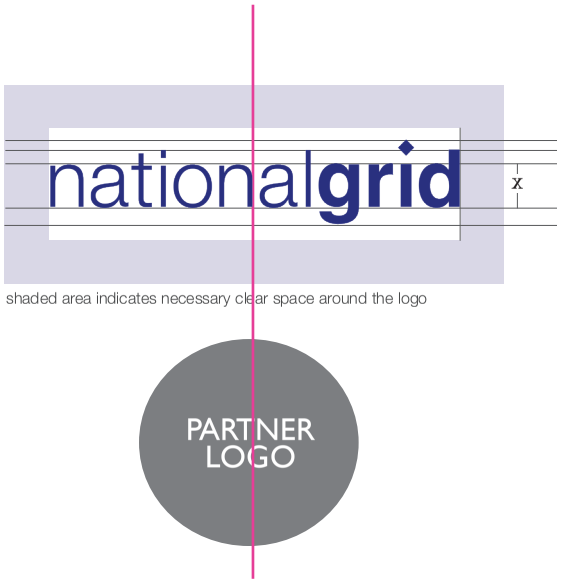
When the National Grid logo is presented with another mark, please follow the logo clear space recommendations.

Co-brand logos should relate in optical size. The National Grid logo and partner logos should correspond in density. This may be done through scale and placement.

Logos should always align along a central axis. The examples to the right shows how the alignment follows a horizontal axis and a vertcal axis.

Note that certain co-branded layouts may benefit from additional clear space.

shaded area indicates necessary clear space around the logo



shaded area indicates necessary clear space around the logo

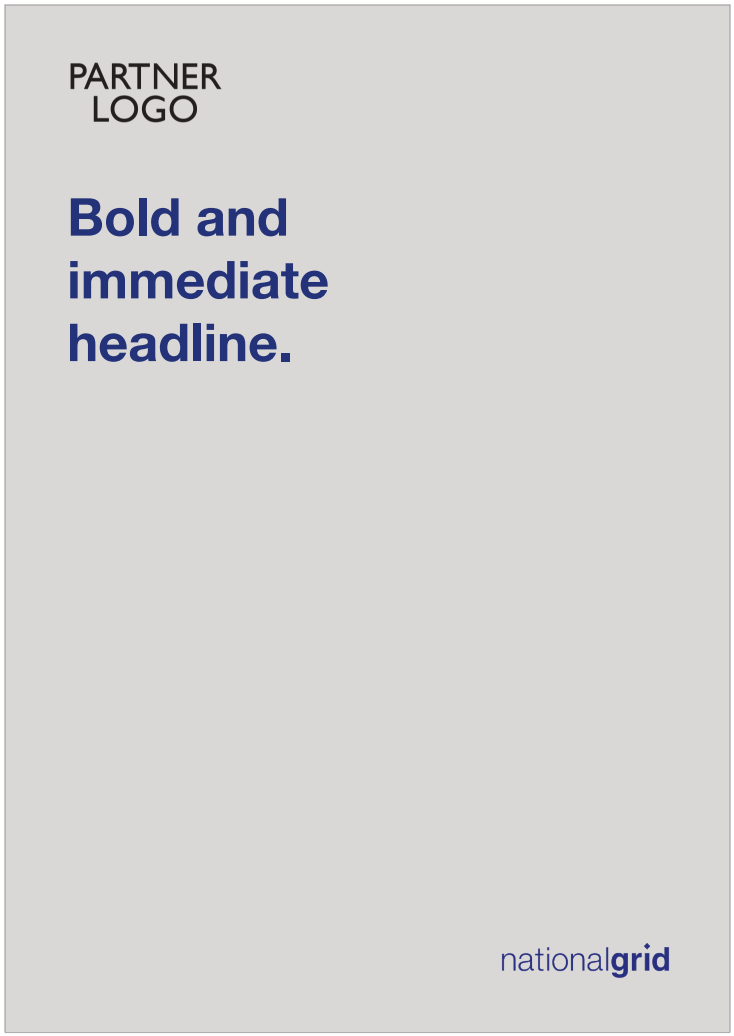
Co-branding: supporting a lead entity

National Grid in a partnership supporting a lead entity.

In cases where the approved partner is providing the entire or significant portion of a promotional cost, they may choose to use the National Grid logo to support their marketing efforts. In such cases, the National Grid logo must be displayed at no less than 75 percent than the minimum size of the partner logo or name.

Specs:

- The National Grid logo should be no less than 75 percent of the partner logo.
- There is a minimum x-height clear space around the National Grid logo.
- The National Grid logo takes a secondary position to partner's logo.



Co-branding: supporting a lead entity

Vendors that are under written program agreement with National Grid:

- Authorized Contractor
- Commercial Direct Install
- Energy Solutions Parner
- Energy Services
- Home Energy Affordability Team
- Participating Contractor
- Project Expediter
- Participating Installer
- Small Business CDO
- Small Business Custom
- Small Business Direct Install
- Value Plus Installer

Specs:

- The “bug” is reflex blue and white or can be used in black and white.
- The “bug” must be prominently placed on lead entity marketing materials.
- The “bug” must have ample clear space around it.

EPS and jpeg files of this bug are available on **https://nationalgrid.onbrandcloud.com**

nationalgrid® Value Plus Installer

PMS Reflex Blue
C100 M90 Y0 K0
R0 G20 B140

WHITE

nationalgrid® Value Plus Installer

BLACK
C0 M0 Y0 K100
R0 G0 B0

WHITE

Co-branding: supporting a lead entity

National Grid in a partnership supporting a lead entity—Brought to you by.

Vendors that are under written agreement with National Grid can also use the “brought to you by” text above our logo.

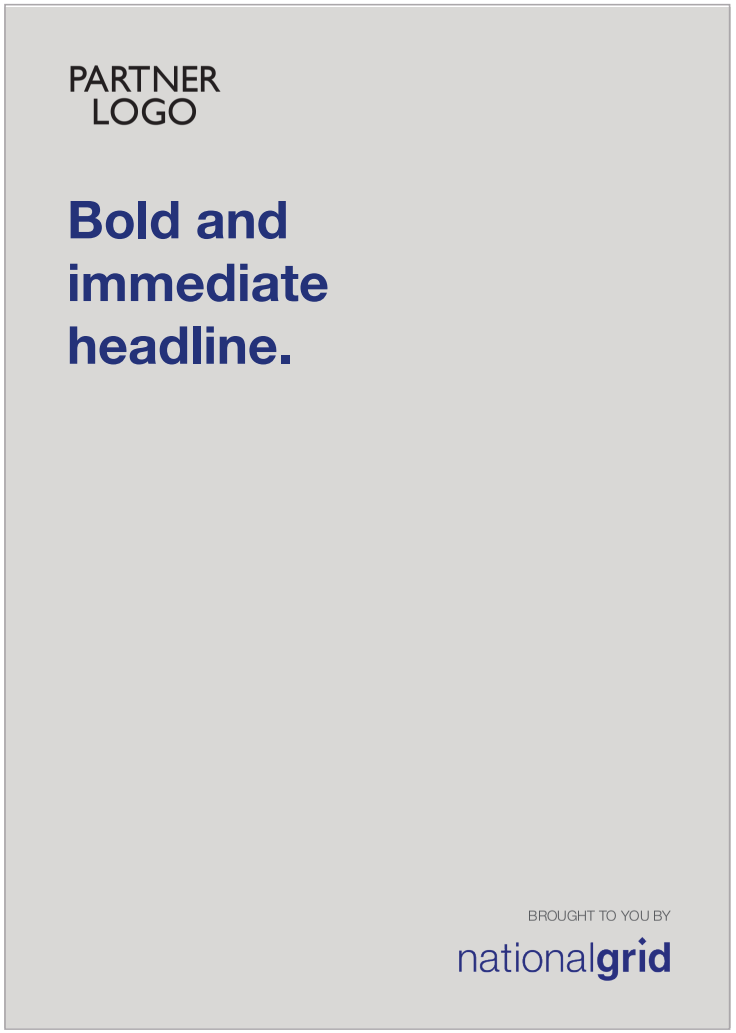
Specs:

- The font of “BROUGHT TO YOU BY” text is Helvetica Neue Light.
- “BROUGHT TO YOU BY” text is PMS Cool Gray 11.
- The text sits flush right with the National Grid logo.

EPS and jpeg files of this bug are available on **https://nationalgrid.onbrandcloud.com**

BROUGHT TO YOU BY

nationalgrid



RISE ENGINEERING™
Efficiency Energized.

Attn: Apartment owners and property managers

National Grid is pleased to announce enhanced incentives designed to help save on your property's common area expenses.

Typically common area LED lighting, weatherization (air sealing and insulation) and, in some cases, upgrading mechanical equipment and controls require an out-of-pocket payment.

You can receive an additional 10% incentive on lighting, weatherization and approved mechanical improvements when taking advantage of all recommended upgrades.

Example offer : 2 story - 20 unit apartment

Proposed measures	Total Project costs	Customer copay	New Customer copay
In unit & common area LED lighting with DHW showerheads & aerators	$1,672.68	$100.00	$100.00
Combustion safety test, air sealing with attic and hatch insulation	$ 14,998.75	$3,749.56	$2,249.81
New High efficiency condensing boilers with DHW heating re-circulator pumps and hydraulic separator	$45,500.00	$22,750.00	$18,200.00
	Total co-pay costs	$26,599.56	$20,549.81
* Eligible measures, savings calculations and proposals generated on a case by case basis only after an on site survey is performed to determine energy saving opportunities.		Overall Savings	$6,049.75

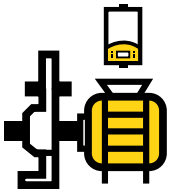
Full participation of all eligible apartment efficiency measures translates into a higher incentive on common areas improvements

Save energy and money while increasing the value of your property.

Incentivized upgrades may include:

LED lighting

Insulation & Air sealing



Mechanical Enhancement

Cap on weatherization measures is $2,000 per residential accounts and $50,000 on commercial accounts

nationalgrid

To learn more about these limited time offers and how to take advanatge of these enhanced incentives please call 1-800-422-5365 x 6122 or email tcowger@RISEengineering.com

RISE ENGINEERING™
Efficiency Energized.

Attn: Condominium Property Managers or Board Members

Energy efficiency improvements for your property's common areas at NO-COST!

National Grid is pleased to announce enhanced incentives designed to help save on your property's common area expenses.

Typically, common area lighting (LEDs) and weatherization upgrades (air sealing and insulation) require an out-of-pocket co-payment.

You can receive up to a 100% common area incentives when the condo units have energy efficiency measures completed.

The more participation from unit owners, the higher the incentives for the common areas.

Save energy and money, while making the units and common areas more comfortable and energy efficient.

Incentivized upgrades may include:

LED lighting

Insulation

Air sealing

Enhanced incentives on custom measures will be determined on a case by case basis

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To learn more about these offers and how to take advantage of these enhanced incentives please call 1-800-422-5365 x 6122 or email tcowger@RISEengineering.com

Division 3-4
Multi-family Programs

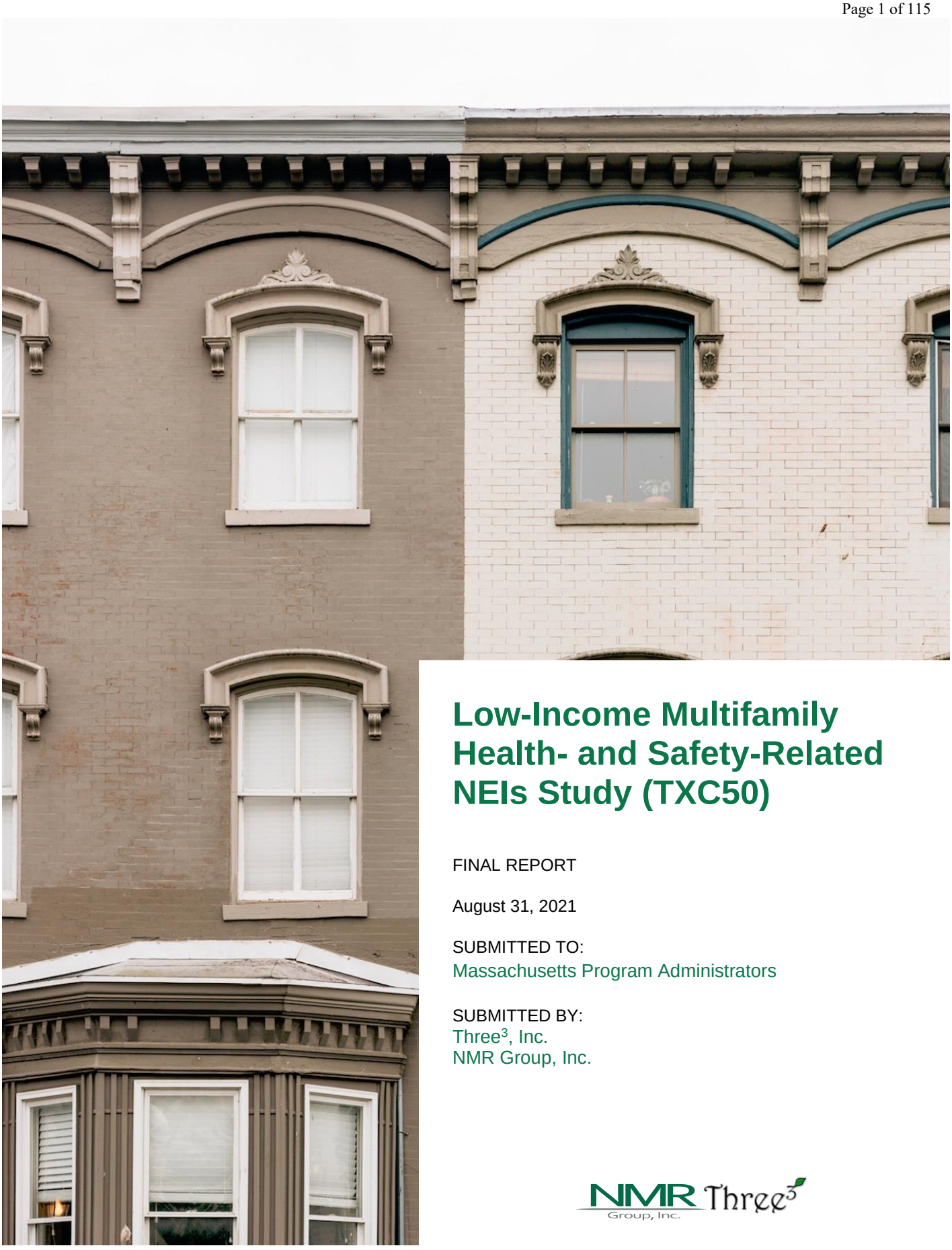
Request:

At Bates 162, the Company indicated that the final results of a Non-Energy Impact Study would be available at the end of August 2021. If the study has been completed, please provide a copy.

Response:

Please see Attachment DIV 3-4 for a copy of the recently completed MA Low-Income Multifamily Health and Safety Non-Energy Impact Study (TXC50).

Prepared by or under the supervision of: Adam Wirtshafter and Angela Li



Low-Income Multifamily Health- and Safety-Related NEIs Study (TXC50)

FINAL REPORT

August 31, 2021

SUBMITTED TO:
Massachusetts Program Administrators

SUBMITTED BY:
Three^3, Inc.
NMR Group, Inc.

Low-Income Multifamily Health- and Safety-Related NEIs

Coordinating with a multi-state evaluation funded through grants awarded by The JPB Foundation, this study quantified and monetized health- and safety-related non-energy impacts (NEIs) attributable to improvements in the energy efficiency of multifamily buildings served through the Mass Save income-eligible coordinated delivery initiative.

Approach

- Quasi-experimental pretest-posttest design to estimate the causal non-energy impacts of weatherization on low-income households without random assignment. Administered surveys to 3 groups of residents:

Weatherized during the study	Not weatherized	Already weatherized
Treatment (T)	Control (C)	Comparison (CwT)

- Identified NEIs with results from statistical analysis or other supporting evidence strong enough to recommend the Massachusetts PAs claim them.
- Produced unadjusted NEI estimates by running simple difference in means tests. For NEIs meeting threshold for statistical significance, produced regression-adjusted estimates to control for differences between study groups and test statistical rigor of estimate.

Key Findings

Four of the NEIs – Arthritis, Thermal Stress (Cold), Home Productivity, and Reduced Fire Risk – met the adoption criteria.

Recommended NEIs Per Housing Unit Per Year

Arthritis	Thermal Stress (Cold)	Home Productivity	Reduced Fire Risk	=	Total per Weatherized Household
$49	$1,426	$49	$13		$1,537

Recommended Percent Attribution of NEI Values by Measure

Air Sealing: 24%	Insulation: 24%	Heating: 52%

NMR Group, Inc. Three3

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Figures

Tables

Acronyms

Acronym	Definition
ASHP	Air-source heat pumps
C	Control
CAP	Community Action Program
CARE	Center for Applied Research and Evaluation
CDC	Centers for Disease Control and Prevention
CHIA	Center for Health Information and Analysis
CO	Carbon Monoxide
CS	Cross-sectional
CVD	Cardiovascular Disease
CWL	Control on Waiting List
CwT	Comparison-with-Treatment
DID	Difference-in-Differences
DOE	Department of Energy
DOT	Department of Transportation
DV	Dependent Variable
ED	Emergency department
EPA	Environmental Protection Agency
HCUP	Healthcare Cost and Utilization Project
HH, HHs	Household, Households
Per HH	Per household (i.e., apartment unit)
HHS	U.S. Department of Health and Human Services
HPC	Health Policy Commission
IAQ	Indoor air quality
IM-DCF	Installed Measures Data Collection Form
LIMF	Low-income multifamily
LISF	Low-income single-family
MEPS	Medical Expenditure Panel Survey
MF	Multifamily
MSA	Metropolitan-statistical area
NCHS	National Center for Health Statistics
NEI	Non-energy impact
NEWHAB	Network for Energy, Water and Health for Affordable Buildings
NPC	Non-Program Control
OOP	Out-of-pocket
PAs	Program Administrators
PM	Property Manager
RES38	RES38 Income-Eligible Process Evaluation
S	Societal
SF	Single-family
T	Treatment
VSL	Value of statistical life
WAP	Weatherization Assistance Program
Wx	Weatherized

ES

Executive Summary

Purpose and Objectives

This report presents final results from the Low-Income Multifamily Health- and Safety-Related Non-Energy Impacts (NEIs) Study, conducted for the Massachusetts energy-efficiency Program Administrators (Berkshire Gas, Cape Light Compact, Eversource, Liberty Utilities, National Grid, and Unitil) by Three[3], Inc., and NMR Group, Inc., (the evaluation team or "the team") as part of the Special and Cross-Cutting NEIs contract. The team conducted this research in conjunction with a multi-state evaluation that was funded through a grant awarded by the JPB Foundation (the JPB study).

The non-energy impacts presented in this study are changes to resident health and safety, and reductions in participating households' costs other than energy, that result directly or indirectly from weatherization. For example, improvements to housing quality through weatherization can reduce the risks of extreme temperatures in dwellings, or indoor "thermal stress," and of fluctuations in relative humidity that can affect the severity of arthritis sufferers. Improvements such as these can result in NEIs, such as avoiding medical visits and associated health care costs.

Research Objective

The objective of this study was to quantify and monetize the health- and safety-related NEIs attributable to improvements in the energy efficiency of multifamily buildings served through the Mass Save® income-eligible coordinated delivery initiative. Monetization entails valuing the impacts of weatherization services on program recipients by calculating money saved, or the dollar value of costs avoided, due to changes in health issues and household budgets resulting from weatherization. For ease of reading, this report refers to the population that is the focus of study as *low-income* (LI) households living in *multifamily* (MF) buildings, or *LIMF*.

This study explored and attempted to monetize a total of 13 NEIs, and to identify which, if any, of the NEIs yielded strong enough results from statistical analysis or other supporting evidence to recommend the Massachusetts Program Administrators (PAs) claim them when screening programs for cost-effectiveness.

Research Methodology

This study collected data from weatherization program participants and non-participants in Massachusetts, while the JPB study collected similar data program participants and non-participants in Illinois, New Hampshire, New York, Pennsylvania, Rhode Island, Vermont, and Wisconsin. Both studies took a quasi-experimental approach to estimate the causal non-energy impacts of weatherization on LI households without random assignment. Using a pretest-posttest design, the two studies administered the same set of survey instruments to three groups of

residents of affordable MF buildings before and after a subset of the buildings was weatherized. The studies supplemented these surveys with information about the mechanical and ventilation systems in the buildings before weatherization and the measures installed during weatherization, as reported by participating partners. This study leveraged the data collected by the JPB study to increase the statistical power and precision of the Massachusetts results at no additional cost to the Massachusetts PAs.

Both studies recruited research participants from among residents of affordable MF buildings that fell into the three groups: a Treatment group, with pre- and post-testing; a Comparison-with-Treatment group, which received its treatment prior to the start of the project; and a Control group.

The team fielded the surveys for this study from January 2018 through May 2019 (pre-weatherization) and from July 2019 through March 2020 (post-weatherization). Table 1 presents the final sample sizes for both studies by number of sites (each of which may comprise multiple buildings) and dwelling units in each sample.

Table 1: Final Sample Sizes by Study Group

	All Groups Combined	CwT	T	C
			Sample Size (n)	
Total Number of Households	**1,921**	**612**	**417[1]**	**892**
MA Sample	461	206	82	173
Other States	1,460	406	335	719
Total Number of Sites	**186**	**72**	**50**	**64**
MA Sample	60	27	10	23
Other States	126	45	40	41

[1] Treatment group households completed both pre- and post-weatherization surveys (MA and "Other States" combined) = 198

Comparability of Study Groups

The convenience sampling approach limited the ability to recruit study participants who were comparable in all aspects. The team compared the three study groups and the Massachusetts sample with the sample of states from the JPB study to assess differences among them. Key observations from this comparison include the following:

- Respondents from Massachusetts and the other states reside in similar housing types. Slightly more than 50% of respondents in both geographic groups lived in buildings with 40+ units. The majority of respondents in both groups resided in low-rise (<5 stories) buildings. The Massachusetts group had higher rates of publicly owned buildings than the JPB group (40% MA versus 18% JPB), while the majority of buildings in the JPB group were owned by non-profits or privately (73% JPB versus 17% MA). [1]
- There were statistically significant demographic differences between the Treatment, Control, and Comparison-with-Treatment sample groups, and between the Massachusetts sample and the JPB study sample from other states. Across study groups,

[1] Type of ownership was reported as "unknown" for 44% of buildings in Massachusetts.

Massachusetts respondents were older (by a mean of seven years) than respondents in the JPB sample, and had a 16% higher rate of both retirees and single-person households. Of all the demographic characteristics, the racial composition between Massachusetts and the JPB sample is the most dissimilar. The Massachusetts sample had close to twice the rate of White respondents as the JPB sample (71% versus 40%) and less than half the rate of Black or African-American respondents (14% versus 36%). Compared to the Treatment and Comparison-with-Treatment study groups, the proportion of Black or African-American respondents was higher in the Control group: half of the Control group identified as Black or African American compared to less than one-quarter of each the Comparison-with-Treatment and Treatment groups.

We conducted regression analysis to assess the possibility of demographic differences among the study groups affecting weatherization outcomes and control for observable differences.

NEIs Examined

This study attempted to monetize a total of 13 NEIs and to identify which, if any, of the NEIs yielded strong enough results from statistical analysis or other supporting evidence to recommend the Massachusetts PAs claim them. The 13 NEIs the study examined are listed below in alphabetical order:

- Arthritis
- Asthma
- Food Assistance
- Food Spoilage
- Home Productivity
- Low-Birth-Weight Infants
- Missed Days of Work
- Prescription Adherence
- Reduced Fire Risk
- Short-Term, High-Interest Loans
- Thermal Stress (from both excessive heat and cold)
- Trips and Falls
- Work Productivity

The evaluation team explored monetizing these NEIs for the following reasons:

- It was possible and reasonable to obtain the primary data needed to measure and monetize the outcomes from each NEI.
- The team could acquire objective secondary cost data for medical encounters needed for monetization.
- The benefits expected from these NEIs would begin almost immediately, allowing households to see differences due to weatherization before the completion of this research.

KEY FINDINGS AND RESULTS

Four of the NEIs this study explored – Arthritis, Thermal Stress (Cold), Home Productivity, and Reduced Fire Risk – met the adoption criteria that were set in advance:

- The NEI accrues at the household level, which is the level at which the PAs are currently able to claim NEIs.
- The NEI is not derived from energy bill savings and so do not risk double-counting.
- For NEIs that rely on primary data, both the results of the difference in means analysis (unadjusted estimate) and the coefficient of the weatherization variable in the regression model (regression-adjusted estimate) are statistically significant at p-value <.10 for the outcome of interest. For the one NEI that relies on secondary data only (Reduced Fire Risk), there is sufficient incidence rate and risk factor data from secondary sources to monetize the NEI from these sources.

The team calculated reduced Thermal Stress from cold and Reduced Fire Risk with and without the benefit of avoided deaths (Value of Statistical Life or VSL). The team used the most recent VSL value recommended by the U.S. Department of Transportation (2016) to monetize this benefit.

RECOMMENDATIONS

The Arthritis, Thermal Stress (Cold), Home Productivity, and Reduced Fire Risk NEIs meet all criteria. The team recommends that the PAs adopt the monetized value of these four LIMF health-and-safety-related NEIs. The annual values for each NEI are Arthritis, $49; Thermal Stress (Cold), $1,426; Home Productivity, $49; and Reduced Fire Risk, $13. The total annual value of the recommended household NEI values per unit, excluding societal benefits, is $1,537 (Table 2).

Table 2: Estimated Annual Values for Recommended NEIs Per Housing Unit, with VSL as Applicable

NEI Values	Per Year
Arthritis	$49
Thermal Stress (Cold)	$1,426
Home Productivity	$49
Reduced Fire Risk	$13
Annual Total of Recommended NEIs per Weatherized Housing Unit	**$1,537**

There is no established methodology by which to attribute NEI values to relevant measures in the BCR models. This study attempted to improve on a previous Massachusetts LI NEI study's approach to attributing NEI values to measures in the BCR models. It developed a simple and empirically-grounded approach using regression analyses and composite NEI values to allocate the recommended NEI values to relevant measures in the BCR models according to each measure's contribution to the change in the composite NEI value. Based on the results of the analysis, the value of each of the recommended NEIs should be allocated across three measures, as follows:

- Air sealing: 24%
- Insulation: 24%
- Heating system upgrades: 52%

For example, the annual total value of recommended NEIs per weatherized housing unit, $1,537, should be allocated across these measures, as follows:

- Air sealing: $369
- Insulation: $369
- Heating system upgrades: $799

CONSIDERATIONS

The team identified lessons from this study that could improve the PAs' future NEI research.

1. When planning future studies of this type, PAs and their evaluators should focus on a narrower range of NEIs. Examining a narrower range of NEIs such as these would mean a shorter survey. The lower response burden would likely result in higher response rates. Another way to boost group sizes is to supplement the current dataset with new data on a narrower range of NEIs, and reanalyze it to yield more definitive results for the selected NEIs.
2. When planning future studies of thermal stress-related NEIs, evaluators should consider using changes in hospitalizations, as well as emergency department visits, to establish the avoided death benefit.
3. In undertaking future studies of this type, PAs and evaluators should be mindful that planning for – and achieving – larger Treatment and Control group sample sizes would increase statistical rigor and the validity of results, especially for NEIs associated with specific chronic illnesses or rare conditions.
4. PAs should ensure that evaluators conducting future studies of MF or SF housing include a household income question in resident surveys.
5. Lack of contact information for property owners/managers and occupants is a substantial impediment to research in the MF rental sector, regardless of the income of occupants. Various steps can be taken in advance of and during research to mitigate this impediment.

   Participating property owners/managers and occupants

   - As part of the program application process, PAs should require – or at least request – that property owners agree in writing to provide access to the building and assist with resident outreach should their building be selected for a PA-sponsored evaluation.

   Non-participating (control group) property owners/managers and occupants

   - Evaluators should develop a sample frame of non-participating rental property owners/managers and occupants of rental properties.

- Evaluators, in combination with PA evaluation, should identify and explore opportunities to work with associations or organizations that house data of affordable multifamily buildings in the state or region of interest, in hopes of leveraging these organizations' data.
- In the near future, the Massachusetts Office of Energy and Environmental Affairs may implement an initiative that includes collecting energy usage data at a municipal or county level. This data will help identify affordable MF properties with high energy usage.

All occupants

- Evaluators should ensure that future research among occupants of MF rental property include budget for in-person canvassing, especially when resident information is unavailable.

6. Be aware of the challenge of establishing building eligibility, group assignment, and measures installed, and prepare for it in advance if possible.
    - PAs should encourage a broader range of low-income stakeholders to become involved in study planning as early as possible to increase the likelihood of obtaining data for participating and non-participating buildings and households.
    - PAs should encourage weatherization agencies and vendors to track participation data more comprehensively, regardless of whether or not jurisdictions outside of Massachusetts are involved.
    - Studies of the MF sector in Massachusetts could be helped by modifying program tracking systems to track participation by facility, not by building, and include the number of units per building.
7. When conducting future studies of this type, evaluators should consider recruiting housing units directly, rather than – or in addition to – recruiting MF buildings first.
8. This study benefited greatly from peer review during the planning process and in the penultimate draft. PAs should consider requiring evaluators to plan for and undertake this practice in future NEI studies.

KEY LIMITATIONS AND SOURCES OF UNCERTAINTY

There are four limitations and potential sources of uncertainty in this study: (1) the possibility of systematic error due to respondents' inaccurate or incomplete recall of past events or experiences (recall bias); (2) a lack of random assignment to Treatment and Control groups, which decreased the likelihood of finding matching groups of buildings and study participants in each sample; (3) bias due to the characteristics of sampled buildings not perfectly representing the population of buildings of interest; and (4) smaller sample sizes than expected, particularly for Treatment buildings, which reduced the power of the analysis.

1

Section 1 Introduction

This report presents final results from the Low-Income Multifamily Health- and Safety-Related Non-Energy Impacts Study, conducted for the Massachusetts energy-efficiency Program Administrators (PAs)[2] by the evaluation team of Three[3], Inc., and NMR Group, Inc., ("the team" or "we") as part of the Special and Cross-Cutting Non-Energy Impacts contract. The team conducted this research in conjunction with a multi-state evaluation managed by Three[3] and Slipstream, Inc. that was funded through a grant awarded by the JPB Foundation (JPB).

1.1 Research Objective

The objective of this study was to quantify and monetize the health- and safety-related non-energy impacts (NEIs) attributable to improvements in the energy efficiency of multifamily buildings served through the Mass Save® income-eligible coordinated delivery initiative.[3] Monetization entails valuing the impacts of weatherization services on program recipients by calculating money saved, or the dollar value of costs avoided, due to changes in health issues and household budgets resulting from weatherization. For ease of reading, this report refers to the population that is the focus of study as *low-income* (LI) households living in *multifamily* (MF) buildings, or *LIMF*.

1.2 Overview of Non-Energy Impacts

1.2.1 Non-Energy Impacts Framework

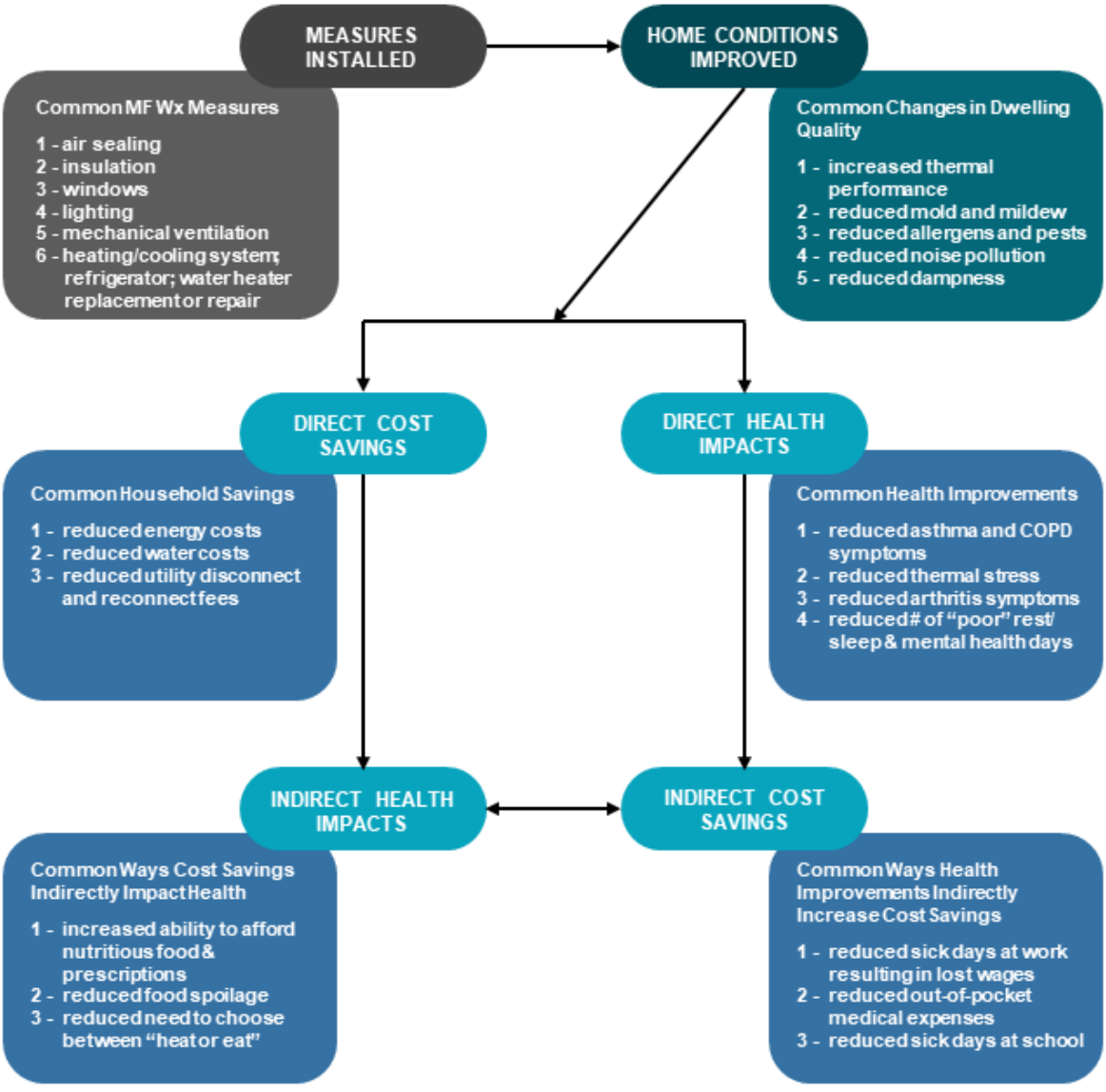
In addition to reducing energy consumption, weatherization changes the physical condition of dwellings, potentially resulting in improvements to resident health and safety and reductions in energy costs and other costs. For example, improvements to dwelling quality can reduce exposure to known asthma triggers, such as mold, dust, and extreme temperatures, thus reducing the incidence of acute asthma symptoms. By improving thermal performance, weatherization can reduce the risks of extreme heat or cold in dwellings, or indoor "thermal stress."[4] Improvements such as these can result in NEIs, such as reducing medical costs and lowering the number of days of work lost due to illness.[5] These lowered or avoided expenses can allow households to better afford key items, such as quality food and healthcare, and avoid "heat-or-eat"

[2] The Massachusetts Program Administrators comprise Berkshire Gas, Cape Light Compact, Eversource, Liberty Utilities, National Grid, and Unitil.
[3] Berkshire Gas, Cape Light Compact, Eversource, Liberty Utilities, National Grid, and Unitil work together as Mass Save to help residents and businesses across Massachusetts save money and energy by providing energy-efficiency programs and services, which helps lead the state to a clean and energy-efficient future.
[4] For example, air sealing and insulation decrease drafts and unsafe temperatures inside the home and improve the resilience of homes during extreme weather events.
[5] For example, reduced costs for water and utility disconnect and reconnect fees.

predicaments.[6] These, in turn, can have additional positive impacts on household members' health.

Figure 1 illustrates how weatherizing housing stock can improve household members' health and finances, resulting in a virtuous cycle of positive feedback effects that reinforce and amplify each other.

Figure 1: How Weatherization Can Yield Health Impacts



[6] Frank et al. "Heat or Eat: The Low Income Home Energy Assistance Program and Nutritional and Health Risks among Children Less Than 3 Years of Age." Pediatrics, Vol. 118, No. 5, November 1, 2006, pp. e1293 -e1302.

1.2.2 NEIs Monetized

This study attempted to monetize a total of 13 NEIs and to identify which, if any, of the NEIs yielded strong enough results from statistical analysis or other supporting evidence to recommend the Massachusetts PAs claim them. We chose these NEIs for monetization for the following reasons:

- It was possible and reasonable for us to obtain the primary data needed to measure and monetize the outcomes from each NEI.
- We could acquire objective secondary cost data for medical encounters needed for the monetization.
- The benefits expected from these NEIs would begin almost immediately, allowing households to see differences due to weatherization before the completion of this research.

Table 3 shows (1) the NEIs we are recommending for adoption and (2) the NEIs that we monetized but are not recommending for adoption. The NEIs we are not recommending are important and substantial, with positive monetizable benefits, but the study did not yield a statistically robust estimate of their monetized values, likely due to insufficient sample size.

The table includes information about the type of NEI (household [HH] or societal [S]) and the potential for double-counting the NEI with energy bill savings. The NEIs the team recommends here for PA adoption have the following characteristics:

- They accrue at the household level, which is the level at which the PAs are currently able to claim NEIs.
- They are not derived from energy bill savings and so do not risk double-counting.
- They either yielded statistically significant results from the regression analysis or there was sufficient incidence rate and risk factor data from secondary sources to monetize the NEIs from these sources.

Table 3: NEIs Monetized in This Study

Monetized NEIs	Type (HH or S)[1]	Derived from Energy Bill Savings (Y/N)
Recommended NEIs		
Arthritis	HH and S	N
Thermal Stress (Cold)	HH and S	N
Reduced Fire Risk	HH and S	N
Home Productivity	HH	N
NEIs Not Recommended for Adoption (due to lack of statistical robustness)		
Asthma	HH and S	N
Missed Days of Work	HH and S	N
Trips and Falls	HH and S	N
Food Spoilage	HH	N
Work Productivity	S	N
Low-Birth-Weight Infants	HH and S	Y (HH)
Short-Term, High-Interest Loans	HH	Y
Food Assistance	S	Y
Prescription Adherence	S	Y

[1] In this and subsequent tables, HH = Household-level NEI; S = Societal-level NEI.

2

Section 2 Research Methodology

2.1 Research Design and Data Collection

We conducted this Massachusetts-specific NEI study in concert with a larger regional study managed by team member Three[3], referred to here as the JPB study. This study was fielded in a similar time frame as the JPB study and was funded through grants from the JPB. The JPB study collected data from weatherization program participants and non-participants in Illinois, New Hampshire, New York, Pennsylvania, Rhode Island, Vermont, and Wisconsin, while this study only collected data from those in Massachusetts. Both studies took a quasi-experimental approach to estimate the causal NEIs of weatherization on LI households without random assignment. Using a pre-test-post-test design, the two studies administered the same set of survey instruments (the resident surveys) to three groups of residents of affordable MF buildings before and after a subset of the buildings was weatherized. The studies supplemented these surveys with information about the mechanical and ventilation systems in the buildings before weatherization and the measures installed during weatherization, as reported by participating partners. This study leveraged the data collected by the JPB study to increase the statistical power and precision of the Massachusetts results at no additional cost to the Massachusetts PAs.

2.1.1 Resident Survey

Team member Three[3] drafted the resident survey used for both the JPB study and this study. The resident survey was based on the national occupant survey used for the U.S. Department of Energy's Weatherization Assistance Program (WAP) evaluations,[7] but with a number of additions. These included more targeted questions to measure relevant NEIs, such as Asthma, Thermal Stress, and Missed Days of Work, and questions to explore other health, well-being, and safety issues that could be impacted by weatherization, such as Arthritis, Food Spoilage, and injuries from Trips and Falls. Wherever possible, Three[3] drew on existing reputable surveys to develop the new questions.

[7] Three[3] staff designed the occupant survey, managed the national WAP evaluations, and conducted the health and household-related impacts attributable to the WAP study while employed as research staff under the auspices of Oak Ridge National Laboratory.

2.1.2 Study Groups

Both studies recruited research participants from among residents of affordable MF buildings that fell into three groups: a Treatment group, with pre- and post-testing; a Comparison-with-Treatment group, which received its treatment prior to the start of the project; and a Control group.

1. Treatment (T): This group comprised buildings that had not been weatherized between March 2008 and the first resident survey, but were scheduled for weatherization within a few months after the first resident survey.[8]
2. Comparison-with-Treatment (CwT): This group comprised buildings that had been weatherized between March 2008 and March 2017.
3. Control (C): This group comprised buildings that had either never been weatherized or that were not weatherized between March 2008 and the completion of data collection.

The baseline (Phase 1) survey measured the dependent variables for participants in each of the three groups. The team administered the second (Phase 2) survey to both the Treatment (ten to 14 months post-weatherization) and the Control (ten to 12 months after the Phase 1 survey) groups to observe any changes in dependent variables. The team only administered the Phase 1 survey to the Comparison-with-Treatment group. (We only used this group as a proxy for post-treatment changes in Phase 1 in order to produce interim results for the PAs and EEAC consultants. For more detail about the study groups, see Appendix E).

2.1.3 Sampling

We conducted a power analysis to set sample size targets for the number of surveys in Massachusetts and the JPB study states. The power analysis relied on two variables: asthma-related emergency department (ED) visits and missed days of work. The team selected these two variables for the power analysis because of all the NEIs measured in the 2016 Massachusetts study of LI Single-Family Health- and Safety-related NEIs,[9] they had the highest values and were among those with the largest effect sizes. We based our estimates of these variables on results from the national evaluation of WAP, using an alpha of 0.1. The team set sample size targets to achieve a confidence level of 90% or higher, with the assumption that the analysis would combine Massachusetts and JPB results. Due to the recruitment challenges described below, we relied on a convenience sampling approach rather than random selection.

[8] Throughout this report, tables and equations use the acronyms for Treatment (T), Comparison-with-Treatment (CwT), and Control (C).
[9] Three[3] and NMR. "Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study." Submitted to *Massachusetts Program Administrators and EEAC Consultants*, 2016. Massachusetts Special and Cross-Cutting Research Area. August 5, 2016 http://ma-eeac.org/wordpress/wp-content/uploads/Low-Income-Single-Family-Health-and-Safety-Related-NonEnergy-Impacts-Study.pdf.

2.1.3.1 Phase 1 Sample Frame

We derived the Massachusetts Treatment sample frame from data provided by the Massachusetts PAs and one Community Action Program (CAP) agency.[10] We obtained the sample frame for other states from numerous lists of eligible buildings provided by state and local agencies, owners of affordable MF buildings, and utilities. The Massachusetts Control sample consisted of (1) projects that had gone through the PAs' or CAP program intake processes were deemed eligible, but were not expected to be weatherized before the start of Phase 2, and (2) LIMF sites in Massachusetts not associated with the Mass Save income-eligible coordinated delivery initiative. (See Appendix E for more details.)

2.1.3.2 Phase 2 Sample Frame

The Treatment and Control respondents from Phase 1 formed the sample pool for Phase 2.

2.1.4 Fielding

We fielded the Phase 1 resident survey from January 2018 through May 2019 and the Phase 2 resident survey from July 2019 through March 2020. We attempted to recruit all respondents to complete the Phase 2 survey at close to the same time of year as they completed the Phase 1 survey (at least within the same season). For the Treatment respondents, this was approximately ten to 12 months after their building was weatherized. For the Control respondents, this was approximately ten to 12 months after they completed their Phase 1 survey. (See Appendix E for more details.)

During Phase 1, we visited 67 eligible sites in Massachusetts and 121 eligible sites in the other states. Each site comprised one or more buildings. We conducted visits in person because the only contact information available was for the property owner/manager of the MF buildings, not for the residents of individual units in each building. During these visits, we also gathered additional contact information to facilitate fielding Phase 2. In-field staff distributed 2,629 survey packets to Massachusetts residents and 5,116 survey packets to residents outside of Massachusetts, for a total of 7,745 surveys. During Phase 2, the team called and/or sent survey packets to 417 households at 50 Treatment sites and 892 households at 64 Control sites. We gave respondents the option of completing the resident survey by telephone or on paper. In Phase 1, we also gave respondents the option of completing the resident survey online.

For households that responded to the Phase 1 survey and provided a phone number, the team called the household to complete the Phase 2 survey. We called each home up to ten times on different days of the week and different times of the day. If the respondent did not answer after ten calls, the phone number was disconnected or otherwise inoperable, or the respondent did not provide a phone number, we mailed a paper survey with an explanatory cover letter, project description, informed consent document, and a $1 bill paper clipped to the cover letter as a gesture of good will and to encourage a response. Upon receiving each completed survey, we mailed the respondent a $40 gift card.

[10] Action for Boston Community Development (ABCD) provided data on behalf of Eversource, Columbia Gas, and Cape Light Compact (CLC).

By November 2019, it became clear that more than enough Control surveys had been returned for the number of Treatment surveys expected, so the team ceased follow-up efforts for the Control group. From this point, if the team had a phone number for a Control home, the team would still attempt phone calls, but not send a paper survey. When there was no phone number on record, we would send a paper survey but no reminder postcard or second survey. This allowed each home to complete the Phase 2 survey while reallocating resources to increase the Treatment response rate.

Due to a number of factors beyond our control, including lack of availability of contact information for building residents, the need for property management approval for the team to enter the premises to recruit residents for the study, and a lower-than-projected rate of MF building weatherization, the Treatment group from Phase 1 was smaller than anticipated. After observing initially low response rates (15%) for the Treatment group in Phase 2, we sent staff back into the field in November 2019 to distribute survey packets in person. To close the response rate gap between the Treatment and Control groups, in-field staff canvassed a handful of Treatment sites from Phase 1.

Our additional efforts to recruit Phase 2 Treatment group respondents were effective, as the final Phase 2 response rate was 47%. From the Treatment group in Phase 2, the team received 198 household surveys that represented 310 persons (57 from Massachusetts and 253 from other states). Table 4 presents the final sample sizes. Note that in this and subsequent tables, the number of households is always equal to the number of units.

Table 4: Final Sample Sizes by Study Group and Characteristic

	CwT	T		C	
Characteristic	P1 (T_Post)	T_Pre	T_Post	P1	P2
	Sample size (n)				
No. of HHs (Total n=1,921)	612	417	198	892	553
No. of Persons (Total n=2,964)	880	742	310	1,273	699
No. of HHs that completed both pre- & post-weatherization surveys (Total n=751)	0	198		553	
No. of Buildings (Total n = 382)	140	103		139	
No. of Sites (Total n = 186)	72	50		64	

On March 25, 2020, the team suspended all survey efforts due to the COVID-19 pandemic. We determined that any survey results collected after that time would be incomparable with those from Phase 1. We excluded from analysis any incoming surveys that were completed after stay-at-home orders were issued and/or schools were closed in the respondent's state.

2.2 SAMPLE CHARACTERISTICS

The following sections characterize the samples, discuss comparability between the samples of buildings and respondents, discuss comparability between the Massachusetts sample and the JPB sample, and present data from participating agencies on property characteristics and installed weatherization measures. The resident survey included questions on home livability and dwelling conditions. While we did not use these data to monetize the NEIs, they serve as supporting evidence for monetization.

For additional summary statistics on home conditions of the sample, see Appendix G.

2.2.1 Building Characteristics

Table 5 shows differences in building characteristics among the three study groups from Phases 1 and 2. As the table shows, Treatment and Control building characteristics remained fairly stable from Phase 1 to Phase 2; the Treatment group changed slightly more than the Control group due to the number of buildings excluded from Phase 2 due to the COVID-19 pandemic. (For example, the Treatment group went from 20% to 0% high-rise buildings because these buildings were scheduled for Phase 2 surveys in Spring 2020, when the pandemic halted data collection.[11])

The Comparison group had a larger proportion of both low-rise units (78%) and senior housing units (56%) than either the Treatment or Control groups, and the respondents were more evenly distributed across the participating states. In contrast, 60-64% of the Control group surveys came from Illinois.

[11] This did not affect the validity of results, as the Phase 1 Massachusetts Treatment building sample did not include high-rise buildings.

Table 5: Building Characteristics

(All States Combined)

Building Characteristic		Comparison with Treatment	Treatment		Control	
		P1 (post-Wx)	T_Pre	T_Post	P1	P2
No. of HHs		612	417	198	892	553
Rise						
Low-rise (< 5 stories)		78%	54%	66%	59%	58%
Mid-rise (5 to 9 stories)		16%	24%	33%	34%	37%
High-rise (10+ stories)		5%	20%	0%	6%	6%
Size (housing units)						
5 to 12 units		22%	30%	41%	14%	12%
13 to 39 units		30%	21%	20%	22%	20%
40 or more units		48%	49%	39%	64%	69%
Ownership						
Private		42%	27%	33%	45%	44%
Non-profit and public		54%	51%	57%	33%	35%
Unknown		4%	22%	10%	22%	22%
Housing Function						
Family		14%	26%	17%	22%	19%
Mixed Use		6%	2%	<1%	8%	7%
Senior		56%	12%	17%	30%	27%
Supportive		5%	7%	5%	27%	31%
Unknown		20%	53%	60%	15%	15%
Region/State						
Midwest	Illinois	16%	<1%	<1%	60%	64%
	Wisconsin	11%	8%	6%	5%	5%
Northeast	Vermont	4%	3%	5%	<1%	<1%
	New York	11%	32%	10%	3%	2%
	Rhode Island	11%	31%	47%	8%	7%
	Pennsylvania	12%	1%	0%	5%	3%
	New Hampshire	2%	5%	7%	0%	0%
Massachusetts		34%	20%	25%	19%	20%

Table 6 shows building characteristics of the Massachusetts sample versus the rest of the sample (the "Other States") for each study group. As the table indicates, respondents from Massachusetts and the other states reside in similar types of housing. Similarity in housing characteristics across the sample are important, as systematic differences in key characteristics of buildings can potentially affect the outcomes as much, or more than, systematic differences in demographic characteristics. (Differences in climate zone are also important, which is why the sample frame only included cold-climate-zone states.) Slightly more than 50% of respondents in both geographic groups lived in buildings of 40+ units. The majority of respondents in both groups resided in low-rise (<5 stories) buildings, although at a lower percentage in Massachusetts (62%)

than the JPB group (89%). The high-rise buildings were the least represented in both groups. Ownership of the buildings differed between the Massachusetts and JPB groups. The Massachusetts group had higher rates of publicly owned buildings than the JPB group (40% versus 18%), while the majority of buildings in the JPB group were owned by non-profits or were owned privately (73% versus 17%).[12] The team performed regression analysis to assess whether differences between regions were confounding factors, and found that none were. (See Appendix C for more information.)

Table 6: Building Sample Profile, by MA versus Other States[1]

Building Characteristic	All Groups Combined		Comparison-with-Treatment (P1 Only)		Treatment (T_Pre and T_Post)		Control (P1 and P2)	
	MA	Other States	MA	Other States	MA	Other States	MA	Other States
n (# of units)	**461**	**1,460**	**206**	**406**	**82**	**335**	**173**	**719**
Rise								
Low-rise (< 5 stories)	62%	89%	63%	86%	61%	87%	61%	93%
Mid-rise (5 to 9 stories)	29%	9%	21%	14%	39%	6%	27%	6%
High-rise (10+ stories)	9%	3%	16%	0%	0%	7%	12%	1%
Size (housing units)								
5 to 10 units	17%	19%	9%	24%	34%	22%	8%	10%
11 to 39 units	26%	29%	35%	32%	5%	32%	38%	23%
40 or more units	57%	52%	56%	44%	61%	46%	54%	67%
Housing Function								
Family	2%	44%	3%	23%	2%	79%	0%	30%
Mixed Use	15%	6%	5%	8%	3%	6%	38%	3%
Senior	72%	33%	92%	60%	62%	9%	62%	30%
Supportive	11%	14%	0%	9%	33%	6%	0%	27%
Ownership								
Non-profit	13%	33%	3%	41%	22%	17%	13%	40%
Private	4%	40%	4%	34%	0%	35%	7%	50%
Public	40%	18%	40%	16%	45%	37%	34%	1%
Unknown	44%	10%	53%	9%	33%	11%	46%	9%

[1] Other states include Illinois, Michigan, Wisconsin, New York, Rhode Island, New Hampshire, and Vermont.

[12] Type of ownership was reported as "unknown" for 44% of buildings in Massachusetts.

2.2.2 Respondent Characteristics

The convenience sampling approach described above limited the degree to which strata were fully comparable. As a result, we found statistically significant demographic differences between the Treatment, Control, and Comparison-with-Treatment study groups, and between the Massachusetts sample and the JPB study sample. Table 7 compares demographic characteristics by study group. Demographic differences between the study groups were more frequently statistically significant in Phase 1 than Phase 2. This may be partly due to the larger sample sizes and number of groups in Phase 1 versus Phase 2. The most substantial differences between Phase 1 and Phase 2 were in the Treatment group. For example, in the Treatment group, the proportion of single-person households and respondents without a high school degree both increased 10% from Phase 1 to Phase 2, and the rate of Hispanic or Latino respondents increased by one-third. It seems likely that the loss of high-rise buildings from the Phase 2 data collection due to the COVID-19 pandemic influenced these differences.

Table 7 also shows racial and ethnic imbalances between groups. These differences persisted from Phase 1 to Phase 2. Half of the Control group identified as Black or African American, compared to less than one-quarter each of the Comparison-with-Treatment and Treatment groups.

Numerous previous studies highlight the correlations among socio-economic status, race, and poor health, particularly asthma and arthritis.[13] We conducted regression analysis to assess the possibility of demographic differences among the study groups affecting weatherization outcomes and control for observable differences. We describe the approach to the regression analysis in the next section and present results in Section 3.2, with additional detail in Appendix C.

[13] For example, Hughes et al. 2016; Forno & Celedon 2009; Asthma and Allergy Foundation of America 2020; Obana & Davis 2016; Greenberg et al. 2013; Riad et al. 2019; Hansen et al. 2013.

Table 7: Survey Respondent Profile, by Group

Respondent Demographics	Comparison-with-Treatment	Treatment		Control	
	P1 (post-Wx)	T_Pre	T_Post	P1	P2
No. of Respondents	**612**	**417**	**198**	**892**	**553**
Age (mean) ***	64	58	60	57	60
Gender (female) (%) **⁺⁺	70%	69%	73%	62%	60%
Primary Wage Earner Employed (%) *	20%	27%	25%	24%	21%
Primary Wage Earner Retired (%) ***	60%	46%	40%	41%	42%
HH Size (mean) ***⁺⁺⁺	1.4	1.8	1.6	1.4	1.3
Single Person HH (%) ***⁺⁺⁺	77%	58%	68%	76%	84%
Education (%)					
No High School Diploma **⁺⁺⁺	20%	29%	39%	20%	21%
High School Graduate ⁺	38%	32%	35%	37%	37%
Some College	20%	20%	15%	24%	24%
College Graduate ⁺	22%	19%	10%	19%	18%
Race					
White ***	63%	37%	39%	38%	38%
Black or African American ***⁺⁺⁺	20%	24%	26%	50%	54%
American Indian or Alaska Native	--	--	<1%	--	2%
Asian ***	6%	2%	2%	1%	<1%
Native Hawaiian or Other Pacific Islander ⁺	<1%	<1%	<1%	<1%	<1%
Hispanic or Latino ***⁺⁺⁺	4%	14%	22%	3%	4%
Other ***	4%	13%	7%	6%	4%
Missing ***⁺⁺	8%	16%	7%	8%	3%**
Do you consider yourself to be of Hispanic or Latino origin? (yes) ***⁺⁺⁺	13%	42%	38%	9%	7%

* Difference between all groups is statistically significant at the p<.05 level in Phase 1.
** Difference between all groups is statistically significant at the p<.01 level in Phase 1.
*** Difference between all groups is statistically significant at the p<.001 level in Phase 1.
⁺ Difference between all groups is statistically significant at the p<.05 level in Phase 2.
⁺⁺ Difference between all groups is statistically significant at the p<.01 level in Phase 2.
⁺⁺⁺ Difference between all groups is statistically significant at the p<.001 level in Phase 2.

Table 8 shows demographic characteristics of respondents from Massachusetts versus those from the states comprising the JPB sample (shown in the table as "Other States"). Across study groups, Massachusetts respondents were older (by a mean of seven years) than respondents in the JPB sample, with a 16% higher rate of both retirees and single-person households. Of all the demographic characteristics, the racial composition between Massachusetts and the JPB sample is the most dissimilar. The Massachusetts sample had close to twice the rate of White respondents as the JPB sample (71% versus 40%) and fewer than half the rate of Black or African-American respondents (14% versus 36%).

Table 8: Survey Respondent Profile, by MA versus Other States[1]

Primary Respondent Characteristics	All Groups Combined		Comparison-with-Treatment (P1 Only)		Treatment (T_Pre and T_Post)		Control (P1 and P2)	
	MA	Other States	MA	Other States	MA	Other States	MA	Other States
n (# of respondents)	461	1,460	206	406	82	335	173	719
Age (mean)	66	58***	68	62*	65	56***	64	56***
Gender (female) (%)	67%	67%	70%	70%	59%	72%*	71%	60%**
Primary Wage Earner Employed (%)	15%	23%	12%	21%**	11%	28%***	23%	21%
Primary Wage Earner Retired (%)	61%	45%***	65%	57%	61%	41%**	58%	37%***
Single Person HH (%)	82%	66%*	83%	71%*	88%	50%***	76%	76%
Education								
No High School Diploma	24%	23%	23%	19%	30%	29%	19%	20%
High School Graduate	30%	34%	30%	38%*	29%	29%	30%	35%
Some College	20%	20%	20%	18%	22%	17%	19%	24%
College Graduate	21%	17%	23%	19%	12%	18%	28%	15%**
Race								
White	71%	40%***	75%	58%***	65%	31%***	74%	30%***
Black or African American	14%	36%***	12%	23%***	18%	26%	13%	58%***
Asian or American Indian, or Alaskan, Hawaiian, or other Pacific Island Native (Phase 2 only)	4%	4%	6%	8%	0%	2%	5%	3%
Hispanic or Latino	3%	8%	3%	4%	1%	17%***	6%	2%
Other	10%	7%	6%	3%	15%	13%	10%	5%
Missing	10%	11%	8%	8%	12%	16%	9%	8%
Self-identify as Hispanic or Latino Origin? (Yes)	9%	24%**	13%	12%	1%	52%***	13%	8%

[1] Other states include Illinois, Michigan, Wisconsin, New York, Rhode Island, New Hampshire, and Vermont
* Difference between the MA sample and the "Other States" is statistically significant at the p<.05 level.
** Difference between the MA sample and the "Other States" is statistically significant at the p<.01 level.
*** Difference between the MA sample and the "Other States" is statistically significant at the p<.001 level.

2.2.3 Existing Mechanical Systems and Installed Measures

We used the installed measure data to attribute the total value of the monetized NEIs to individual measures for cost benefit analysis. We describe our approach in Section 2.4. Here, we summarize some highlights from the existing systems and installed measure data. See Appendix F for the detailed tables on which this information is based.

Prior to weatherization, 19% of all units did not have a working on-demand mechanical ventilation system. Of those that did have ventilation, more than half (65%) had bathroom fans (which may or may not have vented to the outside) and 22% had a kitchen range hood that vented to the outside.

While 3% of units did not have a working heating system, 30% did not have a cooling system. This difference is reflective of the northern climates in which all buildings were located.

In-unit, hallway/stairwell, and building exterior lighting improvements (e.g., new bulbs and/or fixtures) were the most common set of measures installed, at 84%, 61%, and 61%, respectively. The second most common measure installed in the Comparison-with-Treatment and Treatment subsample was building-level air sealing (55%), followed by heating equipment (52%), new refrigerators (52%), insulation[14] (50%), water-saving devices (47%), domestic hot water (37%), and mechanical ventilation (27%). Cooling equipment and windows were the least common measures installed, at 18% and 14% of buildings, respectively.

Incidental repairs was the most common health and safety measure reported (20%).

2.3 Data Analysis Approach

We used two approaches to estimate the change in rate of incidence of the NEI indicators due to weatherization (the *treatment effect*).

1. We first produced **unadjusted estimates** by running simple difference in means tests using a quasi-experimental study design approach.
2. For those NEI indicators that met the threshold for statistical significance, we then produced regression-**adjusted estimates** using a regression analysis to control for differences in the observable characteristics between the study groups and to test the statistical rigor of the estimate. We recommend using the regression-adjusted estimates for monetizing the NEIs that passed these tests, since the adjusted estimates better control for confounding factors, while the unadjusted estimates do not.

[14] Includes the following insulation types: ceiling, above-grade wall, floor, rim/band joist, and foundation wall insulation.

2.3.1 Unadjusted Estimates

We estimated the unadjusted change in rates of incidence of the NEI indicators using resident survey data. By an "indicator," we mean an outcome related to the NEI of interest that could be attributable to weatherization. We calculated the unadjusted change in incidence using one of two quasi-experimental study design approaches to compare change in outcomes between weatherized and non-weatherized study groups: Cross-sectional (CS) or Difference-in-Differences (DID). We hypothesized that the impacts of weatherization would produce a negative post-treatment rate of incidence for most NEI indicators. A negative value translates to a post-treatment reduction (e.g., fewer medical encounters).

We used a cross-sectional approach (Equation 1), where the Comparison-with-Treatment served as the post-weatherization group and the Treatment and Control groups from Phase 1 were combined to form a pre-weatherization group (T_{pre}+C_1).

Equation 1. CS: *Change in incidence (ΔI)* = $I_{CwT} - I_{Tpre+C1}$

In consultation with a Working Group comprising PA staff members and EEAC representatives, we determined that the cross-sectional approach is acceptable when considering NEIs produced by a reduction in "rare events experienced." Specifically, these are events unlikely to strike a household repeatedly over a 12-month period, such as thermal stress-related medical encounters and the birth of a low-weight infant. For NEIs related to "personal needs dependent on circumstances" (e.g., Missed Days of Work, Home Productivity, and Food Spoilage), in consultation with the Working Group, it was also determined that it would be acceptable to use a cross-sectional approach in the absence of sufficient pre- and post-weatherization responses from the Treatment group.

For chronic illnesses, such as Arthritis and Asthma, it is best to measure outcomes experienced by the same household members represented in both the pre- and post-weatherization surveys (i.e., the classic DID analysis using Equation 2 below). For the Arthritis NEI, due to the absence of sufficient Treatment group pre/post responses, obtaining statistical significance through a DID approach was unlikely despite clear evidence of positive outcomes. For this reason, we used a cross-sectional approach to calculate the change in incidence for the Arthritis NEI.

Equation 2. DID: *Change in incidence (ΔI)* = $(I_{Tpost} - I_{Tpre}) - (I_{C2} - I_{C1})$

We performed chi-square and Fisher's exact tests to compare outcomes between categorical or binary variables. We tested for statistical significance of differences in means between groups via an independent samples t-test at a 90% confidence level (corresponding to a p-value <0.1). When conducting a DID analysis, we performed the McNemar test to measure binary outcomes and the non-parametric 2-related samples Wilcoxon signed-rank test to test for statistical significance of differences in means within groups from Phase 1 to Phase 2. We conducted Pearson Chi-square or ANOVA analyses when testing for statistical significance of outcomes calculated by the DID approach.

2.3.2 Regression-Adjusted Estimates

Since we hypothesized that the research outcomes could be affected by regional and demographic differences between the weatherized Comparison-with-Treatment group and the non-weatherized groups (particularly with respect to race and the Midwestern location of most of the control units) and between the two non-weatherized (Treatment and Control) groups, we conducted regression analysis to better control for observable differences. In consultation with the PA and EEAC Working Group, it was agreed that the adoption criterion for NEIs subjected to statistical analysis would be that both the unadjusted and regression-adjusted estimates meet the threshold of statistical significance (p-value<0.10).

We specified a DID regression model as follows:

Equation 3. $Y= \beta_0 + \beta_1*Wx + \beta_2*POST+ \beta_3*POST*Wx + \beta_4*[Covariates] + \epsilon$

Where:

- POST is a dummy variable indicating the post-Wx period
- Wx is a dummy variable indicating whether or not the unit is weatherized
- Covariates are variables included to control for observable differences between the treatment group and comparison group
- β_3 is the difference-in-difference estimate of the treatment effect: the change in Y for treatment group less the change in Y for control group
- ϵ is a "random-error" term

For the CS analysis in the study, there are no pre- and post-Wx observations for the same groups, so we specified the regression model as follows:

Equation 4. $Y= \beta_0 + \beta_1*Wx + \beta_2*[Covariates] + \epsilon$

In Equation 4, the key regression coefficient is β_1, which provides the regression-adjusted estimate of the treatment effect attributable to weatherization.

We conducted regression analysis only for the NEIs for which it was feasible and that the PAs could potentially claim: Arthritis, Thermal Stress, Home Productivity (based on improvement in sleep quality), Food Spoilage (based on replacement of an ineffective refrigerator), and Missed Days of Work. This meant that regression analysis was *not* conducted for the following NEIs:

- NEIs with only societal benefits (Work Productivity, Prescription Adherence, Food Assistance), since the PAs cannot currently claim these
- Household NEIs with extremely small sample sizes or an extremely small or zero NEI value (Asthma,[15] Trips and Falls)
- NEIs derived from energy bill savings, because of the potential for double-counting (Short-Term Loans, Low-Birth-Weight Infants, Prescription Adherence, Food Assistance)

[15] The team excluded asthma from the regression analysis because of the combination of the small sample size and the difference in asthma prevalence between the treatment and control group at baseline.

- NEIs drawn from secondary data (Reduced Fire Risk)

In the regression models, we included the following covariates (control variables):

- Region indicator (Midwest) [16]
- Size of building (# of units)
- Respondent age indicator (55+)
- Gender indicator (Male)
- Race indicator (Black/African American)
- Education indicator (HS Diploma/GED or less)

Since the Thermal Stress NEI, with avoided deaths, accounts for the majority of the total value of NEIs being recommended, the team ran additional regression models for Thermal Stress isolating all care settings, with emergency departments visits and hospitalizations being of most interest. These more-urgent care settings are where deaths are most likely to occur. The dependent/outcome variables used in this analysis were as follows:

- Arthritis
  - Number of arthritis pain-related hospitalizations
- Thermal Stress
  - Number of thermal stress – cold-related medical encounters
    - ED and doctor's office visits and hospitalizations
  - Number of thermal stress – heat-related medical encounters
    - ED and doctor's office visits and hospitalizations
- Number of bad days of rest/sleep (Home Productivity)
- Number of times food thrown away due to bad refrigerator (Food Spoilage)
- Number of days primary wage earner missed work due to illness/ injury (Missed Days of Work)

[16] Participating states in the Midwest were Illinois and Wisconsin. Participating states in the Northeast were Vermont, New York, Rhode Island, Pennsylvania, New Hampshire, and Massachusetts.

2.4 ATTRIBUTION OF NEI VALUES BY MEASURE

Due to the absence of an established methodology to attribute NEI values by measure, we examined a variety of approaches to attribute the total value of the monetized NEIs among individual measures for use in cost-effectiveness (BCR) analysis. The number of measures that can contribute to LIMF NEIs is substantial and the causal pathways between the measures and impacts can be complex, making attribution of NEIs by measure for use in the PAs' BCR models challenging.

The 2016 Massachusetts study of LI Single-Family Health-and Safety-related NEIs[17] attributed the monetized NEI values to measures based on the contribution of each measure to total energy savings. For this study, we attempted to improve on this by developing an empirically grounded approach using regression analyses and composite NEI values.

There are two main categories of composite variables: (1) those created by averaging the values of several component variables and (2) those resulting from grouping component variables that can be meaningfully grouped. Weights can also be given to each component variable. The composite NEI variables created for these analyses are the latter type. We created composite variables in order to calculate the percent attribution of the total NEI value by measure. To produce a total composite NEI value, we weighted the composite variables for the attribution-by-measure approach by the monetized value of each NEI comprising it. (See Appendix A for detailed discussions of these calculations.)

In this approach, the dependent variable in the regression models is the change in composite NEI value and the independent variables are indicators for measures installed. Major measures included in the attribution analysis are air sealing, insulation, and heating systems.[18] Measures are represented as dummy variables so that the magnitudes of the beta coefficients can be consistently and directly interpreted as each measure's contribution to the NEI outcome. Since the avoided deaths component of Thermal Stress comprises a large part of the total NEI value, we used the composite NEI value for households where avoided deaths is included. (For more detail about avoided deaths, see Section 3.3.1.) We then took the difference in the pre- and post-composite NEI values and used it as the dependent variable. We also focused our analysis on measures most closely associated with reduction in Thermal Stress, as this NEI constituted the majority of the total NEI value. We ultimately selected a model that included air sealing, insulation, and heating system replacement or repair.

For regression estimates and calculations used to allocate the recommended NEI values to the relevant measures in the BCR models, see Section 2.4. For detailed regression analysis results see Section 2.3.2.

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[17] Three[3] and NMR. "Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study." Submitted to *Massachusetts Program Administrators and EEAC Consultants*, 2016. Massachusetts Special and Cross-Cutting Research Area. August 5, 2016 http://ma-eeac.org/wordpress/wp-content/uploads/Low-Income-Single-Family-Health-and-Safety-Related-NonEnergy-Impacts-Study.pdf.

[18] Even though indoor heat-related medical conditions are a current and growing concern, and cooling system improvements do reduce the at-times-fatal medical conditions, the Thermal Stress (Heat) analysis did not produce statistically defensible results. For this reason, we did not include the cooling systems measure in the attribution exercise.

3

Section 3 Results and Recommendations

This section presents the unadjusted results for all the NEIs subjected to difference in means tests, and the regression-adjusted results for the NEIs that showed statistically significant differences in means. Here, we describe in detail how we monetized the NEIs we are recommending the PAs adopt, and present the final monetized values for these NEIs. The detailed monetization methodology and estimated values for NEIs we are not recommending at this time can be found in Appendix A.2.

3.1 Unadjusted Estimates

To create the unadjusted estimates, we ran simple difference in means tests using either the CS or DID approach. For NEIs that we are recommending for adoption (other than Reduced Fire Risk), Table 9 presents the approach, unadjusted estimate of the change in rate of incidence, and level of statistical significance using a t-test for the NEIs this study recommends for adoption. Table 10 shows the change in rate of incidence for NEI indicators not recommended for adoption at this time.[19]

Appendix A.2.9 presents statistics for additional NEIs the team explored.

Table 9: Change in Incidence Rate – Approach, Deltas, and Statistical Significance for Recommended NEIs

NEI	Benefit Type	Selected Type of Analysis[1]	Difference in Means (Δ +/-)	p-value
Recommended NEIs				
Thermal Stress (Cold) – (mean # of doctor's office visits)[2]	HH & S	CS	-0.031	0.007**
Thermal Stress (Cold) – (mean # of emergency dept. visits)[3]	HH & S	CS	-0.016	0.024*
Arthritis Pain – (mean # of hospitalizations)[4]	HH & S	CS	-0.089	0.018*
Home Productivity – (mean # of "bad sleep" days)[5]	HH & S	CS	-0.980	0.059✧

[1] CS, using only Phase 1 data
[2] Data includes all persons in the home; n= 2008 (Tpre+C1); n= 879 (CwT).
[3] Data includes all persons in the home; n= 2008 (Tpre+C1); n= 879 (CwT).
[4] Data includes head of household only; n= 577 (Tpre+C1); n= 307 (CwT).
[5] Data includes head of household only; n= 963 (Tpre+C1); n= 468 (CwT).
✧ Difference is statistically significant at the p<0.1 level.
* Difference is statistically significant at the p<.05 level.
** Difference is statistically significant at the p<.01 level.

[19] We calculated incidence rates using either Phase 1 data only (CS) or Phase 1 and Phase 2 data (DID). We then calculated an estimate of change (Δ +/-) using the difference in means from t-tests (either independent samples or paired samples t-tests).

Table 10: Change in Incidence Rate – Approach, Deltas, and Statistical Significance for NEIs NOT Recommended

NEI	Benefit Type	Selected Type of Analysis[1]	Difference in Means (Δ +/-)	p-value
NEIs Not Recommended for Adoption				
Missed Days of Work[2] (mean # of days)	HH & S	CS	-0.47	0.298
Food Spoilage[3] (mean # of times)[4]	HH	CS	-0.66	0.216
Thermal Stress (Cold)[5]	HH & S	CS		
Hospitalizations			-0.006	0.426
Thermal Stress (Heat)[5]	HH & S	CS		
Hospitalizations			-0.004	0.315
ED Visits			+0.006	0.320
Doctor's Office			-0.003	0.557
Asthma[6] (mean # of days)	HH & S	DID		
Hospitalizations			+0.16	0.172
ED Visits			+0.42	0.126
Urgent Care			+1.37	0.056✧

[1] CS using only Phase 1 data; DID using Phase 1 and Phase 2 data.
[2] Data includes head of household only; n= 219 (Tpre+C1); n= 84 (CwT).
[3] Data at household level; n= 37 (Tpre+C1); n= 173 (CwT).
[4] Based on the following NEI indicator: # of times had to throw food away due to spoilage in last 12 months.
[5] Data includes all persons in the home; n= 2008 (Tpre+C1); n= 879 (CwT).
[6] Data includes all persons in the home; n= (Tpre+C1); n= 879 (CwT).
✧ Difference is statistically significant at the p<0.1 level.

Table 11 presents statistically significant changes in rate of incidence from pre- to post-treatment of additional weatherization outcomes that help to substantiate three of the NEIs recommended for adoption: Thermal Stress (Cold), Arthritis, and Home Productivity. Post-weatherization, the Treatment group respondents report less frequent exposures to indoor drafts and unsafe temperatures, a decrease of 17% and 11%, respectively, at statistically significant levels. They also report statistically significant reductions in "hot or very hot" indoor temperatures (a decrease of 43%). Treatment group respondents' reports of "cold or very cold" indoor temperatures decreased, but by much less.

Statistically significant DID results provide further evidence that weatherization, not external factors, is the main driving force behind these outcomes; seven of the nine indicators presented in Table 11 had statistically significant DID results. The team found statistically significant reductions in the frequency of dust (-13%), outdoor noise (-12%) and sleep interference from it (-13%), and outdoor and indoor odors (-11% and -5%, respectively). Reductions in drafts, dust, noise, and odors indicate that the home is better sealed and insulated. See Appendix G for additional summary statistics related to dwelling quality and safety, general health, and household budget and affordability issues.

Table 11: Change in Incidence Rate and Statistical Significance of Supplemental Variables

NEI Indicators (not used for monetization) Respondent Only	Difference in Means (Δ +/-)					
	Treatment		Diff.	Control		DID
	T_Pre	T_Post		P1	P2	
Contributors to Reduced Thermal Stress and Arthritis[1]						
Home too drafty	34% (n=155)	17%	-17%***	17% (n=497)	9%	-8%
Unsafe or unhealthy indoor temperatures	40% (n=181)	29%	-11%**	20% (n=534)	13%	-4%
Hot or very hot indoor temps in the summer – past 12 mo	50% (n=185)	7%	-43%***	37% (n=536)	5%	-11%**
Cold or very cold indoor temps in the winter – past 12 mo	36% (n=183)	29%	-7%*	24% (n=532)	18%	-1%***
Contributors to Reduced Thermal Stress and to Increased Home Productivity (via sleep quality) [2]						
Home too dusty	42% (n=135)	26%	-16%***	28% (n=469)	25%	-13%**
Outdoor noise when windows are closed	31% (n=170)	20%	-11%**	21% (n=531)	22%	-12%**
Sleep interference from outdoor noise	28% (n=111)	16%	-12%*	12% (n=403)	14%	-13%*
Odors from outside	24% (n=134)	12%	-12%**	13% (n=408)	12%	-11%**
Odors from inside	38% (n=135)	31%	-8%	26% (n=412)	23%	-5%*

[1] These are indicators of improvements to indoor temperatures and comfort, both of which we would expect to contribute to reductions in thermal stress and in arthritis-related symptoms and medical visits.
[2] These are indicators of performance of insulation/air sealing that we would expect to contribute to reduced thermal stress and increased home productivity (via improved quality of sleep).
✧ Difference is statistically significant at the p<0.1 level.
* Difference is statistically significant at the p<.05 level.
** Difference is statistically significant at the p<.01 level.
*** Difference is statistically significant at the p<.001 level.

3.2 REGRESSION-ADJUSTED ESTIMATES

For the NEI indicators that showed statistically significant differences in means, we used regression analysis to test the statistical rigor of the indicator. The statistical significance of the regression-adjusted estimates helped determine which NEIs to recommend for adoption. As Section 2.2.3 notes, the regression analysis was meant to isolate the change in outcomes due to weatherization from outcomes due to regional, demographic, or other differences between the study groups.[20] The PA and EEAC Working Group agreed to use p-value <0.10 as an acceptable threshold of statistical significance for the regression-adjusted estimate for an NEI to be recommended for adoption. As Section 3.3.2 shows, the Thermal Stress NEI with Value of Statistical Life (VSL) included accounts for the bulk of the total NEI value. For this reason, the team ran individual regression models for the Thermal Stress NEI that isolated care settings. For both Thermal Stress (Cold) and Thermal Stress (Heat), the dependent variables were change in reported incidence of (1) doctor's office visits, (2) emergency department visits, and (3) hospitalizations. The detailed results of these models can be found in Appendix C.

The team developed ten models for three NEIs. The treatment effect from weatherization (the key coefficient in the regression model) estimated by four of the ten models was statistically significant for the following: doctor's office visits and emergency department visits due to Thermal Stress (Cold), hospitalizations due to Arthritis, and the number of bad days of sleep (associated with Home Productivity). The directionality of change (increase [+] or decrease [-]) for the treatment effect also indicated a decrease in medical encounters. The results give the team confidence in recommending the Thermal Stress (Cold), Arthritis, and Home Productivity NEIs for adoption.

Table 12 presents a summary of the ten models the evaluation team explored. Appendix C presents more detailed findings for each of the models.

[20] The team excluded asthma from the regression analysis because of the combination of the small sample size and the difference in asthma prevalence between the treatment and control group at baseline. The team did not expect the components of the unadjusted results for asthma to be statistically significant given the small sample that reported having asthma. Despite this, the DID estimate for one component of the three components of asthma – Urgent Care visits – was statistically significant and positive, suggesting that weatherization would lead to an increase in the incidence of asthma-related urgent care visits. It is important to note, however, that the proportion of the treatment group subsample with active asthma that reported having an asthma flare-up in the three months before the survey was lower than that of the control group (59% versus 78%, respectively). This suggests that a higher proportion of the control group had uncontrolled asthma at baseline. We would expect household members with uncontrolled asthma to be actively trying to control it, and thus more likely to seek care through doctor visits than urgent care. We suggest a future research study to explore whether this *negative* NEI outcome for the treatment group is founded.

Table 12: Summary of Regression Analysis Results

NEI	Dependent Variable (DV), Change in Incidence of Events	Key Independent Variable (IV)	β Coefficient	*p*-value
Arthritis	*Hospitalizations (mean)*	Weatherized (yes/no)	-0.074	0.094✧
Thermal Stress (Cold)	*Hospitalizations (mean)*	Weatherized (yes/no)	-0.010	0.262
Thermal Stress (Cold)	*ED visits (mean)*	Weatherized (yes/no)	-0.020	0.008**
Thermal Stress (Cold)	*Doctor's office visits (mean)*	Weatherized (yes/no)	-0.032	0.008**
Thermal Stress (Heat)	*Hospitalizations (mean)*	Weatherized (yes/no)	-0.002	0.542
Thermal Stress (Heat)	*ED visits (mean)*	Weatherized (yes/no)	+0.007	0.250
Thermal Stress (Heat)	*Doctor's office visits (mean)*	Weatherized (yes/no)	-0.003	0.250
Home Productivity	*# of bad days of rest/sleep*	Weatherized (yes/no)	-1.15	0.040*
Food Spoilage	*# of times thrown away food due to bad refrigerator*	Refrigerator installed (yes/no)	+0.055	0.522
Missed Days of Work	*# of days missed work due to illness/ injury (primary wage earner)*	Weatherized (yes/no)	+1.02	0.224

✧ Difference is statistically significant at the p<0.1 level.
* Difference is statistically significant at the p<.05 level.
** Difference is statistically significant at the p<.01 level.

3.3 MONETIZATION OF RECOMMENDED NEIS

Monetization entails valuing the impacts of weatherization services on program recipients by calculating money saved, or the dollar value of costs avoided, due to changes in health issues and household budgets as reported by residents on the resident survey. Below, we show how we monetized the avoided death benefit, which is fundamental to certain NEIs, and present the monetization inputs, algorithms, and estimated NEI values for the four NEIs we are recommending the PAs adopt.

3.3.1 Avoided Death Benefit

Two of the NEIs that we monetized – reduced Thermal Stress and Reduced Fire Risk – can be calculated either with or without the benefit of avoided deaths, also known as the VSL.[21] To monetize this benefit, we adopted the VSL value recommended by the U.S. Department of Transportation (DOT) ($9.6 million), which is similar to the VSL value used by the U.S. Environmental Protection Agency (EPA).[22,23,24]

It is important to note that the VSL does not refer to the value of a *life* but rather to the value of a *change in one's mortality risk*. As guidance from the DOT notes, the VSL is "defined as the additional cost that individuals would be willing to bear for improvements in safety (reductions in risks) that, in the aggregate, reduce the expected number of fatalities by one ... what is involved is not the valuation of life as such, but valuation of reductions in risk." [25]

Cost benefit analyses conducted at the federal level do not typically distinguish benefits accrued to individuals or households apart from society as a whole. However, in this study, the benefit of avoided deaths is applied as a household benefit.[26] This is in accordance with Massachusetts guidelines for assessing the cost-effectiveness of the PAs' energy-efficiency programs, as the avoided death benefits assessed in this study are consistent with the allowable class of benefits that accrue to program participants.

We also explored the VSLs used by regulatory agencies in Massachusetts but did not find any in the published literature or through inquiries made to agency personnel. However, we did find a 2010 Massachusetts DOT publication that references the U.S. DOT's 2009 VSL to monetize the value of accidental traffic deaths that could be prevented through improvements to freight infrastructure and operations in the Commonwealth.[27]

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[21] The value of human life (VSL) is a measure used to compare regulatory costs to benefits. See OMB Circular A-4 for more discussion on VSL or visit U.S. EPA's website: https://www.epa.gov/environmental-economics/mortality-risk-valuation#whatisvsl

[22] The DOT issues annual updates to the VSL to adjust for changes in prices and real incomes. Federal agencies, including DOT and U.S. EPA, use the VSL to assess the benefits of their regulations or policies intended to reduce deaths or fatalities (e.g., from traffic accidents or adverse environmental events/conditions). The last known VSL published by the EPA is $7.4M (2006 dollars), which is a central estimate to be inflated to the year of analysis. An article published in the journal *Risk Analysis* provides an overview of VSL application in federal regulatory analyses and states that (1) EPA's and DOT's estimates have become remarkably similar as both now use central VSL estimates somewhat above $9 million; (2) this increasing similarity appears to result at least in part from reliance on the same type of research (wage risk studies); and (3) DOT has updated its guidance more frequently than EPA (Robinson and Hammitt 2015).

[23] At the time of the WAP evaluations, U.S. government agencies were using values ranging from $5-9 million in regulatory cost-benefit analysis. The WAP National Evaluation used a conservative VSL of $6M (in 2000 dollars) adjusted for inflation to $7.5M in 2008 dollars. For the MA LI SF NEI study, the VSL of $7.5M used in the national WAP evaluation was updated to $9.6M, a 2016 VSL recommended by the U.S. DOT. The DOT's Office of General Council reports updated VSLs in the memo Guidance on Treatment of the Economic VSL in U.S. DOT Analyses. The last known published memo was in 2016.

[24] https://www.transportation.gov/sites/dot.gov/files/docs/2016%20Revised%20Value%20of%20a%20Statistical%20Life%20Guidance.pdf

[25] https://www.transportation.gov/sites/dot.gov/files/docs/BCA%20Resource%20Guide%202016.pdf

[26] With the exception of the VSL for firefighters.

[27] Massachusetts Department of Transportation, Chapter 4, Freight Investment Scenarios, Freight Plan, September 2010, pp. 4-10 through 4-11.

3.3.2 Thermal Stress

We used responses to resident survey questions and inputs gleaned from secondary literature[28] to determine annual household and societal savings attributable to reduced medical treatment and avoided deaths due to exposure to extreme temperatures in the home.

For each healthcare setting (doctor's office, emergency department, and hospitalization), we calculated the change in number of visits reported to treat medical conditions associated with exposure to extreme indoor temperatures (Table 13). Due to the rarity of thermal stress events and the low sample size of the T_Post group, we used the cross-sectional, rather than DID, approach to calculate unadjusted change in incidence (ΔI). We used independent samples t-tests to establish the level of statistical significance.

Respondents were asked, "During the past 12 months, how many times [because apartment was too cold or too hot] did anyone in the household have to go to… [a doctor, the emergency department, or be hospitalized]?" Post-weatherization, respondents reported fewer incidences of visits to all care settings for cold-related Thermal Stress and fewer hospitalizations and doctor's office visits for heat-related Thermal Stress. Results from independent samples t-tests show that the changes in both emergency department and doctor's office visits for cold-related thermal stress were statistically significant post-weatherization, but hospitalizations were not. Although there were fewer incidences of hospitalizations for heat-related stress post-weatherization, there was a slight *increase* in emergency department visits for heat, and the differences were not statistically significant.

We conducted regression analyses to control for observable differences between groups and tested robustness of the results by exploring both statistical significance and sensitivity of results to regression model specification. The regression analyses produced statistically significant estimates of change for the same care settings as the independent samples t-tests (doctor's office visits and emergency department visits) for Thermal Stress (Cold). None of the estimates of change for Thermal Stress (Heat) was statistically significant. Table 13 shows the side-by-side comparison of unadjusted and regression-adjusted estimates of change in incidence by care setting.

[28] The team retrieved costs for treatment for cold- and heat-related illnesses associated with thermal stress from online databases provided by the Department of Health and Human Services (DHHS). These databases are sponsored by the Agency for Healthcare Research and Quality (AHRQ), based on the 2015 MEPS and a collection of databases sponsored by AHRQ and referred to as the HCUP. Data related to incidence rates of treatment type and number of deaths following hospitalizations was mined from both the MEPS and HCUP databases using the International Classification of Diseases diagnostic codes, associated with "Effects of reduced temperature" (ICD-9-CM 991.0-991.9) and "Effects of heat and light" (ICD-9-CM 992.0-992.9) as the queries. Several medical conditions are associated with exposure to extreme temperatures, with hypo- and hyperthermia being the most extreme, and less prevalent.

Table 13: Comparison of Estimates of Change – Thermal Stress

Comparison of estimates of change (Δ)	Unadjusted Estimate of Δ		Regression-adjusted Estimate of Δ	
Parameter (n=2,887)	Difference in Means[1]	p-value	β Coefficient	p-value
Number of times stayed overnight in the HOSPITAL due to cold	-0.006	0.426	-0.010	0.262
Number of times went to EMERGENCY ROOM due to cold	-0.016	0.024*	-0.020	0.008**
Number of times went to DOCTOR'S OFFICE due to cold	-0.031	0.007**	-0.032	0.008**
Number of times stayed overnight in the HOSPITAL due to heat	-0.004	0.315	-0.002	0.542
Number of times went to EMERGENCY ROOM due to heat	+0.006	0.320	+0.007	0.250
Number of times went to DOCTOR'S OFFICE due to heat	-0.003	0.557	-0.003	0.250

[1] $[(\Delta I) = I_{CwT} - (I_{Tpre+C1})]$
* Difference is statistically significant at the p<.05 level.
** Difference is statistically significant at the p<.01 level.

Since the estimate of change for heat stress encounters did not meet the threshold of p<.10 for statistical rigor, we are not recommending the Thermal Stress (Heat) NEI, although we believe the benefits are substantial and important.

For comparison purposes, we monetized the NEI for reduced medical encounters using both the unadjusted and the regression-adjusted estimates of change. We recommend that the PAs adopt the monetized NEI value based on the regression-adjusted estimate because the regression adjustment better isolates the impact of weatherization from other confounding factors. A reduction in hospital cases or emergency department visits results in a decrease in risk of mortality, which becomes a substantial household benefit when the VSL is included. (See Appendix D for a detailed discussion of thermal stress-related fatalities.) We calculated the value of avoided deaths from reductions in thermal stress using the estimate of change of emergency department visits. Table 14 presents the monetization approach and inputs. To simplify the table, we used cost multipliers to capture costs by payer, percent of out-of-pocket (OOP) costs based on type on insurance, and percent of annual treatment costs by payer and by care setting type.

Table 15 presents cost multiplier calculations.

Table 14: Monetization Approach and Inputs – Thermal Stress

	Metric / Measure	NEI: Cold Stress Emergency Dept. (ED) Visits	NEI: Cold Stress Doctor Visits	NEI: Cold Stress Avoided Deaths	Total NEI Value
Estimate of Δ					
[A]	Regression model coefficient	-0.020	-0.032	Uses ED visits (-0.020)	NA
[B]	Other Δ estimate (difference in means)	-0.016	-0.031	Uses ED visits (-0.016)	NA
Monetization Parameters					
[C]	Cost multiplier (per person)	$210	$29	$46,648	NA
[D] = [C] * 1.52	Cost multiplier (per household)	$320	$44	$70,905	NA
Monetized NEI					
[E] = [A] * [D]	**Monetized estimate, per household, using [A]**	**$6**	**$1**	**$1,418**	**$1,426**
[F] = [B] * [D]	Monetized estimate, per household, using [B]	$5	$1	$1,134	$1,141

Notes/sources:
- [A] = See Appendix C for regression model specifications yielding the coefficients in this table.
- [B] = Calculated **change in incidence (Δ) by using the difference in means = [(ΔI) = I_{CwT} – ($I_{Tpre+C1}$)]. Used independent samples t-test for testing statistical significance (doctor's office, p=.007; emergency department visits, p=.024).**
- [C], [D] = Cost multipliers are presented here to simplify the table. Cost multipliers capture costs by payer, percent of OOP costs based on type on insurance, and percent of annual treatment costs by payer and by care setting type. Calculations for cost multipliers are provided in
- Table 15.
- [E], [F} = Due to rounding, calculations might not provide exact values. The team reports up to three decimal points, but the calculations used to derive the incidence rates use unrounded values.

Table 15: Calculations for Cost Multipliers (Household Benefit Only) – Thermal Stress (Cold)

Calculations for Cost Multipliers - Monetization of Thermal Stress (Cold) NEI		
Multipliers for each care setting = (% of costs paid by p_2 * C$ paid by p_2 * % of OOP costs from p_2) + (% of costs paid by p_3 * C$ paid by p_3 * % of OOP costs from p_2)		
	a. Doctor Office Visits	**b. Emergency Dept. Visits**
% of costs by payer[1]		
p_1 = Public	32%	42%
p_2 = Private/Other	56%	22%
p_3 = Uninsured	11%	37%
OOPs[2, 3]		
Percent OOPs – publicly insured	5%	5%
Percent OOPs – private/other insured	10%	10%
Percent OOPs – uninsured	44%	44%
Cost (C$) by Payer [4]		
p_1 = Average Public Insurance	$175.28	$820.95
p_2 = Average Private/Other	$354.71	$1,739.12
p_3 = Average Uninsured	$126.48	$959.35
Per person cost multiplier, per year	$28.93	$210.22
Mean household size (=1.52 persons)		
Household NEI cost multiplier for Thermal Stress (Cold)	**$43.97**	**$319.53**

[1] Medical Expenditure Panel Survey (MEPS) – 2015.
[2] Center for Financing, Access and Cost Trends, AHRQ, MEPS, 2017.
[3] Reference Table: Median expenditures per person with expense by source of payment and insurance coverage, United States, 2017. https://meps.ahrq.gov/mepstrends/hc_use/
[4] Bureau of Labor Statistics. Consumer Price Index to price-adjust medical costs for MA, 2020. https://data.bls.gov/timeseries/CUURS11ASAM?amp%253bdata_tool=Xgtable&output_view=data&include_graphs=true

The team calculated the value of avoided deaths by multiplying the change in incidence rate Δ by the rate of emergency department visits (due to cold-related thermal stress) that result in death, multiplied by the VSL. Our analysis determined that 14.8 deaths caused by cold stress were prevented annually in Massachusetts per 100,000 units weatherized in the state. Table 16 shows these values and provides the inputs used to calculate them and the total value of the avoided death benefit for cold stress.

Table 16: Estimating Avoided Deaths from Extreme Cold Stress

	Inputs	Cold-Stress
[A]	Regression-adjusted estimate of change – # of emergency dept. visits for cold stress, *per person*	-0.020
[B]	% of deaths caused by exposure to extreme cold temperatures following emergency dept. visits (national rate) [29]	0.486%
[C] = [A] * [B]	Rate of reduction in deaths caused by cold stress	0.010%
[D]= [C] * 1.52	Rate of reduction in deaths caused by cold stress, per household	0.019%
*[E] = [D] * 100,000*	*Number of avoided deaths post-weatherization, per 100,000 weatherized units*	*14.8 deaths*
NEI = [E] * $9.6M	**Avoided death benefit, per weatherized unit, per year**	**$1,418**

We are recommending a thermal stress-related NEI value (Thermal Stress [Cold]) of **$1,426** from reduced doctor's office and emergency department visits and from avoided deaths due to reductions in unsafe cold temperatures (Table 17). This recommendation only includes the household benefit. Table 17 also presents the estimated societal benefit of the Thermal Stress (Cold) NEI.

Table 17: Estimated Annual Impact of Reduced Thermal Stress (Cold)

Thermal Stress (Cold) NEI	Annual Per Unit Benefit	Annual Per Unit Benefit W/O Avoided Death Benefit
Household	**$1,426***	$8
Society	$38	$38
Total	**$1,464**	**$46**

[29] HCUP parameters are as follows:
- Weighted national estimates from HCUP National (Nationwide) Emergency Department Sample (NEDS), [2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014], AHRQ, based on data collected by individual States and provided to AHRQ by the States.
- Total number of weighted visits in the U.S. based on HCUP NEDS = 120,033,750 (2006); 122,331,739 (2007); 124,945,264 (2008); 128,885,040 (2009); 128,970,364 (2010); 131,048,605 (2011); 134,399,179 (2012); 134,869,015 (2013); 137,807,901 (2014). We used an average of the most recent two years: 2013, 2014.
- Statistics based on estimates with a relative standard error (standard error / weighted estimate) greater than 0.30 or with standard error = 0 in the nationwide statistics (NIS, NEDS, and KID) are not reliable. These statistics are suppressed and are designated with an asterisk (*).

Source: HCUPnet, Healthcare Cost and Utilization Project. AHRQ, Rockville, MD. https://hcupnet.ahrq.gov/. For more information about HCUP data, see http://www.hcup-us.ahrq.gov/

3.3.3 Arthritis

Arthritis prevalence (i.e., respondents self-reporting current arthritis) for the weatherized group for all regions combined was 49%. We calculated the Arthritis NEI using responses to arthritis-related hospitalization questions asked of the head-of-household in the resident survey. We calculated difference in means for each type of medical care used to treat arthritis flares (i.e., urgent care, emergency department visits, and hospitalizations) using cross-sectional analysis of data from respondents that have been diagnosed with arthritis (Table 18). We gathered average cost data for Massachusetts hospitalizations specific to worsening arthritis symptoms from discharge data for all age categories and payer types from the Healthcare Cost and Utilization Project (HCUP). We gathered medical expenditure data for urgent care from the MEPS for arthritis-related outpatient care and emergency department costs.[30] We inflated medical costs data for all treatment types to 2020 costs and adjusted them to reflect costs in Massachusetts. We calculated household and societal costs for the Arthritis NEI using data from the MEPS and the Kaiser Family Foundation's (KFF) State Health Facts. [31,32]

Arthritis has the potential to be a particularly important NEI for the PAs. The varying forms of arthritis are known to limit mobility, daily activities, ability to work, and quality of sleep. They are also known to influence pain medication. All of these can contribute to overall quality of life.[33]

Patients with osteoarthritis are sensitive to cold temperatures.[34] In a related literature review, the authors state that both temperature and humidity appear to worsen symptoms of rheumatoid arthritis. In a 2015 examination of the influence of weather on elderly osteoarthritis sufferers, conditions that were significantly associated with pain were daily average humidity, three-day average humidity, and the interaction between daily average humidity and temperature. In a 2012 study, the authors investigated potential weather factors influencing rheumatoid arthritis emergency department visits and determined statistical significance for daily mean temperature and emergency department visits for respondents in the 50-65 age range. [35] Studies surveying patients with any type of arthritis report that shifts in atmospheric pressure, humidity, temperature, or some combination of all three factors heighten their pain. [36]

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[30] The team determined that it is reasonable to use out-patient claims costs as a proxy for urgent care costs. For example, the urgent care clinic at Mass General Hospital, which treats arthritis flares, codes urgent care charges as "out-patient" claims.
[31] Reference Table: Median expenditures per person with expense, by source of payment and insurance coverage, United States, 2017. https://meps.ahrq.gov/mepstrends/hc_use/
[32] KFF. Health Insurance Coverage of the Total Population. Retrieved from: https://www.kff.org/state-category/health-coverage-uninsured/
[33] Informed Health. Everyday Life with Rheumatoid Arthritis (NCBI, 2013), accessed March 21, 2019, https://www.ncbi.nlm.nih.gov/books/NBK384458/
[34] Penny Moss, Emma Knight, and Anthony Wright. "Subjects with Knee Osteoarthritis Exhibit Widespread Hyperalgesia to Pressure and Cold," PLoS One 11, no. 1 (2016), accessed March 21, 2019, https://doi.org/10.1371/journal.pone.0147526
[35] Lydia Abasolo, Aurelio Tobías, Leticia Leon, Loreto Carmona, Jose Luis Fernandez-Rueda, Ana Belen Rodriguez, Benjamin Fernandex-Gutierrez, and Juan Angel Jover. "Weather Conditions May Worsen Symptoms in Rheumatoid Arthritis Patients: The Possible Effect of Temperature," Reumatología Clínica 9 no. 4, (2012), accessed March 21, 2019. https://doi.org/10.1016/j.reuma.2012.09.006
[36] Josep Vergés, Eulàlia Montell, Elena Tomàs, Gemma Cumelles, Guido Castañeda, Núria Martí, and I. Moller. "Weather Conditions can influence rheumatic diseases." Proceedings of the Western Pharmacology Society 47 (2004): 134-6, accessed March 21, 2019, https://doi.org/10.1016/j.reuma.2012.09.006

It seems reasonable to hypothesize that stabilizing indoor conditions could reduce weather-related arthritis flare-ups and chronic pains.[37] Evidence in literature suggests that fewer fluctuations in temperatures and more comfortable temperature settings and relative humidity levels reduce the severity of pain experienced by at least some percentage of arthritis sufferers and potentially improve overall quality of life.[38,39,40,41,42,43]

Table 18 shows that of those that reported having been diagnosed with arthritis, the number of hospitalizations for worsening pain decreased at statistically significant levels for both the unadjusted and regression-adjusted estimates of change. The data show a decrease in the number of medical encounters at the other care settings (ED and urgent care clinic). The unadjusted estimates were statistically significant using the difference in means test but the regression-adjusted estimates were not. Thus, the emergency department and urgent care settings were not included in the monetization equation.

Table 18: Comparison of Estimates of Change − Arthritis

Comparison of estimates of Change (Δ)	Unadjusted Estimate of Δ		Adjusted Estimate of Δ	
Parameter (n=877)	Mean Difference[1]	p-value	β Coefficient	p-value
Number of hospitalizations for worsening arthritis	-0.089	0.018	-0.074	0.094✧
Number of emergency dept. visits for worsening arthritis	-0.076	0.096	-0.063	0.251
Number of visits to urgent care clinic for worsening arthritis	-0.156	0.009	-0.044	0.568

[1] $[(\Delta I) = I_{CwT} - (I_{Tpre+C1})]$

✧ Difference is statistically significant at the p<0.1 level.

[37] Erik J. Timmermans, Suzan Van Der Pas, Laura A. Schaap, Mercedes Sánchez-Martínez, Sabina Zambon, Richard Peter, Nancy L. Pedersen et al. "Self-perceived weather sensitivity and joint pain in older people with osteoarthritis in six European countries: results from the European Project on OsteoArthritis (EPOSA)." BMC Musculoskeletal Disorders 15, no. 1 (2014): 66.
[38] Scott Pigg, Dan Cautley, Paul Francisco, Beth A. Hawkins, and Terry M. Brennan. Weatherization and Indoor Air Quality: Measured Impacts in Single Family Homes Under the Weatherization Assistance Program. No. ORNL/TM-2014/170. Oak Ridge National Lab. (ORNL), Oak Ridge, TN (United States), 2014.
[39] Bruce E. Tonn, B., Beth Hawkins, B., Erin Rose, E., and Michaela Marincic, M. "Energy and Non-Energy Impacts of Weatherizing Low-Income Multifamily Buildings: Summary of Results from the Evaluations of the U.S. Department of Energy's Weatherization Assistance Program". Three[3], Inc., Knoxville, TN, September., 2017.
[40] Larson, A. A., Pardo, J. V., & Pasley, J. D. (2014). Review of overlap between thermoregulation and pain modulation in fibromyalgia. The Clinical journal of pain, 30(6), 544–555. https://doi.org/10.1097/AJP.0b013e3182a0e383
[41] Farbu EH, Skandfer M, Nielsen C, et al. Working in a cold environment, feeling cold at work and chronic pain: a cross-sectional analysis of the Tromsø Study. BMJ Open 2019;9:e031248. doi: 10.1136/bmjopen-2019-031248
[42] Abasolo L, Tobias A, Leon L, Carmona L, Fernandez-Rueda JL, Rodriguez AB, et al. Weather conditions may worsen symptoms in rheumatoid arthritis patients: the possible effect of temperature. Reumatol Clin. 2013;9:226–8.
[43] Feldthusen C, Grimby-Elkman A, Forsblad-d'Elia H, Jacobsson L, Mannerkorpi K. Seasonal variations in fatigue in persons with rheumatoid arthritis: a longitudinal study. BMC Musculoskelet Disord. 2016;17:59.

We monetized the NEI for reduced hospitalizations due to worsening arthritis symptoms using the monetization approach and inputs presented in Table 19 and inputs presented in Table 20.

Table 19: Monetization Approach and Inputs – Arthritis

	Metric / Measure	NEI: Arthritis Hospitalizations
[A]	Regression model coefficient	-0.074
[B]	Other Δ estimate (difference in means)	-0.089
[C]	Cost multiplier, per household	$1,346
[D]	Arthritis prevalence among program homes	49.4%
[E] = [A] * [C] * [D]	**Monetized estimate, per household, using [A]**	**$49**
[F] = [B] * [C] * [D]	Monetized estimate, per household, using [B]	$59

Notes/sources:

- [A] = See Figure 3 in Appendix C for regression model specifications yielding the coefficients in this table for the Arthritis NEI. **The recommended NEI value for arthritis is based on the regression-adjusted estimate for change in (mean) number of arthritis-related hospitalizations.**
- [B] = **For the Arthritis NEI, calculate change in incidence (ΔI) using the difference in means = [(ΔI) = I_{CwT} – ($I_{Tpre+C1}$)]. Used independent samples t-test to test for statistical significance (p=.018)**. See Section 2.3.1 for details on calculating incidence rates. Table 9 presents changes in incidence rates for the Arthritis indicators.
- [C] = Cost multipliers are presented here to simplify table. Cost multipliers capture costs by payer, percent of OOP costs based on type on insurance, and percent of annual treatment costs by payer and by care setting type.
- [D] = The percent of CwT and T (i.e., program) homes that reported having arthritis.
- [E] = Unlike thermal stress-related questions, questions related to arthritis indicators were asked only of the main respondent. Thus, it is not prudent to apply the 1.52 multiplier (mean number of persons per household). We present monetized values for arthritis at the household-level only.

Table 20: Calculations for Cost Multipliers (Household Benefit Only) - Arthritis

Calculations for Cost Multipliers - Monetization of Arthritis NEI	
Multipliers for each care setting = C$* (% of costs paid by p_2 * % of OOP costs from p_2) + (% of costs paid by p_3 * % of OOP costs from p_2)	
	a. Hospitalizations
% of Costs by Payer [1]	
p_1 = Public	58%
p_2 = Private/Other	40%
p_3 = Uninsured	<1%
OOPs[2, 3]	
p_1 = Public	8%
p_2 = Private/Other	13%
p_3 = Uninsured	100%
Average Cost (C$) [4]	
Average Cost for Hospitalizations	$13,680
Household NEI Cost Multiplier - Arthritis	**$1,346**

[1] MEPS – 2015.
[2] Center for Financing, Access and Cost Trends, AHRQ, MEPS, 2017.
[3] KFF – State Health Facts. Retrieved from: https://www.kff.org/state-category/health-coverage-uninsured/
[4] Bureau of Labor Statistics. Consumer Price Index to price-adjust medical costs for MA, 2020. https://data.bls.gov/timeseries/CUURS11ASAM?amp%253bdata_tool=Xgtable&output_view=data&include_graphs=true

We are recommending an Arthritis NEI value of **$49** attributable to reductions in hospitalizations due to worsening arthritis symptoms. This recommendation only includes the household benefit. Table 21 also presents the estimated societal benefit.

Table 21: Estimated Impact of Reduced Arthritis

Arthritis NEI	Annual Per Unit Benefit
Households	$49
Society	$892
Total	**$941**

3.3.4 Home Productivity

For the Home Productivity NEI, we relied on responses to the resident survey question related to number of days of poor sleep and inputs identified in the secondary literature to determine annual household savings attributable to increases in annual non-market household production (i.e., housework) due to better sleep and rest. Existing literature posits that lack of sleep can have an adverse impact on productivity. The team's research findings indicate that there are reductions in reports of *poor* sleep from respondents that are weatherization recipients. We found that levels of outdoor noise and disturbance from outdoor noise, which can contribute to poor sleep and negative health outcomes, were lower for the Comparison-with-Treatment group. For example, the percentages of the Comparison-with-Treatment group that reported hearing a great deal of outdoor noise and having sleep interfered with by outdoor noise either "extremely" or "very much" were lower by 12% and 13%, respectively.

Table 22 shows that the estimate of change for the Home Productivity indicator (# of poor sleep days in the past 30 days) has a negative value. Both unadjusted and regression-adjusted estimates are statistically significant.

The monetization of the Home Productivity NEI is based on a change in number of poor sleep days (in the past 30 days) using the monetization approach and inputs presented in Table 22 and Table 23.

Table 22: Monetization Approach and Inputs – Home Productivity

	Metric / Measure	NEI: Home Productivity
Estimate of Δ		
[A]	Regression model coefficient	-1.151
[B]	Other Δ estimate (difference in means)	-0.98
Monetization Parameters		
[C] = [A] / 30 days	% change over last 30 days	-3.837%
[D] = [B] / 30 days	% change over last 30 days	-3.267%
[E]	Cost multiplier, per household	$1,275
Monetized NEI		
[F] = [C] * [E]	**Monetized estimate, per household, using [A]**	**$49**
[G] = [D] * [E]	Monetized estimate, per household, using [B]	$42

Notes/sources:

- [A] = See Figure 7: in Appendix C for regression model specifications yielding the coefficients in this table. **The recommended NEI value for Home Productivity is based on the regression-adjusted estimate for change in (mean) number of days (over last 30 days) of poor rest or sleep.**
- [B] = **Calculated change in incidence (ΔI) using the difference in means = [(ΔI) = I_{CwT} – ($I_{Tpre+C1}$)]. Used independent samples t-test to test for statistical significance (p=.059)**. See Section 2.3.1 for details on calculating estimates of change.
- [E] = Cost multipliers are presented here to simplify the table. Cost multipliers capture annual productivity increases attributable to better sleep and rest ($), average annual salary for a U.S. worker, the value of an hour of housework, and % of main respondents employed.

Table 23: Monetization Approach – Home Productivity

Calculations for Cost Multipliers - Monetization of Home Productivity NEI	
Multiplier = (I*W*H*52)	
P = Annual productivity increases attributable to better sleep and rest[1]	$2,500
S = Average annual salary of a U.S. worker ($)[2]	$50,054
I = Productivity increase in housework (=P/S)	5%
W = Value of an hour of housework[3]	$22.80
H = Hours per week spent on housework[4]	21.5 hours/week
Number of weeks/year	52 weeks
Household NEI Cost Multiplier – Home Productivity	$1,275

[1] https://www.rand.org/pubs/research_reports/RR1791.html
[2] https://www.census.gov/newsroom/releases/archives/income_wealth/cb12-172.html
[3] https://www.forbes.com/sites/jennagoudreau/2011/05/02/why-stay-at-home-moms-should-earn-a-115000-salary/#5bb109f275f4
https://www.bea.gov/household-production/
[4] http://www.bls.gov/opub/mlr/2009/07/art3full.pdf

We recommend an annual NEI value of **$49** for increased Home Productivity (Table 24). This recommendation only includes the household benefit. Table 24 also presents the estimated societal benefit of increased home productivity due to improved sleep.

Table 24: Estimated Impact of Increased Home Productivity Due to Improved Sleep

	Annual Per Unit Benefit
Households	**$49**
Society	$0
Total	**$49**

3.3.5 Reduced Fire Risk

Home fires are relatively rare; therefore, reduced fire risk is difficult to capture through self-reported surveys. Larger sample sizes than the ones in this study would be needed to properly measure fire incidence. There were no statistically significant changes in the frequency of building or unit fires from Phase 1 to Phase 2, which was to be expected given the sample sizes and the rarity of home fires.

We used inputs mined from secondary literature to estimate annual household and societal savings attributable to reduced medical treatment and avoided deaths from reduced occurrences of home fires. For the Reduced Fire Risk NEI, the team derived the reduced probability of fire (-0.0003) in a MF unit from the reduced probability of fire in a LISF home.[44] (The findings from the resident survey, presented in Table 87 in Appendix G.1, are only meant to substantiate the secondary data, not to be incorporated into the monetization algorithm.)

[44] Hawkins et al. 2016

Home fires can be prevented by installing measures that reduce fire risk, thereby reducing property damage and cases of occupant injury and/or death, or by repairing systems or equipment that could ignite fires. Measures shown to have the most impact on fire risk reduction are repairing or replacing faulty central space heating systems and clothes dryer vents; making electrical repairs; adding insulation; and installing or replacing smoke detectors. Based on the limited data provided by participating agencies, it appears that no smoke detectors were installed as part of MF weatherization (see Appendix F).

We monetized the NEI for reduced home fire occurrences using the monetization approach and inputs presented in Table 25 and Table 26, respectively.

Table 25: Monetization Approach – Reduced Fire Risk

Monetization Approach
Key Variables
• A_1 = probability of fire in MF apartment • B_1 = reduced probability of fire in MF apartment, attributable to weatherization • A_2 = probability of fire in SF home • B_2 = reduced probability of SF fire, attributable to weatherization • C = estimated occupant deaths from an apartment fire • D = estimated occupant injuries from an apartment fire • E = estimated cost of occupant injuries per apartment fire (HH) • F = estimated cost of occupant injuries per apartment fire (S) • G = estimated firefighter deaths per apartment fire • H = estimated firefighter injuries per apartment fire • I = estimated cost of firefighter injuries (HH) • J = estimated cost of firefighter injuries (S) • K = estimated property loss per apartment fire • L = estimated property loss (HH) • M = estimated property loss per apartment fire (S) • N = value of avoided death
Equation 1. *Reduced probability of MF unit fire, attributable to weatherization*
• $B_1 = A_1*(B_2 / A_2)$ • $B_1 = 0.0011*(0.000585/0.0021)$
Equation 2. *Annual Societal Benefit (per weatherized unit)*
• $= B_1*(G*N) + (H*(F+J) +M))$ • *Societal NEI = 0.00030643*((0.00005*$9.6M) + (0.1*($7,237+$8,614)) + $11,968))*
Equation 3. *Annual Household Benefit (per weatherized unit)*
• $= B_1*((C*N) + (D*(E+I)) + L)$ • *Household NEI = 0.00030643*((0.0037*$9.6M) + (0.0183*($1,391+$0) + $6,732))*

Table 26: Sources/Inputs – Reduced Fire Risk

Inputs/Sources	
Literature: Peer Reviewed and Other	• Estimated S benefits per weatherized SF unit: Hawkins et al. 2016 • Estimated HH benefits per weatherized SF unit: Hawkins et al. 2016 • Adjusted SF fire reduction rates from Hawkins et al. 2016 to MF sector: • https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics/Occupancies/osHomes.pdf • https://www.verisk.com/blog/fire-trends-multifamily-housing/ • https://www.usfa.fema.gov/downloads/pdf/statistics/v18i3.pdf
Open-Source Databases	• Bureau of Economic Analysis: Regional Price Parity to adjust national cost estimates to MA price levels[1] • Bureau of Labor Statistics: Consumer Price Index to price-adjust medical costs from 2008 to 2020[2]

[1] https://apps.bea.gov/iTable/iTable.cfm?reqid=70&step=1&isuri=1&acrdn=8#reqid=70&step=1&isuri=1
[2]https://data.bls.gov/timeseries/CUURS11ASAM?amp%253bdata_tool=XGtable&output_view=data&include_graphs=true

We recommend a Reduced Fire Risk NEI value of **$13**. This recommendation only includes the household benefit. Table 27 also presents the estimated societal benefit and the annual impact of reduced occurrences of home fires.

Table 27: Estimated Impact of Reduced Home Fire Occurrences

Reduced Fire Risk NEI	Annual Per Unit Benefit	Annual Per Unit Benefit W/O Avoided Death Benefit
Households	**$13**	$2
Society[1]	$4	$4
Total	**$17**	**$6**

[1] Avoided injuries and deaths to firefighters are categorized as a societal benefit.

3.4 RECOMMENDED NEIS

The PA and EEAC Working Group agreed that only those NEIs that met the following three criteria, if applicable, would be recommended for adoption:

1. The impacts are at the household, not societal, level. This is because the PAs cannot currently claim NEIs at the societal level. For this reason, we excluded for consideration Work Productivity, Prescription Adherence, and Food Assistance, and did not address these in the regression analysis above.
2. The impacts are not derived from energy bill savings, as agreed-upon with the PA Working Group.[45] This is because of the potential for double-counting the benefits. For this reason, we excluded from regression analysis Short-term loans, Low-Birth-Weight Infants, Prescription Adherence, and Food Assistance.
3. For NEIs that rely on primary data, both the results of the difference in means analysis (unadjusted estimate) and the coefficient of the weatherization variable in the regression model (regression-adjusted estimate) are statistically significant, at p-value <.10 for the outcome of interest. For the one NEI that relies on secondary data only (Reduced Fire Risk), there is sufficient incidence rate and risk factor data from secondary sources to monetize the NEI from these sources.

The **Arthritis**, **Thermal Stress (Cold), Home Productivity, and Reduced Fire Risk NEIs** meet all the criteria, and thus we recommend that the PAs adopt their monetized values.

3.4.1 Recommended NEI Values

Table 28 summarizes the individual monetized values for the four recommended NEIs presented above – broken out into both household and societal benefits.

Although the mathematical monetization algorithms used precise values for inputs, here, we present NEI values rounded to the nearest dollar to avoid conveying a false sense of the precision of these values. For the unrounded NEI values, see Appendix I.

We recommend the PAs adopt the monetary valuations for the four LIMF health-and-safety-related NEIs presented below. The valuations should include VSL, as applicable, and be applied per housing unit per year, assuming one household per weatherized housing unit. The values for each NEI are Arthritis, $49; Thermal Stress (Cold), $1,426; Reduced Fire Risk, $13; and Home Productivity, $49. The sum total value of the recommended household (HH) NEI values per unit, excluding societal benefits, is $1,537 (as presented in the "Per HH w/ VSL" column, highlighted in green).

Although the PAs are only able to claim household benefits at this time, we also present the societal benefits. The sum total of the household and societal NEI values including VSL is $2,471.

[45] A key consideration when quantifying NEIs is to ensure that the impacts do not overlap with other benefits that have already been accounted for elsewhere, such as energy savings. This avoids double-counting. The Working Group identified NEIs with the potential for double-counting prior to the completion of Phase 2 data collection. These NEIs are documented in the August 22, 2019 memo entitled "TXC50 Methodological Challenges and NEI Study Group Discussions."

Table 28: Estimated Annual Values of Recommended NEIs Per Weatherized Housing Unit
(With and Without VSL)

NEI Values	Per HH[1] w/ VSL	Per HH w/o VSL	Societal	Total	Total w/o VSL
Arthritis	$49	$49	$892	$941	$941
Thermal Stress (Cold)	$1,426†	$8	$38	$1,464	$46
Home Productivity	$49	$49	$0	$49	$49
Reduced Fire Risk	$13	$2	$4	$17	$6
Annual Total of Recommended NEIs per Weatherized Housing Unit	**$1,537**	**$108**	**$934**	**$2,471**	**$1,042**

[1] HH = household (assuming one household per housing unit).
† The total Thermal Stress (cold) NEI of $1,426 includes doctor's office visits ($1.41) + emergency dept. visits that do not result in deaths ($6.39) + the value of avoided death ($1,418).

3.5 ATTRIBUTION BY MEASURE

We ran another series of regression models as a simple, defensible way to determine how to allocate the recommended NEI values to the relevant measures in the BCR models. This analysis used the difference of the pre- and post-household composite NEI values as the dependent variable and the indicators for installed measures as the independent variables (see Appendix H for more details).

One of the first models we examined included three independent dummy variables: heating system upgrades (repair/replacement), air sealing, and insulation. We found high collinearity between air sealing and insulation: 87% of units that received insulation also received air sealing, while 78% of units that received air sealing also received insulation. This greatly reduced the impact of the insulation dummy variable. We created a dummy composite variable that combined air sealing and insulation (Air Sealing+Insulation) into one independent variable. Ultimately, our final recommended model produced statistically significant p-values with consistent directionality of the beta coefficients. The two independent variables in the recommended model were (1) Air Sealing+Insulation composite and (2) heating system upgrades. In this model, the magnitude of the normalized beta coefficients also aligned with expectations. Table 29 shows a summary of the results using the total NEI value composite variable (the difference between Phase 1 and Phase 2 total household NEI value including VSL) as the dependent variable (discussed in Section 2.4). For more detailed regression analysis results, see Appendix C.

Table 29: Regression Analysis Results – Attribution by Measure

NEI Values	Independent Variables	β Coefficient	p-value
Dependent Variable: *(Difference between Phase 1 and Phase2 VSL Composite NEI Value)*	Air Sealing+Insulation (X)	-288.960	0.056✧
	Heating System Upgrades (Y)	-312.367	0.029*

✧ Difference is statistically significant at the p<0.1 level.
* Difference is statistically significant at the p<.05 level.

The team used Equations 1 and 2 below to normalize the impacts of the beta coefficients.

- Air sealing + insulation (X)
- Heating system upgrades (Y)

Equation 1: *% attribution for(X) = % of measure combination X / (sum of % of measure combination X + Y)*

-288.96 / (-288.96 + -312.367) = 48**% attribution for** X

Because of the frequency with which air sealing and insulation are installed together, and the similarity in their installation rates (55% for air sealing and 50% for insulation), we recommend evenly splitting attribution for these measures, as follows:

- 48% attribution for X = **24**% for air sealing and **24**% for insulation

Equation 2: *% attribution for Heating System Upgrades (Y) = % of measure Y / (sum of % of measure combination X + Y)*

- -312.367/(-288.96 + -312.367) = **52% attribution for heating system upgrades**

3.5.1 Recommended NEI Allocation by Measure

In summary, the analysis above attributes the recommended NEIs to air sealing, insulation, and heating system upgrades. The value of each recommended NEI should be allocated across these measures as follows:

- **Air sealing: 24%**
- **Insulation: 24%**
- **Heating system upgrades: 52%**

For example, the annual total value of recommended NEIs per weatherized housing unit, $1,537, should be allocated across these measures, as follows:

- **Air sealing: $369**
- **Insulation: $369**
- **Heating system upgrades: $799**

3.6 LIMF VERSUS LISF

From a building science perspective, a LIMF building behaves differently from a LISF home. LIMF and LISF weatherization measures differ as well. The evidence presented here suggests that both LIMF NEIs and their values differ from those of LISF, and thus LISF NEIs should not be applied to LIMF.

Here, we focus on the LIMF Thermal Stress (Cold) NEI value. (The team did not consider Arthritis for the LISF study). The Thermal Stress (Cold) NEI value for LIMF is 32% higher than the same NEI for LISF (a $963 difference). We believe that the LISF NEI value may be undervalued due to the greater rigor of the resident survey questions for LIMF than for LISF.

Specifically, the LIMF survey asked about all persons in the home, asked questions to identify the care setting, and asked the number of times medical attention was sought per care setting per person. The LISF survey only asked about the head of household, did not identify the type of care setting, and did not ask the number of times medical attention was sought.

Had the LISF study asked about all persons in the home, the values for the Thermal Stress (Cold) NEI from that study would likely have doubled, making the LISF and LIMF NEI values comparable. Had the LISF study also asked questions to identify the care setting and the number of times medical attention was sought per care setting per person, the LISF values for Thermal Stress (Cold) might have been even greater than the LIMF values.

In addition, there were differences between the LIMF and LISF samples that would lead us to expect a difference in Thermal Stress (Cold) NEI values between the participants living in LIMF and LISF homes. Overall, the LIMF study groups were older than those in the LISF. The Massachusetts LIMF sample had more public housing than the LISF sample, and more of this housing may have been senior-focused. This could explain why Thermal Stress (Cold) and Arthritis are among the recommended LIMF NEIs, but not NEIs that would likely be more prevalent among a younger population, such as Missed Days of Work or Asthma. (Age was statistically significant in the regression model for doctor's office visits due to cold thermal stress and hospitalizations for arthritis.) Table 30 compares the Thermal Stress (Cold) NEI values for LISF versus LIMF both with and without the avoided death benefit.

Table 30: Comparison of LIMF and LISF Thermal Stress (Cold) Values

	With Avoided Death Benefit	W/O Avoided Death Benefit (out of-pocket expenses only)
LISF (Cold Stress Only)*	$463	$5
LIMF (Cold Stress Only)	**$1,426**	$8

* The LISF study estimated heat stress separately from cold stress, and recommended an NEI for Thermal Stress (Heat). The value of LISF NEI for Thermal Stress (Heat) alone is $146.

3.7 CONSIDERATIONS

3.7.1 Lessons Learned for Future NEI Studies

The team identified lessons from this study that could improve the PAs' future NEI research. Several of these lessons would need to be implemented well before a new NEI study begins in order to be effective, or could be implemented with the next NEI study of any type. The lessons that are in italics are ones that could be implemented immediately.

1. **When planning future studies of this type, PAs and their evaluators should focus on a narrower range of NEIs.** This study provided evidence suggesting that certain NEIs are worth examining further. In particular, the food spoilage and heat stress NEIs were close to, but did not meet, the threshold for statistical rigor. The fact that the Control group reported better asthma-related healthcare outcomes than the Treatment group suggests that it may be worthwhile to investigate asthma NEIs further. Should the PAs choose to study asthma further, it should be with a larger Treatment group that has a higher baseline rate of uncontrolled asthma, more similar to that of the Control group.

   Examining a narrower range of NEIs such as these would mean a shorter survey, and the lower response burden would likely result in higher response rates and larger groups. Another way to boost group sizes is to supplement the current dataset with new data on a narrower range of NEIs, and reanalyze it to yield more definitive results for the selected NEIs. If the new federal administration passes a recovery or infrastructure act that includes substantial funding for WAP, it could present a prime opportunity to scrutinize these NEIs as well as ones that met this study's statistical rigor threshold.

2. **When planning future studies of thermal stress-related NEIs, evaluators should consider using changes in hospitalizations, as well as emergency department visits, to establish the avoided death benefit.** This study relied on survey data from thermal stress-related emergency department visits to estimate the thermal stress NEI, including the avoided death benefit, because the findings related to reduced hospitalizations did not meet the threshold of statistical rigor established for the study. However, changes in costs from hospitalizations due to thermal stress are a major contributor to thermal stress-related NEIs and have been used in previous studies conducted by team member Three[3].

3. **In undertaking future studies of this type, PAs and evaluators should be mindful that planning for – and achieving – larger Treatment and Control group sample sizes would increase statistical rigor and the validity of results, especially for NEIs associated with specific chronic illnesses or rare conditions.** Coordinating with PAs in other jurisdictions with similar climate and housing stock and active low-income programs is likely the most cost- and time-efficient way to increase statistical rigor.

4. **PAs should ensure that evaluators conducting future studies of MF or SF housing include a household income question in resident surveys.** Having self-reported income data linked to utility bill data or data from energy impact studies would facilitate program administrators in calculating program impacts on energy insecurity in their service

areas. Income data would also facilitate identifying households as moderate income for further study of this subset of the MF sector.

5. **Lack of contact information for property owners/managers and occupants is a substantial impediment to research in the MF rental sector, regardless of the income of occupants. Various steps can be taken in advance of and during research to mitigate this impediment.** The team depended on the agencies and vendors that weatherized the buildings in the study to supply the contact information for the property owners. More often than not, the information was provided only after many attempts, or was not available at all. In a few cases, it was available but not provided despite many attempts. We also depended on the property owner's assistance to gain access to residents. The following approaches could help to mitigate this impediment in future MF studies. Some of the approaches could also help with studies that include SF rental properties.

   Participating property owners/managers and occupants

   - *As part of the program application process, PAs should require – or at least request – that property owners agree in writing to provide access to the building and assist with resident outreach should their building be selected for a PA-sponsored evaluation.*

   Non-participating (control group) property owners/managers and occupants

   - Evaluators should develop a sample frame of non-participating rental property owners/managers and occupants of rental properties. This could be done by adding questions to surveys of target populations and the general population to identify the respondents' status; ask if they would be willing to participate in a future research study; and, if so, request their contact information. Non-participating rental property owners/managers could be identified by comparing these data to program records.
   - Evaluators, in combination with PA evaluation, should identify and explore opportunities to work with associations or organizations that house data of affordable multifamily buildings in the state or region of interest, in hopes of leveraging these organizations' data.
   - In the near future, the Massachusetts Office of Energy and Environmental Affairs may implement an initiative that includes collecting energy usage data at a municipal or county level. This data will help identify affordable MF properties with high energy usage.

   All occupants

   - Evaluators should ensure that future research among occupants of MF rental property include budget for in-person canvassing, especially when resident information is unavailable.

6. **Be aware of the challenge of establishing building eligibility, group assignment, and measures installed, and prepare for it in advance if possible.** We found it particularly challenging to identify weatherization status and dates, the number of units per building (for eligibility purposes), and the weatherization measures installed per building, as these weatherization agencies/vendors either did not have this information readily available, or what they had was not current.
    - PAs should encourage a broader range of low-income stakeholders to become involved in study planning as early as possible to increase the likelihood of obtaining data for participating and non-participating buildings and households.
    - PAs should encourage weatherization agencies and vendors to track participation data more comprehensively, regardless of whether or not jurisdictions outside of Massachusetts are involved. When undertaking research in concert with other jurisdictions, PAs should try to interest the PAs, weatherization agencies, and vendors in these jurisdictions to share sample frame data that includes weatherization dates and installed measures for relevant buildings from their tracking systems.
    - *Studies of the MF sector in Massachusetts could be helped by making the following modifications to program tracking systems:*
        - *The Massachusetts program data we received tracked participation by facility, not by building. Facilities can include multiple buildings. Give a unique identification number to each building, and ask that all the PAs use the same number for each building. Track the measures installed, etc., by building, not just facility.*
        - *The program data included the number of units and of buildings per facility, but not the number of units per building. Include the number of units for each building associated with each facility. This would make it easier to identify eligible buildings for study sample frames.*
7. **When conducting future studies of this type, evaluators should consider recruiting housing units directly, rather than – or in addition to – recruiting MF buildings first.** This could help avoid some of the recruitment challenges discussed above and hence reduce data collection costs. This could also improve statistical precision by reducing clustering of observations by building.
8. ***This study benefited greatly from peer review during the planning process and in the penultimate draft. PAs should consider requiring evaluators to plan for and undertake this practice in future NEI studies.***

A

Appendix A Detailed Monetization Approaches and Results

A.1 Use of Secondary Data

Here we describe the team's approach to selecting the secondary data used in assessing and monetizing NEIs.

The team reviewed and vetted dozens of studies and reports to identify the most relevant, recent, high-quality secondary data sources to use as monetization inputs. We also reviewed multiple databases to identify those with recent relevant information to use in monetization calculations. For example, we reviewed online databases from the U.S. DHHS, such as MEPS and HCUP; the Massachusetts Center for Health Information and Analysis (CHIA); and the National Fire Incident Reporting System. Many of these are the same secondary online databases that were used for the WAP national evaluations and the Massachusetts LISF NEI Study.

From these databases, we used the most recent available Massachusetts-specific medical expenditure data. When only national medical costs were available, we adjusted these to reflect medical costs in Massachusetts.[46] In all cases, if the medical cost data were outdated, we adjusted them to reflect medical costs for 2020.[47]

We designed a separate analytical approach for each NEI that considered how weatherization contributes to the NEI and the availability of relevant primary and secondary data.

The team used the resident survey results in most, but not all, of the selected NEIs. Two NEIs – CO poisoning and home fire prevention – are rare and difficult-to-capture events, so they are not based on resident survey findings. For these NEIs, the team reviewed and analyzed secondary data on the effectiveness of installed weatherization measures that could reduce the probability of fire (e.g., smoke detectors, repairs to electrical systems) and measure installation data collected from participating weatherization agencies (e.g., installation of CO monitors).

Estimating the monetary value of reducing hospitalizations related to thermal stress required finding secondary data on the average cost of thermal stress-related hospitalizations. We ensured that all relevant cost data for this and other NEIs were current. For example, in the case of thermal stress, we researched factors ranging from cost of medical treatment (urgent care, hospitalizations, and emergency department visits) to hourly wage rates of LI residents in Massachusetts to estimate the benefit of reducing missed days of work. When current cost data were unavailable, we applied historical costs after making adjustments to reflect 2020 prices and values.

[46] More specifically, the Boston-Brockton-Nashua metropolitan statistical area (MSA). For more information, see: https://www.bls.gov/regions/new-england/news-release/consumerpriceindex_boston.htm
[47] Medical care price indices provided by the U.S. Bureau of Labor Statistics, http://data.bls.gov/timeseries/CUURA103SAM?data_tool=XGtable

The team rigorously explored all NEIs presented in this report for monetizable impacts. For NEIs that fit within the *theory of change* model, which requires quantifiable data from both pre- and post-weatherization groups, we gathered data for statistical analysis and produced monetary values. For NEIs that rely on installed measures data, such as CO and fire-related NEIs, we employed models and algorithms consistent with measuring changes in risk.

Prior to monetizing the NEIs, the team obtained feedback from external reviewers and the PAs on the soundness and applicability of the algorithms (within the context of the LIMF population being served in Massachusetts) and the secondary data sources and specific inputs chosen for the monetization effort.[48]

A.2 NEIs Monetized but Not Recommended for Adoption

Here, we outline the methodology we used to monetize each of the LIMF NEIs that are *not* being recommended for adoption, as well as the algorithms and data sources used for each. We present these in alphabetical order. For each NEI we also present results of questions on home livability and home conditions from the resident survey that provide supporting evidence for the monetized NEIs.

The team's starting hypothesis was that weatherization has either a positive benefit or no benefit at all, as we have not seen any indication that weatherization has a negative impact on any of the NEIs.

A.2.1 Asthma

Asthma prevalence (i.e., respondents self-reporting active asthma) for the entire LIMF population surveyed is 18.5%. The team measured the Asthma NEI using responses to asthma-related healthcare treatment questions from the resident survey. We drew these responses from surveys with all household members with reported active asthma, as well as from those who did not affirm active asthma status but reported both of the following: (1) lifetime asthma (i.e., ever been told by a healthcare professional that they have asthma) and (2) incidence estimates for treatment of asthma across the three types of healthcare settings identified below. Using the resident survey data, the team conducted a DID analysis.[49]

The team calculated means for the number of times each healthcare setting was visited to treat asthma flares, including urgent care, emergency department visits, and hospitalizations. As a first step for measuring the effect of weatherization on asthma-related outcomes, we calculated differences in means for each healthcare type reportedly used to treat asthma flares for the subsamples described above. Results from paired-samples t-tests suggest measurable changes

[48] The preliminary Phase 1 report provided the opportunity for PAs to review the monetization algorithms and data sources.
[49] The two research groups' asthma subsamples showed differing demographics. The treatment group self-identified as Hispanic or Latino descent at higher rates than the control group, and as Black or African American at lower rates. (Just over 50% of the treatment group identified as Hispanic or Latino descent, compared to 6.5% of the control group. Nearly 29% more of the control group self-identified as Black or African American than the treatment group.) This could account for differences between the groups in asthma severity and treatment type. In addition, the control group had higher percentages of females and was older, with an average age of 55 compared to the treatment group's average age of 40.

in incidences of asthma-related healthcare encounters post-weatherization in the treatment group, but not at statistically significant levels (Table 31). The results showed post-weatherization increases in reported urgent care and hospitalizations, but decreases in emergency department visits, for the treatment group subsample. However, results for the control group suggest fewer encounters across all healthcare settings (see Table 31), and there was a statistically significant increase in encounters for urgent care encounters using DID.

It is important to consider that only 59.1% of the treatment group subsample with active asthma reported having an asthma flare-up in the last three months compared to 77.5% of the control group. This difference suggests a higher proportion of the control sample had uncontrolled asthma at baseline, possibly resulting in greater potential for this group to require urgent or emergency care for asthma-related symptoms, and possible increased responsiveness to continuous and effective maintenance of symptoms through non-urgent medical treatment.

Because the control group reported better asthma-related healthcare outcomes than the treatment group, no measurable benefit of MF weatherization on asthma can be claimed. The team reports an NEI value of zero for the Reduced Asthma NEI (Table 32) rather than a *negative* NEI value. Accounting for asthma as a negative NEI presumes that the asthma portion of this study is more definitive than this research suggests it to be.

Table 31: Resident Survey Questions – Asthma

Survey Question	T pre	T post	(+/-)	C pre	C post	DID
Do you still have asthma? (active asthma) (Yes)	16.9% (n=141)	22.0% (n=58)	NA	18.6% (n=231)	18.7% (n=124)	NA
During the past 12 months, how many times did you visit an urgent care center because of asthma? (mean)	0.14 (n=44)	1.05	+0.91	0.79 (n=111)	0.33	+1.37 (p=0.056)
During the past 12 months, how many times did you have to stay overnight in the hospital because of asthma? (mean)	0.11 (n=44)	0.14	+0.03	0.23 (n=111)	0.09	+0.16 (p=0.172)
During the past 12 months, how many times did you visit an emergency department because of asthma? (mean)	0.43 (n=44)	0.36	-0.07	0.67 (n=111)	0.18	+0.42 (p=0.126)

Table 32: Estimated Benefit for Reduced Asthma

	Annual Per Unit Benefit
Households	$0
Society	$0
Total	$0

A.2.2 Food Assistance

It is logical to contend that weatherization could have a positive enough impact on household budgets that some households on food assistance would not feel the need to apply for continued assistance post-weatherization. We observed through the resident survey that, overall, fewer households reported receiving food assistance post-weatherization (Table 33). It is possible that the direct household income benefits attributable to weatherization may allow some households to reduce their needs for food assistance payments.[50]

Table 33: Resident Survey Questions – Food Assistance

Resident Survey Question	CwT	T + C	Change
In the past 12 months did you or any members of your household receive food stamps or WIC assistance (Women, Infants, and Children nutrition program) to help pay for food?	54.9% (n=586)	59.5% (n=1252)	-4.6%✧

✧ Difference is statistically significant at the p<0.1 level.
* Difference is statistically significant at the p<.05 level.
** Difference is statistically significant at the p<.01 level.
*** Difference is statistically significant at the p<.001 level.

The team monetized the NEI for reduced need for government-subsidized food assistance using the monetization approach and inputs presented in Table 34 and Table 35, respectively.

Table 34: Monetization Approach – Food Assistance

Monetization Approach
Key Variables
• a = change in the number of HHs needing Food Assistance (%) • d = average HH size • h = average Food Assistance per person per month ($)
Equation 1. *Annual Societal Benefit (per weatherized unit)*
• *= a*d*h*12 months*

Table 35: Sources/Inputs – Food Assistance

Inputs/Sources	
Resident Survey	• Change in number of HHs needing food assistance: 4.6% • Average HH size (of those reporting food assistance): 1.42 people
Literature: Peer Reviewed and Other	• Average food assistance per person per month:[1] $126

[1] https://www.cbpp.org/sites/default/files/atoms/files/snap_factsheet_massachusetts.pdf

[50] For example, households may have enough money for food so that even if they are eligible for food assistance based on their income, they may not believe that re-applying is worth their time and/or may feel relieved at not experiencing the stigma of being on food assistance.

Table 36 presents annual estimates of the NEI Reduced Need for Food Assistance.

Table 36: Estimated Impact of Reduced Need for Food Assistance

	Annual Per Unit Benefit
Households	$0
Society	$99
Total	**$90**

A.2.3 Work Productivity

Existing literature posits that lack of sleep can negatively impact productivity. Our research findings indicate that there are reductions in reports of *poor* sleep from respondents that are weatherization recipients.

Table 37: Resident Survey Questions – Work Productivity

Survey Question	CwT	T + C	Change
During the past 30 days, for about how many days have you felt you did not get enough rest or sleep? (n=1431)	6.28 (n=468)	7.26 (n=963)	-0.98†

† **p<.1**

The team monetized the NEI for increased work productivity due to improved sleep using the monetization approach and inputs presented in Table 38.

Table 38: Monetization Approach – Work Productivity

Monetization Approach
Key Variables
• p = annual productivity increases attributable to better sleep and rest ($) • a = average annual salary U.S. worker ($) • d = percent change in # of days main respondents get better sleep and rest • w = value of an hour of housework • h = hours per week housework • i = productivity increase in housework (=p/a) • s = % of main respondents employed
Equation 1. *Annual Societal Benefit for Increased Work Productivity (per Wx unit)*
• = p*d*s

Table 39: Sources/Inputs – Work Productivity

Inputs/Sources	
Resident Survey	• % of main respondents employed: 23.3%
Literature: Peer Reviewed and Other	• Annual productivity increase attributable to better sleep and rest: $2,500 https://www.rand.org/pubs/research_reports/RR1791.html • Value for an hour of non-market HH production (housework): $22.80 https://www.forbes.com/sites/jennagoudreau/2011/05/02/why-stay-at-home-moms-should-earn-a-115000-salary/#5bb109f275f4 https://www.bea.gov/household-production/
Open-source Databases	• Average # of hours per week spent on housework: 21.5 hours/week • http://www.bls.gov/opub/mlr/2009/07/art3full.pdf • Average annual salary U.S. worker: https://www.census.gov/newsroom/releases/archives/income_wealth/cb12-172.html

The estimated annual impacts of increased work productivity due to improved sleep are presented in Table 40.

Table 40: Estimated Impact of Increased Work Productivity Due to Improved Sleep

	Annual Per Unit Benefit
Households	$0
Society	$17
Total	**$17**

A.2.4 Food Spoilage

It is logical to assume a direct correlation between faulty refrigerators and food spoilage. Spoiled food is a major issue for LI populations, as evidenced by findings from the resident survey. The survey results presented in Table 41 suggest that weatherization has a measurable impact on reducing the frequency of discarded food from insufficient refrigeration.

A study that looked at power outage-related expenses estimated a total of $150 billion is incurred by U.S. homeowners, annually, including the costs related to food spoilage. The 2011 study reports that, per household, an average of $160 was spent on replacing food from a power outage lasting at least 12 hours.[51]

The team hypothesized that the LI population would incur lower costs from food spoilage due to having a tighter grocery budget than the general population. We subjectively chose a conservative estimate of 50% less, resulting in an estimated average of $80 spent on replacing food after each incident. We then adjusted the $80 cost estimate for inflation from 2011 costs to 2020 costs (Table 42).

[51] https://www.aagenpro.com/often-overlooked-costs-extended-power-outage/

Table 41: Resident Survey Questions –Food Spoilage

Resident Survey Question	CwT	T + C	(+/-)
In the past 12 months how many times did you have to throw away food because your refrigerator was broken or lost power? (mean)	0.17 (n=173)	0.83 (n=37)	**-0.66**

✧ Difference is statistically significant at the p<0.1 level.
* Difference is statistically significant at the p<.05 level.
** Difference is statistically significant at the p<.01 level.
*** Difference is statistically significant at the p<.001 level.

The team monetized the NEI for reduced food spoilage using the approach and inputs presented in Table 42 and Table 43, respectively.

Table 42: Monetization Approach – Reduced Food Spoilage

Monetization Approach
Key Variables
• D = Change in # of times had to throw food away (mean)
• C$ = Average cost of food replacement per incident of Food Spoilage
Equation 1. *Total Household NEI value*
• *Total HH NEI = D * C$*

Table 43: Sources/Inputs – Reduced Food Spoilage

Inputs/Sources	
Resident Survey	• Change in # of times had to throw food away because of faulty refrigerator or loss of power: -0.66
Literature: Peer-Reviewed and Other	• Cost of food replacement per incident of food spoilage, adjusted by 50% for LI population: $80 [1,2]
Open-Source Databases	• Bureau of Labor Statistics ○ Consumer Price Index to price-adjust medical costs for MA, 2020[3]

[1] https://www.aagenpro.com/blog/often-overlooked-costs-extended-power-outage/
[2] https://www.kohlerpower.com/home/common/pdf/RES_Infographic.pdf
[3] https://data.bls.gov/timeseries/CUURS11ASAM?amp%253bdata_tool=XGtable&output_view=data&include_graphs=true

Table 44 presents the annual NEI estimates of reduced food spoilage.

Table 44: Estimated Impacts of Reduced Food Spoilage

	Annual Per Unit Benefit
Households	$57
Society	$0
Total	**$57**

A.2.5 Low-Birth-Weight Infants

The team used responses to the resident survey questions and inputs from secondary literature to determine annual household and societal savings attributable to the reduced number of low-birth-weight infants born by pregnant mothers with poor nutrition and lower levels of food insecurity. It is possible that the direct household income benefits attributable to weatherization may allow some households to increase their food security. Studies have shown that pregnant women with high food insecurity are more likely (18.7% more likely) to have low-birth-weight infants, which require more medical care in their first year of life.[52]

Table 45: Resident Survey Questions – Low-Birth-Weight Infants

Survey Question	CwT	T + C	Change
Over the past 12 months, how often has your household not purchased food in order to pay an energy bill? (% yes, at least once in 12 months)	13.1% (n=374)	21.9% (n=644)	-8.8%
In past four weeks, did you or a household member go a whole day and night without eating anything because there was not enough food? (Yes)	6.0% (n=583)	8.6% (n=1222)	-2.6%✧
In past four weeks, did you worry household members would not have enough nutritious food? (Yes)	11.8% (n=585)	14.2% (n=1232)	-2.4%
(New composite variable): Did household member say "Yes" to one or more of the above questions related to food insecurity? (Yes)[1]	**24.3% (n=387)**	**36.3% (n=697)**	**-12.0%**

[1] Created a composite variable that includes three indicators of food insecurity. Used the change in the composite variable (-12.0%) to monetize the Low-Birth-Weight Infants NEI.

✧ Difference is statistically significant at the p<0.1 level.
* Difference is statistically significant at the p<.05 level.
** Difference is statistically significant at the p<.01 level.
*** Difference is statistically significant at the p<.001 level.

[52] Borders, Ann E., William A. Grobman, Laura B. Amsden, and Jane L. Holl. "Chronic Stress and Low Birth Weight Neonates in a Low-Income Population of Women," Obstetrics & Gynecology 109, no. 2 (2007): 331-338.

The team monetized the NEI for reduced low-birth-weight infants using the monetization approach and inputs presented in Table 46 and Table 47, respectively.

Table 46: Monetization Approach – Low-Birth-Weight Infants

Monetization Approach
Key Variables
• B = Average number of infants born among the program population • C= Change in number of low-birth-weight infants (%) • D= HHs that moved from higher to lower level of food insecurity (%) • R = Reduced risk of having low-birth-weight baby if high level of food insecurity • C$ = Average medical cost resulting from care of a low-birth-weight baby
Equation 1. *Average number of Infants born among the program population*
*B = (# women of child-bearing age reported in Phase 1-Resident Survey) * (birth rate for women ages 15-44)*
Equation 2. *Change in number of low-birthweight infants (%)*
*C = D * R*
Equation 3. *Annual Societal Benefit (per weatherized unit)*
*S NEI = B * C * C$*

Table 47: Sources/Inputs – Low-Birth-Weight Infants

Inputs/Sources	
Resident Survey	• Avg. number of women of child-bearing age (15-44) per HH: (0.202) • Birth rate for women ages 15-44: (0.0628) • Percent of HHs moved from higher to lower level of food insecurity (Table 45):(12%)
Literature: Peer Reviewed and Other	• S Costs of Preterm Birth (2007): $31,290 (Birth to five years of age) plus $3,812 (Delivery)[1,2] • Chronic Stress and Low Birth Weight Neonates in a LI Population of Women (2007):[3] 18.7% reduction in risk of low-birth-weight infants for pregnant women with low versus high food insecurity
Open-Source Databases	• Bureau of Economic Analysis: Regional Price Parity to adjust national to MA price levels[4] • Bureau of Labor Statistics: Consumer Price Index to price-adjust medical costs from 2015 to 2018 dollars[5]

[1] https://www.ncbi.nlm.nih.gov/books/NBK11358/
[2] Team adjusted these costs using price indexes.
[3] https://www.ncbi.nlm.nih.gov/pubmed/17267833
[4] https://apps.bea.gov/iTable/iTable.cfm?reqid=70&step=1&isuri=1&acrdn=8#reqid=70&step=1&isuri=1
[5] https://data.bls.gov/timeseries/CUURS11ASAM?amp%253bdata_tool=XGtable&output_view=data&include_graphs=true

Table 48 presents the estimated annual impacts of fewer low-birth-weight infants.

Table 48: Estimated Impact of Fewer Low-Birth-Weight Infants

	Annual Per Unit Benefit
Households	$0
Society	$10
Total	**$10**

A.2.6 Missed Days of Work

Missed days of work can negatively impact household income. The team used responses to the resident survey questions and inputs from secondary literature to determine annual household savings attributable to reduced days of work missed because of illnesses or injuries to the respondent or another person in the home.

In the results presented below, we included responses only from primary wage earners. We excluded reports of 31 or more days of missed work for the previous 12 months, as we would expect work absences of a month or more to be due to communicate disease or disability, not health issues that are responsive to weatherization.

Table 49: Resident Survey Questions – Missed Days of Work

Survey Question	CwT	T + C	Change
Mean # of missed workdays (primary wage earner) due to illness or injury for self or other HH member – last 12 mo.	3.63 (n=83)	3.16 (n=214)	-0.47

The team then used a linear regression model to estimate the impact of weatherization on missed days of work due to health of self or another household member. This model contains the weatherization *dummy* as the independent variable. In this model, the p-value (.224) is not statistically significant. We included region, size of building, gender, race, age (55+), and level of education as independent variables in the model to assess differences across the weatherized and unweatherized samples. The significance levels of the independent variables indicate that there was no statistical issue related to differences across the samples (Appendix C).

The team monetized the NEI for reduced missed days of work using the monetization approach and inputs presented in Table 50 and Table 51, respectively.

Table 50: Monetization Approach – Missed Days of Work

Monetization Approach
Key Variables
• w = average wage rate per hour for LI worker ($) • d = change in the number of missed days of work due to health of self or others (%) • e = percentage of main respondents employed • s_1 = percentage of LI workers without sick leave • s_2 = percentage of LI workers with sick leave
Equation 1. *Annual Household Benefit (per weatherized unit)*
• = *w*(8 hours)*d*e*s*
Equation 2. *Annual Societal Benefit (per weatherized unit)*
• = $w*(8\ hours)*d*e*s_2$

Table 51: Sources/Inputs – Missed Days of Work

Inputs/Sources	
Resident Survey	• Change in the number of missed days of work due to health of self or others: -0.47 days • Percentage of main respondents employed or self-employed: 23%
Literature: Peer Reviewed and Other	• Average wage rate per hour for LI workers: $12.46 http://www.massbudget.org/reports/swma/poverty.php http://www.massbudget.org/reports/swma/wages-income.php • Percentage of LI workers w/o sick leave: 77% – Bureau of Labor Statistics (2017): https://www.bls.gov/news.release/ebs2.t06.htm

Table 52 presents the estimated annual impacts of fewer missed days of work.

Table 52: Estimated Impact of Fewer Missed Days of Work

	Annual Per Unit Benefit
Households	$8
Society	$3
Total	**$11**

A.2.7 Prescription Adherence

It is possible that the direct household income benefits attributable to weatherization may allow some households to afford prescription medicines after weatherization, subsequently decreasing medical expenses. An important benefit to society for complying with physician directed prescriptions is a substantial reduction in hospitalization rates. We used responses to the resident survey questions and inputs drawn from secondary literature to determine annual societal savings attributable to improved prescription medication adherence.

Table 53: Resident Survey Questions – Prescription Adherence

Survey Question	CwT	T + C	Change
During the past 12 months, was there any time your household members needed prescription medicines but did not get them because you couldn't afford it? (n=683)	10.0% (n=)	15.4% (n=)	-5.4*

* Difference is statistically significant at the p<.05 level.

The team monetized the NEI for increased prescription adherence using the monetization approach and inputs presented in Table 54 and Table 55, respectively.

Table 54: Monetization Approach – Prescription Adherence

Monetization Approach
Key Variables
• e = annual cost to national economy due to lack of prescription medication adherence • p = U.S. population • i = % of population taking prescriptions • n = % of population non-prescription adherent • c = cost to society: lack of prescription medication adherence ($) • d = change in the percentage of HHs better able to afford prescriptions (%) • a = adjustment factor, some HHs still will not adhere to prescriptions (%)
Equation 1. *Societal Costs for Prescription Non-Adherence*
• *c = e/(p*i*n)*
Equation 2. *Annual Societal Benefit (per weatherized unit)*
• *= c*d*a*

Table 55: Sources/Inputs – Prescription Adherence

Inputs/Sources	
Resident Survey	• Change in the percentage of HHs better able to afford prescriptions: -5.4
Literature: Peer Reviewed and Other	• Annual cost to society for an individual being non-prescription adherent: http://annals.org/aim/fullarticle/1357338/interventions-improve-adherence-self-administered-medications-chronic-diseases-united-states) • % of population taking prescriptions: 70% • % of population non-prescription adherent: 50% • Cost to economy of prescription non-adherence: Cutler R. L., *et al (2018).* Economic impact of medication non-adherence by disease groups: a systematic review. *BmJ Open*; 8: e016982. doi: 10.1136/bmjopen-2017-016982. • Adjustment factor: 0.5 Liberman et al (2011). Are caregivers adherent to their own medications? Journal of the American Pharmacists Association, Volume 51, Issue 4, 492–498. https://doi.org/10.1331/JAPhA.2011.10006
Open-Source Databases	• U.S. population December 2019: 328,239,523 http://census.gov

Table 56 presents the estimated annual impacts of improved prescription adherence.

Table 56: Estimated Impact of Prescription Adherence

	Annual Per Unit Benefit
Households	$0
Society	$59
Total	**$59**

A.2.8 Short-Term High-Interest Loans

We used responses to the resident survey questions and inputs gleaned from secondary literature to determine annual household savings attributable to reduced need for taking out Short-Term, High-Interest (predatory) loans due to improved budget situations (e.g., from reduced energy costs or decreased medical expenses).

Table 57: Resident Survey Questions – Short-Term Loans

Survey Question	T+C	CwT	Change
In the past year, have you used any of the following to assist with paying your energy bill? **(n=355)**			
Payday loan	0.039	0.022	-0.017
Tax refund anticipation loan	0.019	0.017	-0.002
Car title loan	0.005	0.007	+0.002
Other type of short term, high-interest loan	0.023	0.015	-0.008
Pawn shop	0.056	0.047	-0.009

The team monetized the NEI of the reduced use of short-term, high-interest loans using the monetization approach and inputs presented in Table 58 and Table 59, respectively.

Table 58: Monetization Approach – Short Term Loans

Monetization Approach
Key Variables
For each loan type (a); payday, tax refund, car title, other, pawn • l = average interest payment per loan (a) ($) • d = change in # of loans assumed by HHs (mean)
Equation 1. *Annual Household Benefit (per weatherized unit)*
• *= l * d (for every loan type a)* • *NEI = 0.017*$90 + 0.0102*$35 + (-0.002)*$250 + 0.008* $119 + 0.009*$30*

Table 59: Sources/Inputs – Short Term Loans

Inputs/Sources	
Resident Survey	• Change in the # of loans assumed by HHs by loan type (a)
Literature: Peer Reviewed and Other	• Federal Deposit Insurance Corporation (2015). National Survey of Unbanked and Underbanked Households.[1] • Neil Bhutta, Jacob Goldin, Tatiana Homono (2015). Consumer Borrowing After Payday Loan Bans. • The Pew Charitable Trusts (2015). Auto Title Loans: Market practices and borrowers' experiences.[2] • Consumer Financial Protection Bureau (2013).[3] • Robert B. Avery (2011). Payday Loans versus Pawnshops: The Effects of Loan Fee Limits on HH Use.

[1] https://www.fdic.gov/householdsurvey/2015/2015report.pdf
[2] http://www.pewtrusts.org/~/media/assets/2015/03/autotitleloansreport.pdf
[3] https://files.consumerfinance.gov/f/201304_cfpb_payday-factsheet.pdf

Table 60 presents the estimated annual impacts of reduced use of short-term, high-interest loans.

Table 60: Estimated Impact of Reduced Use of Short-Term, High-Interest Loans

	Annual Per Unit Benefit
Households	$2
Society	$0
Total	**$2**

A.2.9 Trips and Falls

Adults aged 65 and older are at greater risk of falling in their dwellings compared to the general population, and the resulting medical costs increase with age.[53] According to the Centers for Disease Control and Prevention (CDC), the medical costs associated with trips and falls in this age group were estimated at over $50 billion nationally in 2015. [54] Given the advanced mean age of the study population, trips and falls pose a serious concern for many program recipients. The CDC[55] and the National Safety Council[56] recommend installing good lighting, stair handrails, and shower grab bars to prevent trips and falls in the home.[57] Because lighting improvements are often included in weatherization as energy conservation measures and fall prevention measures, and are at times considered allowable incidental health and safety repairs,[58] there is reason to believe weatherization can reduce the rate of trips and falls requiring medical attention.

The results indicated a decrease in incidences of trips and falls inside common areas of weatherized apartment buildings that produced 30.3% fewer visits to the doctor's office. This difference is statistically significant (Table 61). The team used this input for monetizing the Trips and Falls NEI (Table 62). Note that the Comparison-with-Treatment group reported fewer urgent care medical encounters than the unweatherized (T_Pre+C) group for trips and falls in common areas, though not at a statistically significant level. Between the lack of statistical significance and the low likelihood of weatherization causing trips and falls, we report a $0 benefit for the urgent care medical encounters. The survey results for trips and falls that occurred inside *apartment units*, shown in Table 61, were unexpected. The Comparison-with-Treatment homes group reported a higher number of medical encounters than the T+C group. Interestingly, 80% of units received some type of lighting upgrade, although none of the agencies reported any type of incidental repairs or installation of fall-avoidance measures.

One potential explanation for the higher incidence in reported trips and falls among the Comparison-with-Treatment group is that the average age of the Comparison-with-Treatment group was higher than that of the Treatment+Control group by a statistically significant amount. Assuming older individuals are more prone to trips and falls than younger individuals, one might reasonably hypothesize a higher trip and fall rate in the Comparison-with-Treatment group. An additional factor to consider is the slightly higher prevalence of women in the Comparison-with-Treatment group. In one peer-reviewed article, women were roughly 20% more likely to be hospitalized and 10% more likely to visit an emergency department than men when they needed

[53] Elizabeth R. Burns, Judy A. Stevens, Robin Lee. The direct costs of fatal and non-fatal falls among older adults – United States, J of Safety Res, Vol. 58, 2016, pgs 99-103. https://doi.org/10.1016/j.jsr.2016.05.001.
[54] https://www.cdc.gov/homeandrecreationalsafety/falls/adultfalls.html
[55] Centers for Disease Control and Prevention, 2017. Important Facts About Falls, 2017. Retrieved accessed 19 June 19, 2018 from: https://www.cdc.gov/homeandrecreationalsafety/falls/adultfalls.html
[56] National Safety Council. 2018. Fall-prevention Measures Can Keep Older Adults Independent. Retrieved accessed 19 June 19, 2018 from: https://www.nsc.org/home-safety/safety-topics/older-adult-falls
[57] https://www.cdc.gov/steadi/pdf/check_for_safety_brochure-a.pdf
https://www.nsc.org/home-safety/safety-topics/older-adult-falls
[58] Not all LI weatherization agency programs are able to provide incidental health and safety repairs for their clients. Some programs that do can include fall prevention measures as an allowable health and safety measure.

medical attention for a fall.[59] However, men were 37% more likely to go to a doctor's office or urgent care when needing medical care for a fall.[60]

The team does not report in-unit lighting as an outcome of MF weatherization.

Table 61: Resident Survey Questions – Trips and Falls

Resident Survey Question (all persons: n=57)	CwT	T + C	Change
For those that reported needing medical care for a trip or fall inside common areas of apartment building, what types of medical attention did that individual seek?			
Non-Urgent Care [1]	5.6%	35.9%	-30.3%**
Urgent Care	16.7%	5.1%	+11.6%
Emergency Department	61.1%	59.0%	+2.1
Hospital	27.5%	20.5%	+7.0%
For those that reported needing medical care for a trip or fall inside their apartment unit, what types of medical attention did that individual seek?			
Non-Urgent Care	32.6%	27.9%	+4.7%
Urgent Care	30.4%	6.6%	+23.8%**
Emergency Department	50.0%	61.3%	-11.3%
Hospital	19.6%	30.6%	-11.0%

[1] Used as monetization input for Trips and Falls NEI.
** Difference is statistically significant at the p<.01 level.

The team monetized the NEI for reduced trips and falls using the monetization approach and inputs presented in Table 62 and Table 63, respectively.

Table 62: Monetization Approach – Trips and Falls

Key Variables

- C$ = average cost of non-urgent medical treatment for a trip or fall inside the building
- T_{pre} = number of trips and falls resulting in non-urgent medical treatment
- T_{post} = number of trips and falls resulting in non-urgent medical treatment
- S$ = cost impact per weatherized unit related to non-urgent medical treatment
- TS$ = total impact per weatherized unit

Equation 1. *Annual Impact (per weatherized unit)*

- S$ = [((C$*$T_{post}$) / number of pre-weatherization HHs) - ((C$*$T_{pre}$) / number of post-weatherization HHs)]

[59] Elizabeth R. Burns, Judy A. E., Stevens, J., Robin Lee, R. "The direct costs of fatal and non-fatal falls among older adults – United States," Journal of Safety Research 58 (2016). The direct costs of fatal and non-fatal falls among older adults – United States, J of Safety Res, Vol. 58, pgs: 99-103., accessed April 1, 2019, https://doi.org/10.1016/j.jsr.2016.05.001.
[60] Ibid.

Table 63: Sources/Inputs – Trips and Falls

Inputs/Sources	
Resident Survey	• Change in incidences of trips and falls in common areas of building resulting in non-urgent care (-30.3%)

Open-Source Databases	• Average cost of non-urgent medical treatment for a trip or fall[1]
	• Bureau of Economic Analysis[2]
	  ○ Regional Price Parity to adjust national to MA price levels
	• Bureau of Labor Statistics:
	  ○ Consumer Price Index to price-adjust medical costs from 2015 to 2020 dollars

[1] Elizabeth R. Burns, Judy A. Stevens, Robin Lee. The direct costs of fatal and non-fatal falls among older adults – United States, J of Safety Res, Vol. 58, 2016, pgs. 99-103. https://doi.org/10.1016/j.jsr.2016.05.001.
[2] https://www.bea.gov/

Table 64 presents the estimated annual impacts of fewer trips and falls.

Table 64: Estimated Impact of Fewer Trips and Falls

	Annual Per Unit Benefit
Households	$3
Society	$46
Total	**$49**

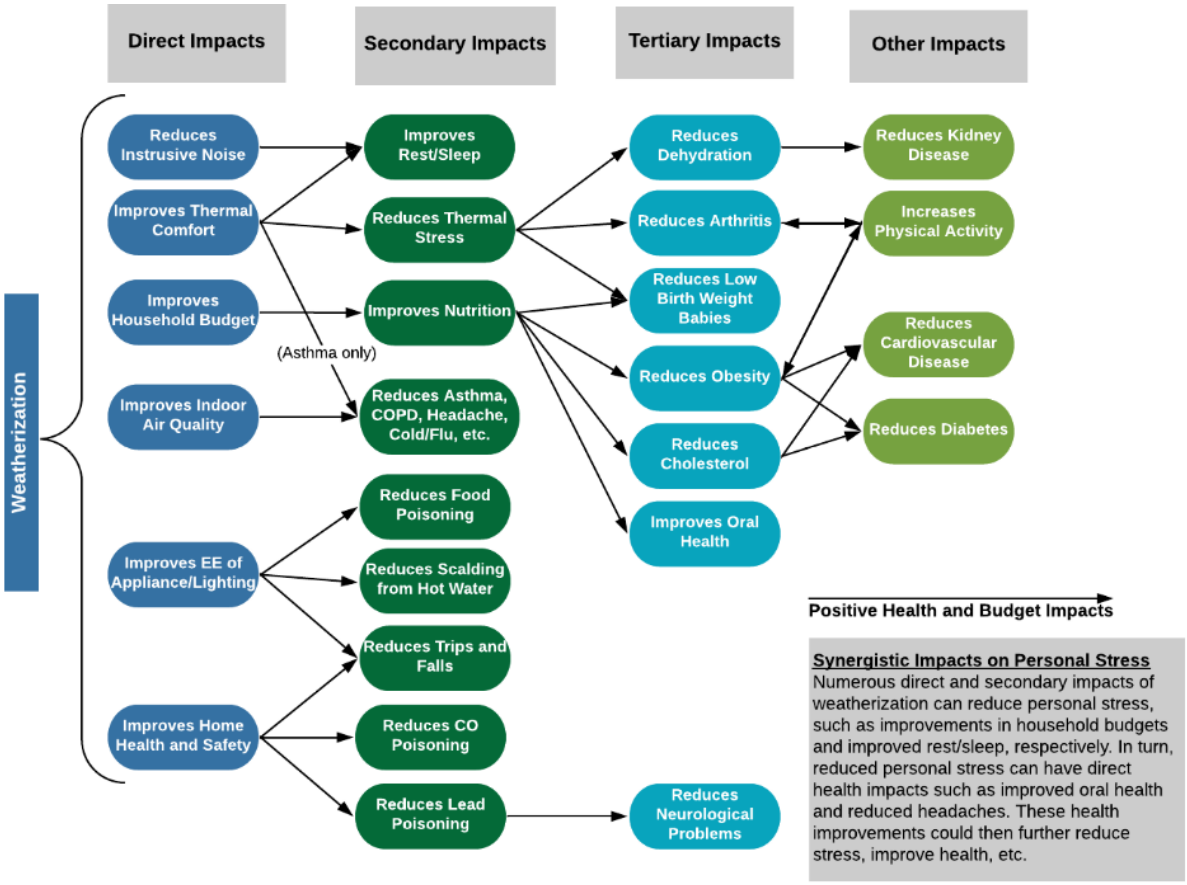
B

Appendix B Additional LIMF NEIs to Consider

Research into the potential health and household-related NEIs of LI weatherization continues to evolve. The work undertaken in this, and the JPB study, are at the forefront of research exploring new NEIs to consider monetizing.

Figure 2 presents a more detailed depiction of the relationships between weatherization and its direct, secondary, and tertiary impacts on health than the graphic presented in Section 1.2.1. The figure posits that improvements in household budgets can lead to improvements in nutrition as fewer households report trading-off buying food to pay their utility bills. Improved nutrition can lead to reduced obesity and improved overall health. In addition, improved thermal performance can reduce indoor thermal stress, which can reduce arthritis symptoms via decreased pain. Decreased pain could spur individuals to increase their physical activity. These impacts can, in turn, synergistically and positively impact cholesterol levels. Lastly, as the figure shows, the relationships between weatherization and psychosocial stress are complex. A few of the direct impacts of weatherization can also directly reduce individuals' stress levels. For example, reducing energy costs can reduce challenges surrounding household budgets, which can improve both quality of life and general health. Improvements in health, which range from decreased thermal stress to feeling more rested and sleeping better, can also reduce psychosocial stress. Reductions in mental stress can have beneficial physical health impacts, such as reducing headaches, improving sleep, or reducing stress hormone levels, thereby improving cardiovascular health.

Figure 2: Relationships Between Weatherization and Health Benefits



The resident survey contains questions to support the consideration of an additional 17 NEIs. In the remainder of this appendix, we identify NEIs we consider promising for future monetization studies, based on two factors: (1) likely strong evidence of change pre- to post-weatherization, and (2) likely magnitude of the NEI. Here, we identify these additional health-and household-related NEIs. Developing robust analytical and monetization approaches for these NEIs was beyond the scope of this study. The team presents strong initial results of statistical analysis, but not does not present NEI values.

Table 65 shows the NEIs to consider for future monetization, with justification. Table 66 shows a list of additional NEIs to consider for future exploration and notes potential challenges to monetizing these NEIs.

Table 65: NEIs to Consider for Future Monetization

NEI	Justification for Future Monetization
CVD	Sound theory of change; results of statistical analysis are promising
Headaches	Sound theory of change; initial results of statistical analysis are promising
Energy assistance	Sound theory of change; initial results of statistical analysis are promising
Noise pollution	Sound theory of change; strong initial results of statistical analysis
Mental health and well-being	Sound theory of change; strong initial results of statistical analysis
Refrigerated medicines	Initial statistical results suggest this is an important issue for MF population and could have a high monetary benefit; however, the weatherization may not impact this NEI
Electrical medical equipment	Initial statistical results suggest this is an important issue for MF population and could have a high monetary benefit; however, the weatherization may not impact this NEI
Residential instability	Sound theory of change (re thermal conditions); initial results are promising

Table 66: NEIs to Consider for Future Exploration

NEI	Potential Challenges to Monetization
Burns from water	Likely lack of evidence of change
Disconnect notices	Potential double counting at HH level; already claimed by PAs at utility level
Disconnections	Potential double counting at HH level; already claimed by PAs at utility level
Food poisoning	Likely lack of evidence of change
Lead poisoning	Programs infrequently address lead issues
Missed days of school	Likely lack of evidence of change

The rest of this appendix presents descriptive statistics for the NEIs listed above, grouped by topic (i.e., health and well-being, safety, dwelling quality, and budget issues). Table 67 through Table 80 show the resident survey findings on which we based the likelihood of monetization.

B.1 Additional Health-Related NEIs

Lead poisoning is a significant public health issue. It can be addressed, in part, through lead remediation of homes and buildings. Lead remediation is not part of the MF weatherization program in MA.

Table 67: Resident Survey Questions – Lead Poisoning

Resident Survey Question	CwT	T + C	(+/-)
Has anyone in the household ever experienced lead poisoning? (Yes) (n=2698)	0.2% (n=828)	0.5% (n=1870)	-0.3%

Poor mental health is a major health issue in the U.S. Weatherization can lead to improvements in mental health by reducing stress about bills; improving home comfort; reducing the intrusion of outdoor noise; and reducing other irritants, such as odors and pests. The survey results presented in the table immediately below suggest that weatherization may have a measurable impact on mental health.

Table 68: Resident Survey Questions – Mental Health and Well Being

Resident Survey Question	CwT	T + C	(+/-)
Thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good? (mean) (n=1411)	4.72 (n=464)	5.64 (n=947)	-0.93†
During the past 30 days, for about how many days did poor physical or mental health keep you from doing your usual activities, such as self-care, work, or recreation? (mean) (n=1397)	4.28 (n=461)	4.49 (n=936)	-0.21

† p<0.1

Cardiovascular disease (CVD) is another major health issue that afflicts U.S. citizens. The team hypothesized that weatherization could reduce symptoms of CVD by improving home comfort and IAQ. For example, if symptoms of arthritis are lessened, individuals are better able to be mobile or more active, which could also reduce CVD symptoms. The survey results reported immediately below are promising, though the questions themselves are not phrased to directly explore whether respondents have heart disease.

Table 69: Resident Survey Questions – CVD

Resident Survey Question	CwT	T + C	(+/-)
When engaged in moderate activity, your heart beats faster than normal; you can talk but not sing. Examples include fast walking, aerobics class, doing weights, or swimming gently. *How many days per week do you do moderate physical activities for at least 30 minutes? (mean) (n=1501)*	2.86 (n=482)	2.93 (n=1019)	-0.07
When engaged in vigorous activity, your heartbeat increases a lot, you can't talk, or your talk is broken up by large breaths. Examples include jogging, running, basketball, or hiking up a steep hill. *How many days per week do you do vigorous physical activities for at least 20 minutes? (mean) (n=1389)*	1.40 (n=442)	1.63 (n=947)	-0.23†

† p<0.1

Headaches are a source of discomfort for many Americans. Weatherization can reduce the incidence of headaches by improving home comfort, reducing the intrusion of outdoor noise, improving indoor lighting, and reducing stress. The survey results presented in Table 70 suggest that weatherization may have a measurable impact on headaches.

Table 70: Resident Survey Questions – Headaches

Resident Survey Question	CwT	T + C	(+/-)
In the past three months, have you had headaches that are either new or more frequent or severe than ones you have had before? (Yes) (n=695)	18.2% (n=587)	22.2% (n=1244)	-2.0%†

† p<0.1

Weatherization can reduce the incidence of burns from hot water simply by reducing the temperature to which water is heated. However, the initial survey results suggest that this issue is fairly rare (Table 71).

Table 71: Resident Survey Questions – Burns from Hot Water

Resident Survey Question	CwT	T + C	(+/-)
In the past 12 months, did anyone in the household see a medical professional because of burns from scalding hot water coming out of a faucet or showerhead inside your home? (Yes) (n=1846)	0.2% (n=590)	0.2% (n=1256)	0%

Weatherization can reduce the number of days that students miss school by improving student health and the health of their care givers. However, the initial survey results do not support this hypothesis (Table 72).

Table 72: Resident Survey Questions – Missed Days of School

Resident Survey Question	CwT	T + C	(+/-)
In the past 12 months, how many days of preschool has this child missed due to illness? (mean) (n=29)	7.85(n=7)	4.50 (n=22)	+3.36†
In the past 12 months, how many days of school has this child missed due to illness? (mean) (n=130)	5.35 (n=34)	5.40 (n=94)	-0.05

† p<0.1

The team hypothesized that weatherization could reduce the incidence of food poisoning by replacing inefficient, malfunctioning refrigerators. The survey results suggest that food poisoning is a rare event and the initial results do not support the hypothesis (Table 73).

Table 73: Resident Survey Questions – Food Poisoning

Resident Survey Question	CwT	T + C	(+/-)
In the past 12 months, did anyone in the household see a medical professional for food poisoning because your refrigerator was not at a temperature that was safe for food? (Yes) (n=1844)	0.9% (n=587)	1.0% (n=1257)	-0.1%

B.2 Additional Safety-Related NEIs

The results presented in Table 74 indicate that a sizable proportion of households have someone who relies on electrical medical equipment, and over one-half report that it would be life threatening to them if the equipment were unpowered for an extended period. Because of the importance of this equipment to this population, this NEI warrants further consideration (though it is also the case that weatherization may not directly reduce power outages to units).

Table 74: Resident Survey Questions – Electrical Medical Equipment

Resident Survey Question	CwT	T + C	(+/-)
Do you or does anyone else in your household rely on medical equipment that would stop working if the power goes out? (Yes) (n=1771)	14.1% (n=560)	14.0% (n=1211)	NA
Would it be life threatening if your electric medical equipment was unable to be powered for an extended period? (Yes) (n=219)	55.2% (n=67)	66.4% (n=157)	NA

Table 75 indicates that a sizable proportion of households have someone who relies on refrigerated medicines and just under one-half report that it would be life threatening to them if their medicines were unrefrigerated for an extended period. Because of the importance of this equipment to this population, this NEI warrants further consideration.

Table 75: Resident Survey Questions – Refrigerated Prescriptions

Resident Survey Question	CwT	T + C	(+/-)
Do you or anyone else in your household take prescription medicines that need to be kept in the refrigerator? (Yes) (n=1836)	17.4% (n=579)	15.6% (n=1257)	+1.8%
Would it be life threatening if the medicines were not refrigerated for an extended period because of a power outage? (Yes) (n=235)	48.1% (n=81)	44.8% (n=154)	+3.3%

B.3 Additional Dwelling Quality-Related NEIs

Noise is a problem that is endemic to urban areas in the U.S. Weatherization can reduce the stress from the intrusion of noise into apartment units through insulation and air sealing and repairing and replacing broken windows and doors. The survey results in Table 76 strongly suggest that weatherization may have a measurable impact on noise.

Table 76: Resident Survey Questions – Noise

Resident Survey Question	CwT	T + C	(+/-)
How much outdoor noise do you hear indoors when the windows are closed? (a great deal or some) (n=1846)	52.0% (n=586)	62.7% (n=1260)	-10.7%***
Thinking about the past 12 months, how much of this outdoor noise interfere with your sleep at night? (Extremely, very much, or moderately) (n=1536)	22.7% (n=471)	28.1% (n=1065)	-5.4%*
How much does outdoor noise bother, disturb, or annoy you when you are inside your apartment? (moderately or great deal) (n=1648)	26.7% (n=535)	33.2% (n=1113)	-6.5%**

✧ Difference is statistically significant at the p<0.1 level.
* Difference is statistically significant at the p<.05 level.
** Difference is statistically significant at the p<.01 level.
*** Difference is statistically significant at the p<.001 level

Odors seeping in from outdoors and adjacent units also negatively impact apartment dwellers. Weatherization can reduce odors through air sealing and insulation and improving ventilation. The survey results in Table 77 strongly suggest that weatherization may have a measurable impact on odors. This NEI could be considered an indicator of other NEIs, such as improved well-being, rather than its own NEI. A decrease in frequency of chronic headaches may be correlated with a decrease in odors.[61]

Table 77: Resident Survey Questions – Odors

Resident Survey Question	CwT	T + C	(+/-)
How often do you smell odors from outside your home when the windows are closed? (very or fairly often) (n=1905)	13.3% (n=607)	21.7% (n=1298)	-8.4%***
How often do you smell odors from other apartments or the hallway when you are inside your apartment? (very or fairly often) (n=1613)	23.8% (n=529)	28.0% (n=1084)	-4.2%✧

✧ Difference is statistically significant at the p<0.1 level.
* Difference is statistically significant at the p<.05 level.
** Difference is statistically significant at the p<.01 level.
*** Difference is statistically significant at the p<.001 level

B.4 Additional Budget-Related NEIs

Residential instability is a serious problem for LI renters across the U.S. The team hypothesizes that weatherization could reduce the probability of situations that could force households to temporarily move out of their apartments. The survey results presented in Table 78 suggest that weatherization may have a measurable impact on residential instability by preventing dwellings from being uninhabitable because they are too hot or cold.

Table 78: Resident Survey Questions – Residential Instability

Resident Survey Question	CwT	T + C	(+/-)
In the past 12 months, did you have to temporarily move out of your apartment because of any of the following reasons: (Yes)			
Did not have power	1.4% (n=588)	1.9% (n=1273)	-0.5%
Flooding	0.7% (n=588)	0.7% (n=1272)	0.0%
Fire	0.2% (n=588)	0.1% (n=1272)	+0.1%
Apartment too hot	0.5% (n=588)	1.3% (n=1272)	-0.8%
Apartment too cold	0.7% (n=588)	1.4% (n=1272)	-0.7%

[61] https://www.ninds.nih.gov/Disorders/Patient-Caregiver-Education/Hope-Through-Research/Headache-Hope-Through-Research

Weatherization can directly lead to reduced needs for energy assistance by making energy bills easier to afford. This benefit accrues to society (e.g., government energy assistance programs, friends, and family), not individual households. The survey results in Table 79 suggest that weatherization may have a measurable impact on energy assistance.

Table 79: Resident Survey Questions – Energy Assistance

Resident Survey Question	CwT	T + C	(+/-)
Some agencies offer assistance with paying for energy bills. Did your household receive energy assistance this year? (Yes) (n=1012)	34.0% (n=365)	36.6% (n=647)	-2.6%

Weatherization can directly lead to reduced disconnection notices and disconnections by making energy bills easier to afford. This benefit can accrue to both households and the utilities. The team has not monetized these NEIs because of potential double-counting at the household level and because the PAs already claim this benefit from the ratepayers' perspective.

Table 80: Resident Survey Questions – Disconnect Notices and Disconnections

Resident Survey Question	CwT	T + C	(+/-)
When home energy bills are not paid on time, it is common for energy utilities and suppliers to send late notices. During the past 12 months, how often did you receive a disconnect, shut-off, or non-delivery notice? (almost every month or some months) (n=935)	9.3% (n=343)	12.2% (n=592)	-2.9%
In the past 12 months, was your electricity or natural gas ever disconnected because you were unable to pay your home energy bill? (Yes) (n=1066)	1.8% (n=386)	4.6% (n=680)	-2.8%*
While your electricity or natural gas was disconnected, was there a time when you wanted to use your main source of heat but were unable to? (Yes) (n=34)	60.0% (n=5)	37.9% (n=29)	+22.1%
While your electricity was disconnected, was there a time when you wanted to use your air conditioner but were unable to? (Yes) (n=36)	50.0% (n=6)	36.7% (n=30)	+13.3%

* Difference is statistically significant at the p<.05 level.

C

Appendix C Regression Analysis Results

Figure 3 through Figure 9 contain detailed outputs from all regression models explored. The bullets below describe the independent variables that were statistically significant.

- The size of the building (number of units) indicator variable was statistically significant in the medical encounters (emergency department and doctor's office visits) for Thermal Stress (Cold) models.
- The age variable was statistically significant in all models except emergency department visits for Thermal Stress (Cold) hospitalizations for Thermal Stress (Hot) and number of missed days of work due to illness or injury.
- The education, race (Black/African American = 1), and gender (male = 1) variables were all statistically significant in the bad days of rest/sleep model for the Home Productivity NEI.

Figure 3: Arthritis Hospitalizations – Regression Analysis Parameters and Results

Key coefficient / estimate of Δ

- Beta coefficient from regression estimate = -.074

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.220	.067		3.296	.001
	PrePostGroups	-.074	.044	-.060	-1.674	.094
	region_MW	.011	.049	.009	.224	.823
	# of Units in Building	.000	.000	-.017	-.457	.648
	HSorLess	.023	.040	.020	.591	.555
	age55	-.145	.059	-.084	-2.456	.014
	RESPONDENT GENDER	.038	.047	.028	.810	.418
	race_black	.063	.051	.048	1.237	.217

a. Dependent Variable: How many different times were you admitted to a hospital in the past 12 months because of your arthritis?

Dependent variable

- Number of arthritis related hospitalizations

Independent variables

- Weatherization indicator [CwT - (T+C)] "PrePostGroups"
- Region indicator (Midwest)
- Size of building (# of units)
- Education indicator (HS Diploma/GED or less)
- Respondent age indicator (55+)
- Gender indicator (Male)
- Race indicator (Black)

Dataset characteristics

- Regression performed on Phase 1 household level data – using [T + C] for pre-weatherization group and [CwT] for post-weatherization group

Sample Size (n)

- # in the model = 877

Significance (regression)

- R^2 = .018
- p-value = .094

Figure 4: Thermal Stress (Cold) Emergency Department and Doctor's Office Visits – Regression Analysis Parameters and Results

Key coefficient / estimate of Δ

- Beta coefficient from regression estimate (ED visits - cold) = -.020
- Beta coefficient from regression estimate (doc visits - cold) = -.032

Model 1

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.026	.009		3.003	.003
	PrePostGroups	-.020	.008	-.053	-2.638	.008
	region_MW	.004	.008	.011	.508	.612
	# of Units in Building	.000	.000	-.042	-2.074	.038
	HSorLess	.001	.007	.002	.110	.913
	age55	.004	.007	.012	.587	.557
	Gender	.001	.007	.004	.183	.855
	race_black	-.001	.008	-.002	-.073	.942

a. Dependent Variable: Number of times went to EMERGENCY ROOM: COLD

Model 2

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.081	.014		5.822	.000
	PrePostGroups	-.032	.012	-.053	-2.645	.008
	region_MW	-.013	.013	-.023	-1.022	.307
	# of Units in Building	.000	.000	-.036	-1.761	.078
	HSorLess	.000	.011	.000	.017	.987
	age55	-.032	.011	-.056	-2.803	.005
	Gender	-.013	.011	-.023	-1.181	.238
	race_black	.008	.013	.014	.647	.518

a. Dependent Variable: Number of times went to DOCTORS OFFICE: COLD

Dataset characteristics

- Regression performed on Phase 1 person-level data – using [T + C] for pre-weatherization group and [CwT] for post-weatherization group

Sample Size (n)

- # in the model: 2,887

Significance (ED Visits)

- R^2 = .003
- p-value = **.008**

Significance (Doc Visits)

- R^2 = .009
- p-value = **.008**

Dependent variable

- Number of thermal stress – cold-related ED visits (Model 1)
- Number of thermal stress – cold-related doctor's office visits (Model 2)

Independent variables (same for Model 1 & Model 2)

- Weatherization indicator [CwT - (T+C)] "PrePostGroups"
- Region indicator (Midwest)
- Size of building (# of units)
- Education indicator (HS Diploma/GED or less)
- Respondent age indicator (55+)
- Gender indicator (Male)
- Race indicator (Black/African American)

Figure 5: Thermal Stress (Cold and Heat) Hospitalizations – Regression Analysis Parameters and Results

Key coefficient / estimate of Δ

- Beta coefficient from regression estimate (Hosp - cold) = -.010
- Beta coefficient from regression estimate (Hosp - hot) = -.002

Model 1

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.013	.010		1.315	.189
	PrePostGroups	-.010	.009	-.022	-1.121	.262
	region_MW	-.009	.009	-.023	-1.046	.295
	# of Units in Building	-4.424E-5	.000	-.012	-.596	.551
	HSorLess	-.003	.008	-.007	-.355	.722
	age55	.022	.008	.054	2.696	.007
	Gender	.001	.008	.002	.083	.934
	race_black	.007	.009	.017	.757	.449

a. Dependent Variable: Number of times stayed overnight in the HOSPITAL: COLD

Model 2

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.003	.005		.724	.469
	PrePostGroups	-.002	.004	-.012	-.611	.542
	region_MW	.004	.004	.020	.915	.360
	# of Units in Building	2.124E-5	.000	.013	.622	.534
	HSorLess	-.001	.004	-.004	-.233	.816
	age55	.001	.004	.006	.276	.782
	Gender	-.003	.004	-.017	-.884	.377
	race_black	.002	.004	.012	.547	.584

a. Dependent Variable: Number of times stayed overnight in the HOSPITAL: HOT

Dataset characteristics

- Regression performed on Phase 1 person-level data – using [T + C] for pre-weatherization group and [CwT] for post-weatherization group

Sample Size (n)

- # in the model: 2,887

Significance (Hosp - cold)

- R^2 = .003
- p-value = .262

Significance (Hosp - hot)

- R^2 = .002
- p-value = .542

Dependent variable

- Number of thermal stress – cold hospitalizations (Model 1)
- Number of thermal stress – hot hospitalizations (Model 2)

Independent variables (same for Model 1 & Model 2)

- Weatherization indicator [CwT - (T+C)] "PrePostGroups"
- Region indicator (Midwest)
- Size of building (# of units)
- Education indicator (HS Diploma/GED or less)
- Respondent age indicator (55+)
- Gender indicator (Male)
- Race indicator (Black/African American)

Figure 6: Thermal Stress (Heat) Emergency Department and Doctor's Office Visits – Regression Analysis Parameters and Results

Key coefficient / estimate of Δ

- Beta coefficient from regression estimate (ED visits - hot) = +.007
- Beta coefficient from regression estimate (doc visits - hot) = -.003

Model 1

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.002	.007		.237	.813
	PrePostGroups	.007	.006	.023	1.151	.250
	region_MW	.017	.006	.058	2.628	.009
	# of Units in Building	-4.021E-6	.000	-.002	-.076	.940
	HSorLess	3.709E-5	.005	.000	.007	.995
	age55	.005	.006	.019	.930	.353
	Gender	-.009	.006	-.029	-1.533	.125
	race_black	.000	.007	-.001	-.028	.978

a. Dependent Variable: Number of times went to EMERGENCY ROOM: HOT

Model 2

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.015	.006		2.527	.012
	PrePostGroups	-.003	.005	-.011	-.562	.574
	region_MW	.007	.005	.029	1.318	.188
	# of Units in Building	-2.515E-5	.000	-.011	-.558	.577
	HSorLess	-.007	.005	-.027	-1.425	.154
	age55	.000	.005	-.001	-.062	.950
	Gender	-.002	.005	-.007	-.358	.720
	race_black	.000	.006	-.001	-.049	.961

a. Dependent Variable: Number of times went to DOCTORS OFFICE: HOT

Dataset characteristics

- Regression performed on Phase 1 person-level data – using [T + C] for pre-weatherization group and [CwT] for post-weatherization group

Sample Size (n)

- # in the model: 2,887

Significance (ED Visits)

- R^2 = .004
- p-value = .250

Significance (Doc Visits)

- R^2 = .002
- p-value = .574

Dependent variable

- Number of thermal stress – hot-related ED visits (Model 1)
- Number of thermal stress – hot-related doctor's office visits (Model 2)

Independent variables (same for Model 1 & Model 2)

- Weatherization indicator [CwT - (T+C)] "PrePostGroups"
- Region indicator (Midwest)
- Size of building (# of units)
- Education indicator (HS Diploma/GED or less)
- Respondent age indicator (55+)
- Gender indicator (Male)
- Race indicator (Black/African American)

Figure 7: Home Productivity – Regression Analysis Parameters and Results

Key coefficient / estimate of Δ

- Beta coefficient from regression estimate = -1.151

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	10.179	.693		14.697	<.001
	PrePostGroups	-1.151	.560	-.058	-2.054	.040
	region_MW	.912	.580	.048	1.573	.116
	# of Units in Building	-.008	.005	-.046	-1.590	.112
	age55	-1.437	.563	-.070	-2.553	.011
	HSorLess	-1.511	.494	-.081	-3.059	.002
	Respondent gender	-1.798	.538	-.092	-3.345	<.001
	race_black	-1.214	.605	-.061	-2.005	.045

a. Dependent Variable: During the past 30 days, for about how many days have you felt you did not get enough rest or sleep?

Dependent variable

- During the past 30 days, for about how many days have you felt you did not get enough rest or sleep?

Independent variables

- Weatherization indicator [CwT - (T+C)] "PrePostGroups"
- Region indicator (Midwest)
- Size of building (# of units)
- Respondent age indicator (55+)
- Education indicator (HS Diploma/GED or less)
- Gender indicator (Male)
- Race indicator (Black/African American)

Dataset characteristics

- Regression performed on Phase 1 person-level data – using [T + C] for pre-weatherization group and [CwT] for post-weatherization group

Sample Size (n)

- # in the model = 1,431

Significance

- R^2 = .029
- p-value = .040

Figure 8: Food Spoilage – Regression Analysis Parameters and Results

Key coefficient / estimate of Δ

- Beta coefficient from regression estimate = .050

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.514	.122		4.202	.000
	31_fridge_installed	.050	.087	.032	.579	.563
	region_MW	-.190	.119	-.096	-1.600	.111
	# of Units in Building	-.002	.001	-.063	-1.139	.255
	age55	-.294	.108	-.151	-2.725	.007
	Respondent gender	.112	.101	.060	1.101	.272
	race_black	.067	.126	.031	.532	.595

a. Dependent Variable: In the past 12 months how many times did you have to throw away food because your refrigerator was broken or lost power?

Dependent variable

- In the past 12 months how many times did you have to throw away food because your refrigerator was broken or lost power?

Independent variables

- Weatherization indicator [CwT - (T+C)] "PrePostGroups"
- Region indicator (Midwest)
- Size of building (# of units)
- Education indicator (HS Diploma/GED or less)
- Respondent age indicator (55+)
- Gender indicator (Male)
- Race indicator (Black/African American)

Dataset characteristics

- Regression performed on Phase 1 person-level data – using [T + C] for pre-weatherization group and [CwT] for post-weatherization group

Sample Size (n)

- # in the model = 1,627

Significance

- R^2 = .032
- p-value = .563

Figure 9: Missed Days of Work – Regression Analysis Parameters and Results

Key coefficient / estimate of Δ

- Beta coefficient from regression estimate = -1.019

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	4.303	.859		5.007	.000
	PrePostGroups	-1.019	.836	-.075	-1.219	.224
	region_MW	-.378	.837	-.031	-.451	.652
	# of Units in Building	-.004	.007	-.040	-.616	.539
	HSorLess	-.755	.718	-.062	-1.051	.294
	age55	.097	.739	.008	.132	.895
	Respondent gender	.180	.842	.013	.213	.831
	race_black	-.517	.856	-.042	-.604	.546

a. Dependent Variable: In the past 12 months, about how many days of work did the primary wage earner miss because of illness or injury? .

Dependent variable

- In the past 12 months, about how many days of work did the primary wage earner miss because of illness or injury

Independent variables

- Weatherization indicator [CwT - (T+C)] "PrePostGroups"
- Region indicator (Midwest)
- Size of building (# of units)
- Education indicator (HS Diploma/GED or less)
- Respondent age indicator (55+)
- Gender indicator (Male)
- Race indicator (Black/African American)

Dataset characteristics

- Regression performed on Phase 1 person-level data – using [T + C] for pre-weatherization group and [CwT] for post-weatherization group

Sample Size (n)

- # in the model = 303

Significance

- R^2 = .011
- p-value = .224

D

Appendix D Thermal Stress-Related Deaths

D.1 Overview

The risks of thermal stress, including heat and cold-related mortality, are very real and substantial. A review of heat stress trends found that the historical annual average of heat-related fatalities across the U.S., from 1975 to 2010, was 1,300.[62,63] The National Health Statistics Report offers more conservative statistics from 2006 to 2010; this report found only 620 heat-related deaths per year in the U.S., but almost twice the number of cold-related fatalities.[64] The same report noted that there were 307 thermal stress related deaths per year in the northeast region during this period.

In the year 2016, the world felt the hottest temperatures on record. Data reported by the Natural Resources Defense Council captures the impact of these extreme temperatures. In the Boston metro area alone, there were close to 70 heat-related deaths.[65] Since Boston accounts for roughly 70% of the population of Massachusetts, one could extrapolate an estimated 100 heat-related deaths statewide in 2016.

Since 2016, the U.S. keeps seeing record-breaking summer temperatures.[66] A 2020 report in *GeoHealth* claimed between 40-50 heat-related deaths per million people annually in Massachusetts, which translates to approximately 300 deaths total based on the state's population.[67,68]

The *Environmental Research Letters* reported on another study in 2020 that modeled the reduction of heat-related mortality rates through installation of green or cool roofs across all housing types throughout New England. Results indicated that heat-related mortality rates would decrease by 0.21% and 0.17% through installation of green and cool roofs, respectively. This study provides data points related to heat stress deaths and energy-efficiency measures that directly impact indoor temperatures; however, the methodology and sample population does not

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[62] https://www.nrdc.org/sites/default/files/killer-summer-heat-paris-agreement-compliance-ib.pdf
[63] Marcus C. Sarofim et al., Temperature-related Death and Illness, chapter 2 in The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment (U.S. Global Change Research Program, 2016). s3.amazonaws.com/climatehealth2016/low/ClimateHealth2016_02_Temperature_small.pdf.
[64] Berko, Jeffrey, Deborah D. Ingram, Shubhayu Saha, and Jennifer D. Parker. "Deaths Attributed to Heat, Cold, and Other Weather Events in the United States," 2006–2010. National Health Statistics Reports. Number 76 (July 30, 2014). http://www.cdc.gov/nchs/data/nhsr/nhsr076.pdf
[65] Constible, J. "Killer Summer Heat: Paris Agreement Compliance Could Avert Hundreds of Thousands of Needless Deaths in America's Cities." Natural Resources Defense Council. Retrieved from: https://www.nrdc.org/sites/default/files/killer-summer-heat-paris-agreement-compliance-ib.pdf
[66] National Aeronautics and Space Administration, NASA, NOAA Data Show 2016 Warmest Year on Record Globally (January 18, 2017), www.nasa.gov/press-release/nasa-noaadata-show-2016-warmest-year-on-record-globally.
[67] n.a. (2020). Metropolitan and Micropolitan Statistical Areas Population Totals and Components of Change: 2010-2019. U.S. Census Bureau. Retrieved from: https://www.census.gov/data/tables/time-series/demo/popest/2010s-total-metro-and-micro-statistical-areas.html#par_textimage_1139876276
[68] Massachusetts. United States Census Bureau. Retrieved from: https://data.census.gov/cedsci/profile?q=Massachusetts&g=0400000US25

allow for direct comparison with the LIMF NEI study. We did not find estimates for deaths from avoided thermal stress deaths due to the installation of standard weatherization measures in affordable MF buildings in the literature.

A study in *Environmental Health Perspectives* analyzed mortality risks from heat waves. Results indicated that with a one degree increase in heatwave intensity the risk of death is increased by close to 2.5%, and a one day increase in heat wave duration increased the risk of mortality due to heat by 0.38%.[69]

By the mid-2040s, the annual average of U.S. heat-related fatalities is predicted to climb to close to 14,000 from the historical annual average of about 1,300 from 1975 to 2010 – equivalent to about 150 deaths per summer day."[70] Boston, Baltimore, Chicago, Philadelphia, and New York are expected to experience the largest increases in heat-related fatalities.[71] The U.S. Global Change Research Program stated, "A warmer future is projected to lead to increases in future mortality on the order of thousands to tens of thousands of additional premature deaths per year across the United States before the end of this century."[72] It should be noted that cold-related illnesses and deaths are expected to decline as the world warms.

D.2 LIMF POPULATION

Social and environmental factors drive extreme temperature-related at-home mortalities.[73] A recent study (2020) looking at the association between extreme heat and at-home mortalities, specifically within the City of Boston census tracts, showed "a greater proportion of low-to-no income individuals or those with limited English proficiency being more highly represented among those who died during the study period; but small-area built environment features, like street trees and enhanced energy efficiency, were able to reduce the relative odds of death within and outside the home."[74] Individuals that have a high relative risk of dying at home when exposed to extreme heat are as follows: [75,76]

- MF housing residents;
- those that live in "intra-urban" heat islands;

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[69] G. Brooke Anderson and Michelle L. Bell, "Heat Waves in the United States: Mortality Risk During Heat Waves and Effect Modification by Heat Wave Characteristics in 43 U.S. Communities," Environmental Health Perspectives 119 (February 2011), 210-218, https://doi.org/10.1289/ehp.1002313
[70] Constible, J. "Killer Summer Heat: Paris Agreement Compliance Could Avert Hundreds of Thousands of Needless Deaths in America's Cities." Natural Resources Defense Council. Retrieved from: https://www.nrdc.org/sites/default/files/killer-summer-heat-paris-agreement-compliance-ib.pdf
[71] Ibid.
[72] Marcus C. Sarofim et al., Temperature-related Death and Illness, chapter 2 in The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment (U.S. Global Change Research Program, 2016). s3.amazonaws.com/climatehealth2016/low/ClimateHealth2016_02_Temperature_small.pdf.
[73] Medina-Ramón, M.; Zanobetti, A.; Cavanagh, D.P.; Schwartz, J. "Extreme Temperatures and Mortality: Assessing Effect Modification by Personal Characteristics and Specific Cause of Death in a Multi-City Case-Only Analysis." Environ. Health Perspectives. 2006, 114, 1331–1336.
[74] Williams, A.A.; Allen, J.G.; Catalano, P.J.; Spengler, J.D. "The Role of Individual and Small-Area Social and Environmental Factors on Heat Vulnerability to Mortality Within and Outside of the Home in Boston, MA." Climate 2020, 8, 29.
[75] Ibid.
[76] Heat islands are areas disproportionally dominated by heat-absorbing buildings and pavements, with minimal trees and greenery.

- those with low-socio-economic status;
- non-Hispanic persons of color;
- women;
- seniors over 65;
- children under five; and/or
- those with pre-existing medical conditions.

The entirety of the LIMF study sample can be characterized by at least two of these heat vulnerability risk factors: LI and residents of MF buildings. Furthermore, the majority of the study sample comprises seniors and female. Despite being high risk, the respondents reported hospitalizations and emergency department visits from both cold- and heat-related thermal stress relatively infrequently. A slight increase in emergency department visits from heat-related thermal stress was observed.

The team used the primary data collected by the resident survey on the number of emergency department visits (pre/post) and the secondary data from HCUP on the national rate of deaths following emergency department visits for exposure to cold-related thermal stress to calculate the rate of reduction in thermal stress-related deaths post-weatherization. The rate of avoided death for extreme cold exposure is 0.4859%. (See Section 3.3.2 for details on the monetization of the Thermal Stress (Cold) NEI.)

A production rate of 2,233 MF units weatherized per year was extrapolated using primary data provided by participating Massachusetts utilities on eligible Comparison-with-Treatment properties treated from 2008-2017. Using the Massachusetts production rate and the rate of avoided death from cold-related thermal stress, the team estimated that Massachusetts' participating LIMF weatherization programs prevent 0.16 deaths from cold-related thermal stress annually. [77] A substantial number of thermal stress-related deaths distributed across the Massachusetts general population were reported in the studies referenced above. Statistics show that a large percentage of these deaths would undoubtably occur among residents of LI housing. It is within reason to assert that reducing frequent exposure to unsafe temperatures through weatherization would avoid at least one death out of thousands of high-risk individuals. Therefore, it is certainly within reason to argue that the Massachusetts LIMF weatherization programs contribute to the avoidance of at least an average of 0.0001 deaths per year (or 14.8 deaths per 100,000 housing units weatherized per year) from cold-related thermal stress as estimated through this study (Table 16).

[77] 0.16 deaths prevented annually, per household = [0.4859% * 2,233 * 1.52 (mean # of persons in the home)].

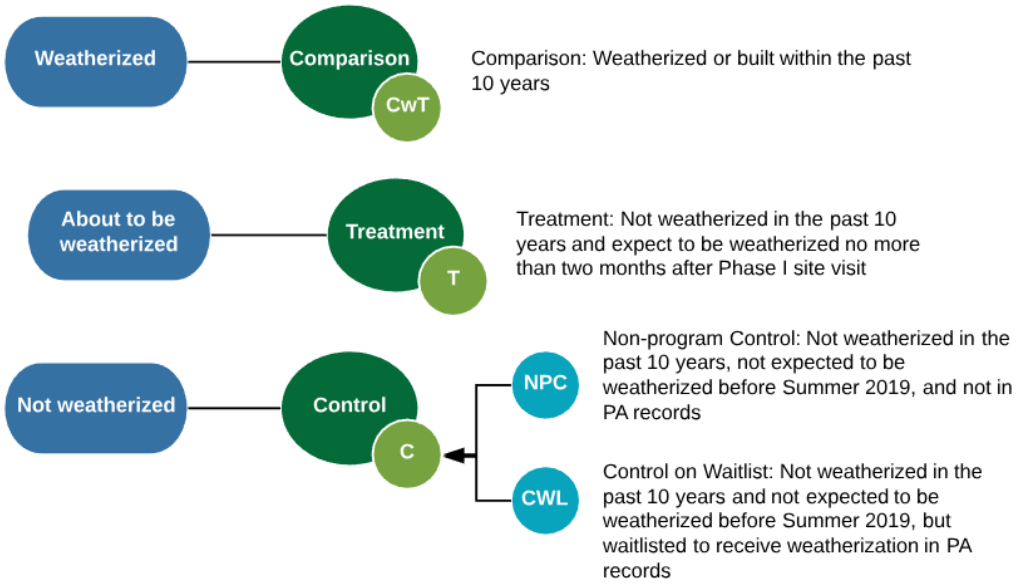
E

Appendix E Additional Methodological Details

E.1 Study Groups

The team stratified the sample into three groups: Comparison-with-Treatment, Treatment, and Control. The Control group is composed of two subgroups: the Non-Program Control and Control on Waiting List. We define the groups and subgroups in Figure 10.

Figure 10: Study Groups



E.2 Classifying Projects' Weatherization Status

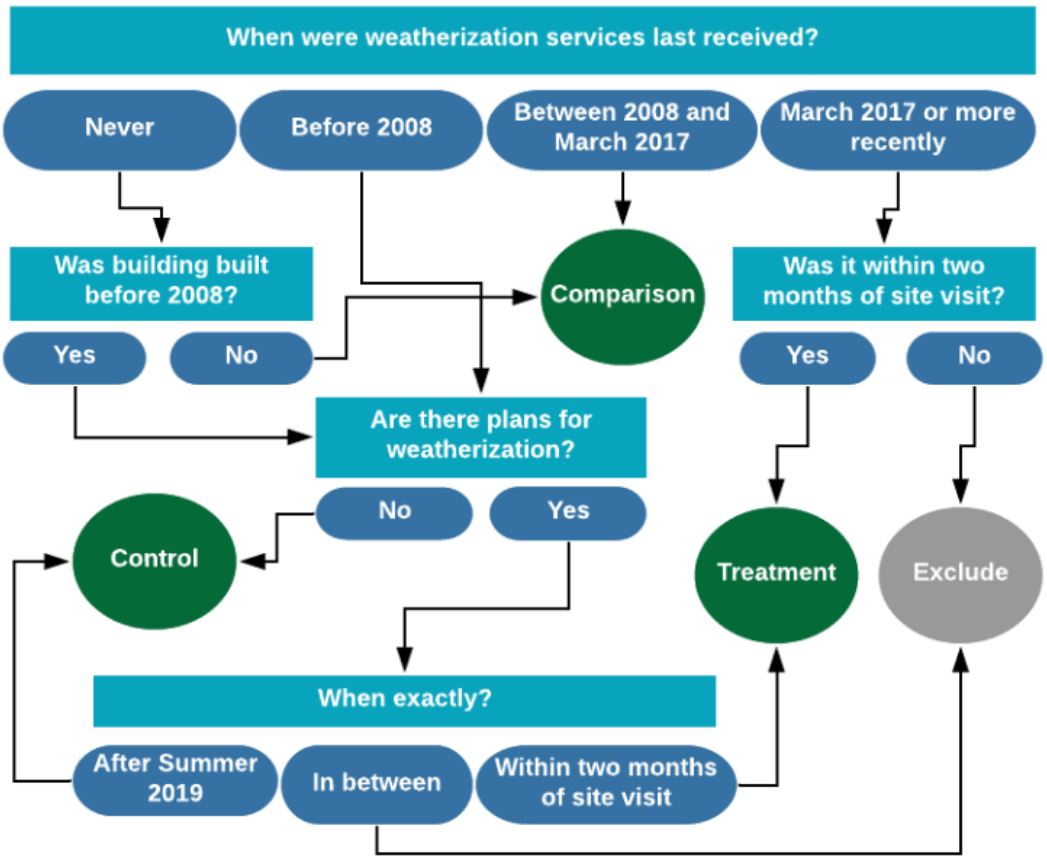
We used program participation data fields, such as Application Status and Project Status, to preliminarily classify Massachusetts project sites into study groups, using the following order of operations:

1. **Comparison (CwT) (surveyed in Phase 1 only)**. If a project's Application Status was designated in the database as *paid*, *invoiced*, or *installation complete,* or if the Project Status was *completed* prior to March 2017, we classified them as CwT.
2. **Treatment (T)**. We classified projects with an Application Status of *audit complete* or Project Status of *audited/work pending*, *installation contractor selected*, or *contract signed* as Treatment projects.

3. **Control on Waitlist**. If a project did not have an install date and had an Application Status of *pre-audit* or a Project Status of *not yet audited,* we placed them in the Control on Waiting List group.
4. **Excluded**. If sites were unlikely to be MF based on the ratio of number of housing units to buildings (i.e., an average of less than five units per building), weatherized after March 2017, listed as *canceled,* or for any other reason appeared to be currently in the process of receiving weatherization services, we excluded them from the sample.

Recruiters verified each site's status by asking when weatherization services were last received, when the building was built, and about any near-term plans for receiving weatherization services. We considered a site to be weatherized if it had been insulated, been air- or duct-sealed, or had energy-efficient heating or cooling equipment installed within the past ten years. We also considered sites built in the last ten years as weatherized. Figure 11 maps the classification process. To qualify as a Treatment project in Phases 1 and 2, a site had to have been weatherized within two months before and two months after the Phase 1 site visit.

Figure 11: Weatherization Classification Process



E.3 Developing a Non-Program Control Group

As noted earlier, we used multiple non-PA data sources to develop the Non-Program Control group. For Massachusetts sampling, this involved contacting roughly 50 housing authorities; reviewing publicly listed properties through community and economic development corporations; and cataloguing over 250 LI properties using the Boston Metrolist, a clearinghouse of income-restricted and affordable housing opportunities in Boston and neighboring communities, posted by the city of Boston.[78] The broader JPB study undertook similar types of research to develop their sample frame for other states.

We also collaborated with the *RES38 Income-Eligible Process Evaluation* team, who prepared a database of income-eligible properties in Massachusetts using property tax data. Additionally, as in other JPB states, our Massachusetts recruiters asked *all* PMs (not just Control group PMs) if they managed or owned other sites that they did not expect would receive weatherization in the coming two years.

Our Control sample frame did not encompass all possible Control sites due to the following reasons:

1. Not all housing authorities and property management agencies of Non-Program Control properties were willing to speak with us about their properties. Site characteristics were not always included in the publicly available lists. (Section 2.1 discusses recruitment rates.)
2. Not all sites provided by the Massachusetts PAs and CAP met study eligibility criteria. Of the 535 Massachusetts sites we contacted, 83 (16%) were ineligible.[79]
3. The RES38 property tax data did not include the site details needed to determine if sites met study eligibility criteria. In an attempt to mirror population characteristics, we prioritized RES38 sites based on their size and metro area and contacted 80 of them.[80] Twelve (15%) were ineligible.

E.4 Phase 1 Sample Frame

Table 81 summarizes the sample frames for Massachusetts and the states in the JPB study. In addition to weatherization status, the original sampling plan considered rise, number of units, ownership structure, and metropolitan-statistical area (MSA).[81,82] Sites in the sample frame were most often low-rise (less than five floors), in buildings with fewer than 80 units, and in urban areas. Our recruitment approach initially attempted to mirror the distribution of these characteristics.

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[78] https://www.boston.gov/metrolist
[79] On average, for Phase 1, each Control site was contacted over three times, Treatment site over six times, and Comparison-with-Treatment sites about three times.
[80] The RES38 data included over 1,700 properties.
[81] The National Center for Health Statistics (NCHS) developed a six-level urban-rural classification scheme for U.S. counties. We considered the two most urban levels (large central metro and large fringe metro) to be one metro area, and the four most rural levels (medium metro, small metro, micropolitan, and non-core) to be a second metro area. This site describes the MSA categories and provides the classifications by county: https://www.cdc.gov/nchs/data_access/urban_rural.htm
[82] We considered developing targets by housing function (e.g., senior, family), but PA data did not widely capture this characteristic.

Table 81: Sample Frame Property Site Characteristics[1]

Property Characteristic	Comparison-with-Treatment				Treatment				Control[3]			
	MA		Other States[2]		MA		Other States		MA		Other States	
	Sites	Units	Sites	Units	Sites	Units	Sites	Units	Sites	Units	Sites	Units
n	**474**	**33,580**	**239**	**14,605**	**55**	**4,288**	**126**	**6,715**	**458**	**4,216**	**63**	**3,804**
Rise												
Low-rise (< 5 stories)	82%	61%	71%	38%	76%	51%	58%	47%	11%	48%	75%	54%
Mid-rise (5 to 9 stories)	11%	19%	10%	16%	13%	28%	10%	9%	2%	14%	13%	26%
High-rise (10+ stories)	5%	14%	12%	44%	6%	20%	5%	18%	1%	15%	6%	19%
Unknown	3%	6%	7%	3%	6%	1%	26%	25%	86%	22%	6%	2%
Size (housing units)												
5 to 10 units	17%	2%	47%	14%	18%	1%	33%	4%	3%	2%	30%	4%
11 to 79 units	50%	27%	29%	25%	42%	23%	48%	26%	9%	33%	41%	24%
80 to 149 units	17%	26%	19%	40%	20%	26%	10%	19%	2%	26%	14%	25%
150 + units	12%	45%	5%	21%	15%	50%	10%	50%	2%	39%	14%	47%
Unknown	3%	†	0%	0%	5%	†	1%	†	84%	†	0%	0%
Metro-Statistical Area												
Large central and fringe metro	75%	71%	26%	312%	69%	74%	62%	57%	91%	68%	51%	58%
Medium and small metro, micropolitan	25%	29%	74%	88%	31%	26%	38%	43%	7%	32%	49%	42%

[1] Percentages may not total 100% due to rounding and because property site characteristics were not always available.
[2] Other states include Illinois, Michigan, Wisconsin, New York, Rhode Island, New Hampshire, and Vermont.
[3] Only includes sites for which we could verify or clearly observe eligibility.
† Data not available.

E.5 PHASE 2 SAMPLE FRAME

Before beginning Phase 2 surveys, the team verified that all Treatment buildings had received weatherization and that all Control buildings had *not* received weatherization since the Phase 1 survey. If weatherization had not been completed as scheduled on a Treatment building, it was shifted to the Control group. If a building that categorized as Control received weatherization within 1-2 months after Phase 1, it was shifted to the Treatment group.

Table 82 shows sample sizes by Treatment and Control group by state. Respondents from Illinois dominated the Control group, while New York, Rhode Island, and Massachusetts respondents represented the majority of the Treatment group. As mentioned previously, the team had to rely on a convenience sampling approach, which resulted in an unintended imbalance among states. Some of our partnering weatherization agencies were simply not weatherizing MF buildings at the anticipated rate, such as in Illinois and Massachusetts, but were able to contribute many Control buildings.

Table 82: Phase 2 Sample Frame for Treatment and Control Groups by State

	T (HHs)	T (Sites)	C (HHs)	C (Sites)	TOTAL (HHs)
IL	2	1	534	20	544
MA	82	10	173	23	254
NY	133	16	28	3	161
RI	130	3	67	3	198
VT	12	2	3	1	15
WI	32	15	46	10	64
NH	22	2	0	0	22
PA	4	1	41	4	46
Total	**417**	**50**	**892**	**64**	**1,309**

E.6 AIR-SOURCE HEAT PUMPS

The PAs asked the team to prioritize projects where ASHPs were installed with program support.[83] Given the potential for additional health and safety impacts for ASHPs – including those associated with cooling – and PA concerns about the cost-effectiveness of ASHPs, assessing health and safety characteristics of these projects offers opportunities for NEIs to be factored into the measure's cost-benefit ratio. The sample frame included 24 sites where program data indicated ASHPs had been installed through the program: one Control on Waiting List, three Treatment, and 20 Comparison with Treatment. The team attempted to contact and recruit all sites with ASHPs and looked for ASHPs while in the field to identify sites not captured in the original program data. Ultimately, we were only able to recruit five sites with ASHPs.

[83] This was ultimately only relevant for Comparison-with-Treatment sites since we had to conduct census sampling for Treatment and Control on Waiting List sites.

F

Appendix F Existing Systems and Installed Measures

The team analyzed data provided by participating agencies on existing (i.e., pre-weatherization) mechanical systems and weatherization measures installed through the PAs' programs and through programs in the other states. Table 83 shows the prevalence of pre-weatherization ventilation and heating/cooling systems, respectively, in a subsample of the Comparison-with-Treatment and Treatment buildings. Prior to weatherization, 19% of units did not have a working mechanical ventilation system. Of those that did have ventilation, more than half (65%) had bathroom fans, while only 22% had a kitchen range hood that vented to the outside.

Table 83: Existing Ventilation Measures – Pre-Weatherization

Subsample of CwT and T Buildings (n=189 buildings)	% of Units[1] (n=3,484)
Existing Ventilation System[2]	
No Working Mechanical Ventilation System	**19%**
In-unit bathroom fan	65%
Kitchen Range Hood (that vents outside)	22%
In-unit central exhaust	12%
Building has corridor supply	12%
Building has "Other"	1%
Building has corridor exhaust	3%
In-unit central supply	0%

[1] Some totals do not equal 100% as not all answers were mutually exclusive.
[2] Of those that reported having some type of ventilation system present pre-weatherization.

The most common heating system prior to weatherization was central hot water/steam boiler (65%), followed by individual electric baseboard (18%). Two percent of the units reported individual split system heat pumps or in-unit air-source heat pumps (ASHPs). While 3% of units did not have a working heating system, 30% did not have a cooling system. This difference is reflective of the northern, colder climates in which most buildings were located. Of those units with a cooling system, 20% had window or wall A/C, 18% reported a central chiller, and 16% had in-unit sleeve A/C.

Table 84: Existing Heating/Cooling Measures – Pre-Weatherization

Subsample of CwT and T Buildings (n=189 buildings)	% of Units[1] (n=3,484)
Existing Heating System (Pre-Weatherization)[2]	
No Working Heating System	**3%**
Building has central hot water/steam boiler	65%
Individual electric baseboard	18%
Building has "Other" heating system (no description provided)	8%
Individual forced air furnace	5%
Individual split system heat pump	2%
Individual ASHP	0%
Existing Cooling System (Pre-Weatherization)[2]	
No Working Cooling System	**30%**
Individual window/wall unit	20%
Building has central chiller	18%
Individual sleeve A/C	16%
Building has "Other" cooling system (no description provided)	1%
Individual packaged terminal air conditioner	1%
Individual split-system or heat pump	2%

[1] Some totals do not equal 100% as not all answers were mutually exclusive.
[2] Of those that reported an existing working heating system or cooling system pre-treatment.

Table 85 energy-saving measures that were installed in the Comparison-with-Treatment and Treatment subsample. In-unit, hallway/stairwell, and building exterior lighting improvements (e.g., new bulbs and/or fixtures) were the most common set of measures reported, at 84%, 61%, and 61%, respectively. The second most common measure installed in the Comparison-with-Treatment and Treatment subsample was building-level air sealing (55%), followed by heating equipment (52%), new refrigerators (52%), insulation[84] (50%), water-saving devices (47%), domestic hot water (37%), and mechanical ventilation (27%). Cooling equipment and windows were the least common measures, at 18% and 14% of buildings, respectively.

[84] Includes the following insulation types: above-grade wall, floor, rim/band joist, and foundation wall insulation.

Table 85: Installed Energy Conservation Measures – Post-Weatherization

Energy Conservation Measures	% of buildings (n=189)
Lighting (within unit)	84%
Lighting (hallway/stairwell)	61%
Lighting (exterior of building)	61%
Air Sealing	55%
Heating Equipment (replacement or repair[1])	52% [2]
New Refrigerator	52%
Insulation (any type)	50%
Water Saving Device	47%
Domestic Hot Water	37%
Mechanical Ventilation	27% [3]
Cooling Equipment	18% [4]
Windows	14%

[1] Sixteen percent (of the 52%) included repairs, programmable thermostats, or pipe insulation.
[2] Thirteen percent of changes made to heating systems were justified by health and safety.
[3] Twenty-one percent of changes made to ventilation systems were justified by health and safety.
[4] Six percent of changes made to cooling systems were justified by health and safety.

Table 86 reports measures installed specifically due to health and safety concerns. Structural repairs, reported as "Other" health and safety measures, were the most common (20%). Common areas in 5% of buildings received asbestos and lead paint remediation and smoke detectors. Seven percent of buildings received in-unit smoke detectors and 5% received some in-unit electrical repairs. The low rate of CO monitor installation (5%) impeded the team's ability to monetize avoided CO poisoning.

Table 86: Installed Health & Safety Measures – Post-Weatherization

Health & Safety Measures Installed	% of buildings (n=189)
"Other" Health and Safety Measures	20%[1]
Emergency Lighting	9%
Electrical Repairs (in common area)	7%
Smoke Detectors (in unit)	7%
Smoke Detectors (in common area)	5%
CO Monitors (in unit)	5%
Electrical Repairs (in unit)	5%
Asbestos Remediation (in common area)	5%
Lead Paint Remediation (in common area)	5%

[1] Forty-three percent (of the 20%) included structural or general repairs.

G

Appendix G Summary Statistics

The tables in this appendix report Treatment and Control respondents' perceptions of their dwellings' safety and quality, respectively. The results in the far-right column of these tables are based on the classic DID calculation. This captures changes experienced by Control group respondents, ensuring that the changes reported by the Treatment respondents can be attributed to weatherization rather than external factors. In this section, we see a number of reductions in various conditions, but none is statistically insignificant.

G.1 Dwelling Quality, Safety, and Other Conditions

Despite the fact that lighting upgrades were the most common measures installed in the Treatment subsample that returned an IM-DCF, the Treatment group as a whole reported no change in how dark their building hallways and stairwells were. It is possible the lighting upgrades included lightbulb replacement but not additional lighting fixtures. The survey also did not ask about brightness or darkness inside units, only in hallways and stairwells and outside the building. There were no statistically significant changes in the frequency of building or unit fires. This was expected given that fires rarely occur. Larger sample sizes would be needed to properly measure fire incidence.

Table 87: Changes in Dwelling Safety

Resident Survey Question (Respondent Only)	Treatment		Diff.	Control		DID[1]
	P1 (pre-Wx)	P2 (post-Wx)		P1	P2	
Inside of building is somewhat dark, very dark	12.0% (n=196)	12.0%	0.0%	7.1% (n=541)	6.2%	+0.9%
Outside of building is somewhat dark, very dark	14.8% (n=176)	15.4%	+0.6%	15.9% (n=532)	14.7%	+1.8%
# times fire department called - last 12 mo (mean)	0.08 (n=136)	0.01	-0.07	.02 (n=479)	0.01	-0.06
Fire as a result of using alternate heating source - last 12 mo (Yes)	1.1% (n=183)	0.5%	-0.6%	0.4% (n=543)	0.6%	-.0.8%

[1] This column presents the results of the classic DID equation to calculate changes in incidence rates among household members represented in both the pre- and post-weatherization surveys , (ITpost – ITpre) – (IC2 – IC1).

As Table 88 shows, post-weatherization, there was a 7% increase in reports of pest infestation and an incremental increase in rodent infestation. A small decrease in visible mold inside the home was reported. These are all evidence-based asthma triggers. (See Appendix A.2 for a discussion on asthma).

Table 88: Changes in Dwelling Quality

Resident Survey Question (Respondent Only)	Treatment		Diff.	Control		DID
	P1 (pre-Wx)	P2 (post-Wx)		P1	P2	
Home is extremely or very infested with pests (Yes)	71.2% (n=170)	77.6%	+6.5%	84.6% (n=518)	83.8%	+7.2%
Home is extremely or very infested with rodents (Yes)	67.6% (n=165)	70.0%	+2.3%	86.3% (n=525)	87.8%	+0.8%
Visible mold - past 12 months (Yes)	30.7% (n=163)	28.8%	-1.8%	14.7% (n=482)	13.5%	-0.6%

G.2 General Health

As shown in Table 89, the Treatment group reported a slight increase (about 1.5) in the mean number of days that their mental or physical health was "not good" or that "poor" physical or mental health impacted usual activities.

Table 89: Changes in General Health

Resident Survey Question (Respondent Only)	Treatment		Diff.	Control		DID
	P1 (pre-Wx)	P2 (post-Wx)		P1	P2	
# days mental health "not good" - past 30 days (mean)	7.1 (n=183)	7.3	+0.2	5.8 (n=480)	4.6	+1.4
# days "poor" physical or mental health impacted usual activities - past 30 days (mean)	5.4 (n=180)	6.3	+0.9	4.4 (n=468)	3.7	+1.6

G.3 Household Budget and Affordability Issues

Table 90 presents results from questions about challenges respondents faced in affording their energy bills and trade-offs they made in order to pay for energy. Sample sizes in the Treatment group were low, in part because only 36% (n=195) directly paid for an energy bill in Phase 2; the other 64% had all utilities included in their rent. While the percent of households receiving energy assistance went down by 8.4% from Phase 1 to Phase 2, the difference was not statistically significant. On the whole, these findings indicate that LIMF weatherization has minimal impact on household energy burden and budgetary trade-offs.

Table 90: Energy Affordability and Trade-Offs

Resident Survey Question (Respondent Only)	Treatment		Diff.	Control		DID
	P1 (pre-Wx)	P2 (post-Wx)		P1	P2	
Received a disconnect, shut-off, or non-delivery notice almost every month, or some months, over past 12 months (Yes)	16.7% (n=42)	21.4%	+4.8%	8.7% (n=229)	11.4%	+2.1%
Electricity or natural gas disconnected because could not afford (Yes)	6.1% (n=49)	6.1%	0.0%	3.6% (n=249)	5.2%	-1.6%
Very hard or hard to pay energy bills (Yes)	37.5% (n=40)	40.0%	+2.5%	37.0% (n=238)	34.5%	+5.0%
Did not fill a prescription in order to pay an energy bill every or every other month - past 12 months (Yes)	4.7% (n=43)	4.7%	0.0%	2.9% (n=239)	0.8%	+2.1%
Did not pay an energy bill in order to fill a prescription every or every other month - past 12 months (Yes)	2.6% (n=36)	5.3%	+2.6%	1.3% (n=225)	0.0%	+4.0%
Received energy assistance this past year	31.3% (n=42)	22.9%	-8.4%	47.9% (n=229)	47.9%	-8.4%

H

Appendix H Attribution by Measure

For the purposes of our attribution by measure analysis, we computed a composite variable that aggregates the household monetized values attributable to a subset of individual NEIs for $Household_a$ at $Time_y$.[85]

The individual NEI variables we selected for inclusion in the composite variable were those that (1) only produced household benefits or produced both household and societal benefits, (2) were *not* derived from bill savings, and (3) exhibited survey results that indicated that weatherization yielded an NEI. The subset of NEIs included in the composite NEI variable that was used in the attribution by measure approach is as follows:

- Thermal Stress (Cold)
- Arthritis
- Trips and Falls
- Home Productivity
- Missed Days of Work

NEIs based on the value of avoided medical costs (Arthritis, Thermal Stress, Trips and Falls) follow these general steps:

1. *The number of times seeking medical treatment at care setting X for treatment of condition A is multiplied by the cost of treatment for condition A to produce value X_y. Repeat for each care setting of condition A and add all care settings together into X_A.*
2. *The number of times seeking medical treatment at care setting X for treatment of condition B is multiplied by the cost of treatment for condition B to produce value X_z. Repeat for each care setting of condition B and add all care settings together into X_B.*

For example, if household #1 reported two doctor's office visits for thermal stress, then one component of the calculation would be 2 * the cost to the household for treatment of condition A (e.g., thermal stress) for care setting X (e.g., doctor's office). If no one in the household reported being treated for thermal stress in any care setting, then the value for this component would be zero. The same logic is used for arthritis. If no one in household #1 reported having arthritis (e.g., condition B), then the value for this component would be set to zero. Otherwise, the composite value for arthritis would be based on the number of reported medical encounters multiplied by the cost of these encounters.

1. *Continue steps for remaining NEIs (X_I and so on...)*

For NEIs unrelated to medical encounters – Home Productivity and Missed Days of Work – the team adapted their individual monetization methodologies (see Appendix A) for the composite approach. For Home Productivity, this meant estimating the productivity losses attributable to one night's poor sleep and multiplying it by the number of days of poor sleep reported by the

[85] $Time_y$ is either Phase 1 or Phase 2.

respondent. For Missed Days of Work, the team multiplied together (1) the number of days missed by the primary wage earner, (2) the average wage for a LI worker in MA, and (3) eight hours of work in a day.

2. *Sum of $X_A + X_B + X_C\ldots$ = Composite NEI Value*

Figure 12 provides the parameters and results from the regression model that includes the change in composite NEI value as the dependent variable. The team used estimates of change from the regression to determine how to allocate the recommended NEI values to the relevant measures in the PAs' BCR models.

Figure 12: Attribution by Measure – Regression Analysis Parameters and Results

Key coefficient / estimate of Δ
- Beta coefficient from regression estimate (Air Sealing + Insulation) = -288.96
- Beta coefficient from regression estimate (Heating system) = -312.37

Dependent variable:
- Difference between Phase 1 and Phase 2 total household NEI value including VSL (composite variable)

Independent variables:
- Combined measures (air sealing and insulation)
- Heating system changes (repair/replacement)

Dataset characteristics:
- Regression performed on Phase 1 and Phase 2 household-level data – Treatment group only.
- Composite variable for *combined* measures was created for air sealing and insulation (See Section 3.4 in the report)

Significance:
- R^2 = .098
- Air Sealing + Insulation; p = .056
- Heating System, p = .029

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	658.151	133.734		4.921	.000
	AirSealingANDInsulation	-288.960	148.974	-.198	-1.940	.056
	12_HeatingSystemChanges	-312.367	141.012	-.226	-2.215	.029

a. Dependent Variable: Diff_T1andT2Total$houVSL

Equation 1: % attribution for [Air Sealing + Insulation] (X) = % of measure combination X / (sum of % of measure combination X + Y)
- -288.96 / (-288.96 + -312.367) = **48%** attribution for [Air Sealing + Insulation]

Evenly split **48%** attribution for [Air Sealing + Insulation] = **24% for air sealing and 24% for insulation**

Equation 2: % attribution for Heating System (Y) = % of measure Y / (sum of % of measure combination X + Y)
- -312.367/(-288.96 + -312.367) = **52% attribution for heating system changes**

Appendix I Unrounded Estimated NEI Values

Table 91 presents the individual monetized values to the nearest cent for the four LIMF NEIs recommended for adoption by the PAs. We calculated each NEI estimate using the individualized monetization algorithms and inputs presented in Section 3.3.

Table 92 shows the estimated NEI values for the NEIs not recommended for adoption due to lack of statistical precision. We calculated each NEI estimate using the individualized monetization algorithms and inputs presented in Appendix A.2.

All NEI estimates are presented on a per-weatherized-unit basis, broken out by their societal and household benefit components. We present NEIs that include the benefit of avoided deaths both with and without the VSL.

Table 91: Estimated Annual Values (Unrounded) of Recommended NEIs Per Weatherized Housing Unit

(With and Without VSL)

Annual NEI Values	Per HH w/ VSL[1]	Per HH w/o VSL	Societal	Total	Total w/o VSL
Arthritis	$**49.07**	$49.07	$892.06	$941.13	$941.13
Thermal Stress (Cold)	$**1,425.90***	$7.80	$38.03	$1,463.93	$45.83
Home Productivity	**$48.90**	$48.90	$0.00	$48.90	$48.90
Reduced Fire Risk	**$12.96**	$2.07	$4.12**	$17.08*	$6.04***
Annual Total for Recommended NEIs per Weatherized Housing Unit	**$1,536.83**	**$107.84**	**$934.21**	**$2,471.04**	**$1,041.90**

[1] HH = household (assuming one household per housing unit)
* The total Thermal Stress (Cold) NEI of $1,426 includes doctor's office visits ($1.41) + emergency dept. visits that do not result in deaths ($6.39) + the value of avoided death: $1,418.10.
** The value of societal benefits without including firefighter deaths (VSL) is $3.97; with firefighter deaths (VSL) the societal benefit is $4.12.
*** Total w/o VSL for Home Fires does not include the $0.15 societal benefit per unit for firefighter deaths (VSL); therefore, the total sum of HH w/o VSL plus societal benefits is $6.04 rather than $6.19.

Table 92: Estimated Annual Values (Unrounded) of NEIs Not Recommended, Per Weatherized Housing Unit

(With and Without VSL)

Estimated Annual NEI Values	Per HH w/ VSL[1]	Per HH w/o VSL	Societal	Total	Total w/o VSL
Food Spoilage	$57.20	$57.20	$0.00	$57.20	$57.20
Trips and Falls	$3.26	$3.26	$46.36	$49.62	$49.62
Missed Days of Work	$8.41	$8.41	$2.51	$10.92	$10.92
Short-Term, High-Interest Loans	$2.32	$2.32	$0.00	$2.32	$2.32
Work Productivity	$0.00	$0.00	$16.91	$16.91	$16.91
Prescription Adherence	$0.00	$0.00	$58.78	$58.78	$58.78
Food Assistance	$0.00	$0.00	$98.76	$98.76	$98.76
Low-Birth-Weight Babies	$0.47	$0.47	$10.09	$10.56	$10.56
Asthma	$0.00	$0.00	$0.00	$0.00	$0.00
Thermal Stress (Heat)	$0.00	$0.00	$0.00	$0.00	$0.00
Annual Total NEI per Weatherized Housing unit	**$71.66**	**$71.66**	**$233.41**	**$305.07**	**$305.07**

[1] HH = household (assuming one household per housing unit)

J

Appendix J References

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Division 3-5
Residential High Efficiency Heating, Cooling and Hot Water

Request:

At Bates 185, the Company reports that customers who complete a Home Energy Assessment (HEA) through EnergyWise Program can apply for a 0% heat loan for qualified high efficiency space heating and cooling and hot water equipment upgrades.

a. Are the customers time-limited in applying for a loan after completion of the HEA? For instance, must they apply for the 0% loan within a specified number of months?
b. If not, does the Company have an opinion on whether a time window to receive a 0% loan would incentivize a customer to move forward with upgrades?

Response:

a. The HEAT Loan financing offer is valid for one-year from the date of the home energy assessment (HEA), as stated on the financing form. However, exceptions can be made based on the customer's need and program offerings at the time. If a customer's HEA is more than three-years old, the program requires a new HEA.

b. As stated above, the HEAT Loan financing offer is valid for one-year after the HEA by design to encourage customers to move forward with installation of upgrades.

Prepared by or under the supervision of: Laura Rodormer and Angela Li

Division 3-6
Customer Feedback

Request:

At Bates 147 and 154, the Company reported very strong numbers from EnergyWise Single-Family and Multifamily customers via post-project surveys. Please provide a copy or summary of the results of those surveys.

Response:

For EnergyWise Single Family, please see response PUC 1-39 where a sample customer survey and the survey results from Q3 2021 are included as Attachments PUC 1-39-1 - HEA Survey and Attachment PUC 1-39-2 - HEA result report.

The Multifamily customer survey and 2021 average results are attached to this response as Attachment DIV 3-6. Differences between the results and the plan numbers are due to timing. The most up-to-date results are used when drafting the plan, but time has elapsed form the drafting period and the most recent values are used in this response.

Prepared by or under the supervision of: Angela Li and Jennifer Amatore

Multifamily Survey Questions	2021 YTD Average Results thourgh (10/31/21)
How satisfied were you with the ease of signing up for energy efficiency	5
If you experienced any dissatisfaction with signing up for energy efficiency	
How satisfied were you with the timeliness of the program representatives and contractors throughout the process? (1-5 scale)	4
Did the program representatives and contractors present themselves	5
Did the program representatives and contractors present themselves	
Did the program representatives explain the work to be performed, including the specific energy efficiency items being installed?	
How well did the program representatives explain the benefits of the energy efficiency services being offered? (1-5 scale)	4
How satisfied were you with the contractor's clean up following the	4
If you experienced any dissatisfaction with the contractor's clean up, please	
How well did the energy efficiency improvements you made to your home or property meet your expectations? (1-5 scale)	4
How satisfied are you with the energy efficiency services you received? (1-5	4
If you experienced any dissatisfaction with the overall energy efficiency	
Would you recommend this service to family, friends, and/or colleagues?	5
Would you recommend this service to family, friends, and/or colleagues?:	
What else would you like to tell us about your experience?	
Zip Code:Please share your home or property's general location. If you would like us to follow up with you regarding this survey or your	
Property Name and/or Street Address:Please share your home or property's general location. If you would like us to follow up with you regarding this survey or your participation in the Program, please let us know how to	
Unit:Please share your home or property's general location. If you would like us to follow up with you regarding this survey or your participation in	
Name:Please share your home or property's general location. If you would like us to follow up with you regarding this survey or your participation in	
City:Please share your home or property's general location. If you would like us to follow up with you regarding this survey or your participation in	
State:Please share your home or property's general location. If you would like us to follow up with you regarding this survey or your participation in	
Phone:Please share your home or property's general location. If you would like us to follow up with you regarding this survey or your participation in	
Email:Please share your home or property's general location. If you would like us to follow up with you regarding this survey or your participation in	
Final Survey Score	93

Division 3-7
Customer Feedback

Request:

At Bates 181, the Company reported that its Lead Vendor for the Home Energy Reports completes an annual Customer Engagement Tracker (CET) to assess customers' perception of the program.

a. Please provide a copy of or a summary of the results of the CET for the past three completed assessments.
b. Please provide a copy of the questions used in the CET assessment.

Response:

a.

2020 Customer Engagement Tracker Results	Attachment Div 3-7-1
2019 Customer Engagement Tracker Results	Attachment Div 3-7-2
2017 Customer Engagement Tracker Results	Attachment Div 3-7-3

b. Please find the 2020 Customer Engagement Tracker Survey in attachment Div 3-7-4.

Prepared by or under the supervision of: Angela Li

ORACLE

2020 Customer Engagement Tracker Survey

Prepared for National Grid

February 2021

Methodology

Survey interviews with 2062 National Grid customers in Home Energy Report program

- 1336 recipients of Home Energy Report communications
- 726 “control” customers (non-recipients to be used as baseline)
- ~700 respondents in each region: Upstate UNY, MA, RI

Stratified random sample of customers from across all Home Energy Report deployments in each territory

- Slight oversample of UNY Clifton Park customers: Solar MA customers; data weights applied when examining overall population
- Contains individuals across all six “personas” defined by National Grid (RI and MA); Low income census tract customers
- Results compared to similar yearly survey efforts going back to 2013
  - Context of COVID-19 meant program experience was different over the course of this year
- Where applicable, questions also included regarding High Usage Alerts, Weekly Electricity Reports, Conservation Days, and online energy management tool usage

Telephone survey fielded between Nov 19, 2020 and Jan 17, 2021

- Interviews conducted by CASRO/ESOMAR provider, ISA
- Fielding paused across Thanksgiving and winter holidays
- Questionnaire designed in conjunction with National Grid, aligned with previous survey questionnaires

Summary of key findings

Strong continued engagement with the Home Energy Report communications

- No notable decline due to COVID-19: more than three quarters of customers (77%) actively reading communications, in line with previous years' readership; Half of customers (49%) indicate the reports have motivated them to save energy
- Refreshed Home Energy Report experience appears to improve customer interest over old design by ~9%

Program yielding gains in National Grid brand perception and program awareness

- 95% of customers report recipients indicate positive (32%) to neutral (63%) impact on satisfaction with National Grid
- Statistically significant differences observed between report recipients and non-recipient controls at UNY and RI
  +10% Familiarity with other National Grid EE programs (UNY, RI)
  +10 to +11% National Grid helps me manage my monthly energy usage (UNY, RI)
  +8% National Grid wants to help me save money (UNY)
  +6 to +10% National Grid provides useful suggestions on ways to lower my bills (UNY, RI)

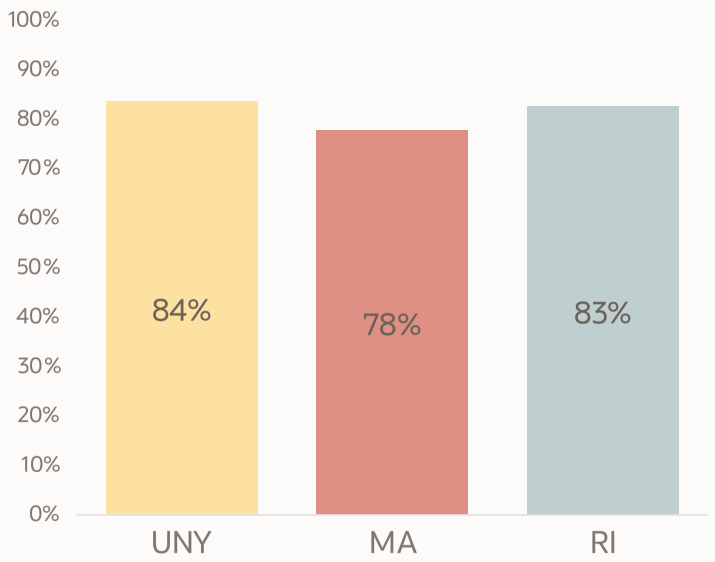
Opportunities to improve outcomes

- Significant growth in awareness of web tools, up to 31% from 18% in the previous year likely due to July rollout of web widgets. There still appears to be considerable room to grow online awareness, particularly among Mature Basic segment
- COVID-19 appears to have an outsized impact on Low Income customers in terms of bill anxiety and motivation to reduce usage. A related effect is also seen with the Help Wanted persona. Similar to previous studies, this population also demonstrates higher levels of satisfaction with the Home Energy Report and other outbound experiences

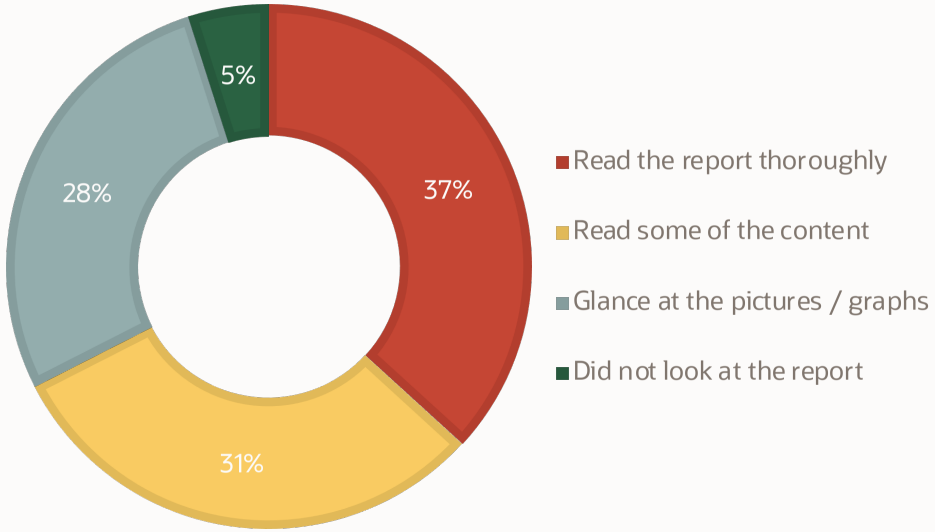
Home Energy Reports

Majority of customers reading reports

Home Energy Report Recall



Home Energy Report Reading



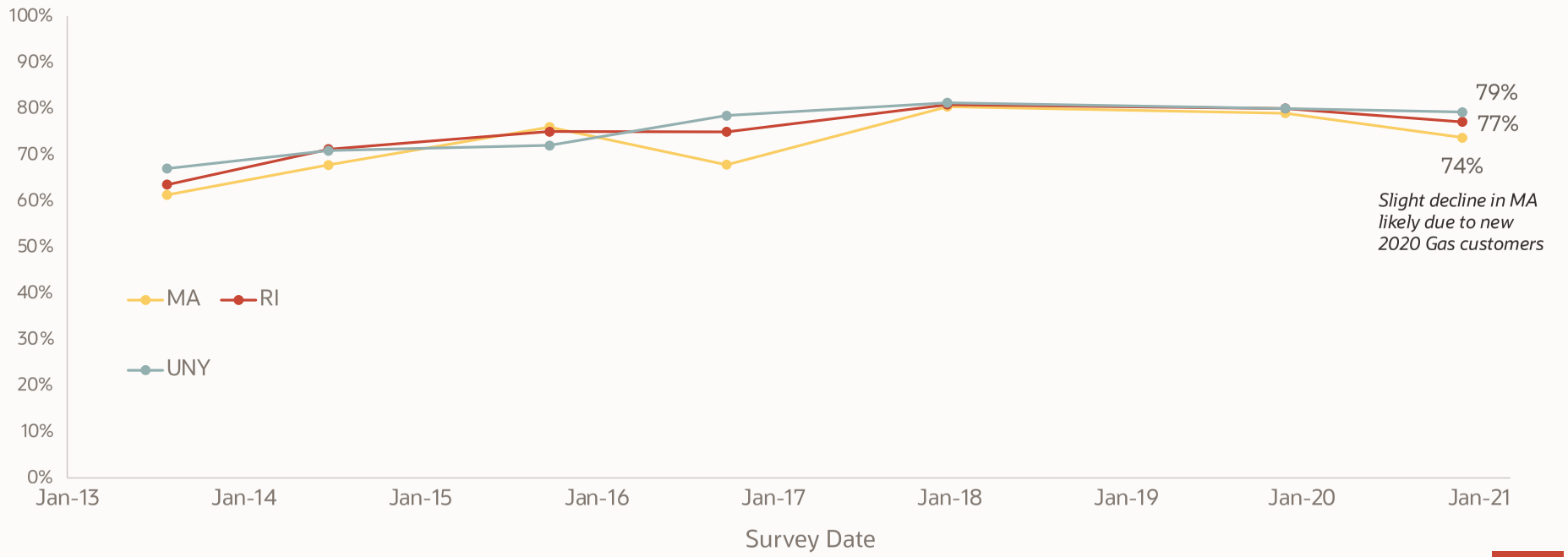
77% Overall Readership

5 *In the past six months, do you remember receiving a Home Energy Report from National Grid about your in-home energy use?*
Thinking of all the reports you have received, in general, what have you done with them? Did you…

Readership sustained at a high level several years into program

Home Energy Report Readership Over Time

7 surveys of report recipients

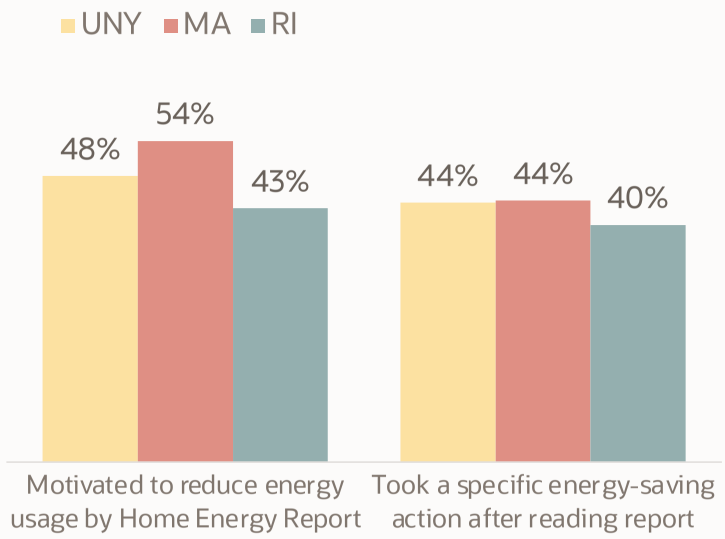


6 *In the past six months, do you remember receiving a Home Energy Report from National Grid about your in-home energy use? Thinking of all the reports you have received, in general, what have you done with them? Did you...*

Half of customers motivated to reduce usage, large proportion report taking concrete action

Energy Savings Action

All customers who have read reports



What actions did you take?

Samples of open-ended responses

Being more conscious about leaving lights on have timers for them thermostat with timer keeping temp lower.

Changing bulbs to more efficient ones, bugged my kids to turn off lights when leaving rooms

I have adjusted the thermostat; and lower the thermostat when nobody is home; made sure storm windows are sealed good and I am in the process of pricing to replace storm windows in the cellar.

I have added storm doors, energy efficient windows, weather stripping and LEDs

We bought a new energy saving washer and dryer. I run my dishwasher less.

Installed solar panels, storage battery, new thermostats, new insulation, new windows, new furnace

I had Mass Save come in here and change out all the light bulbs for led ones.

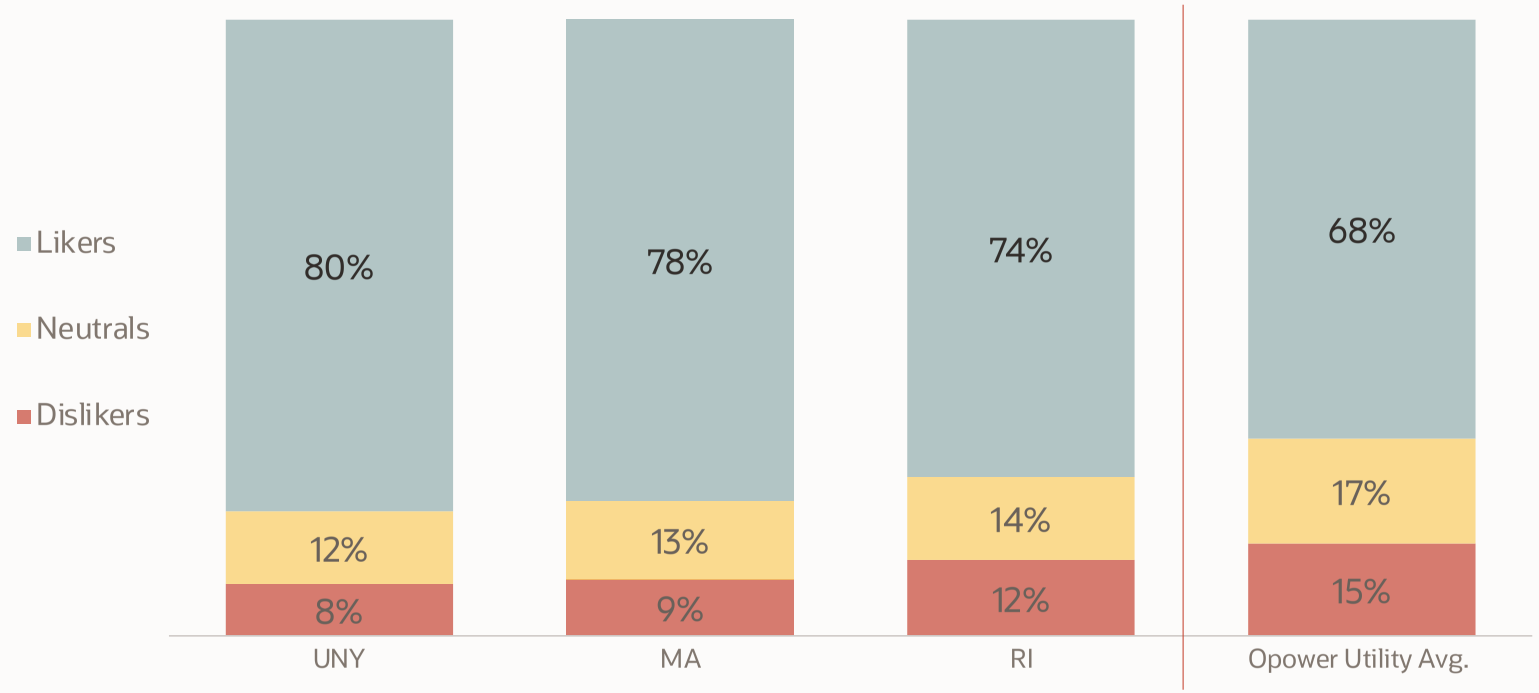
I did the connected solutions, changed to energy saving light bulbs and more.

7 *Did the Home Energy Report motivate you to reduce your energy usage?*
After reviewing your report, have you taken a specific energy-saving action?

78% of recipients like experience, exceeding other utility programs

Home Energy Report Liking

All customers who have read reports

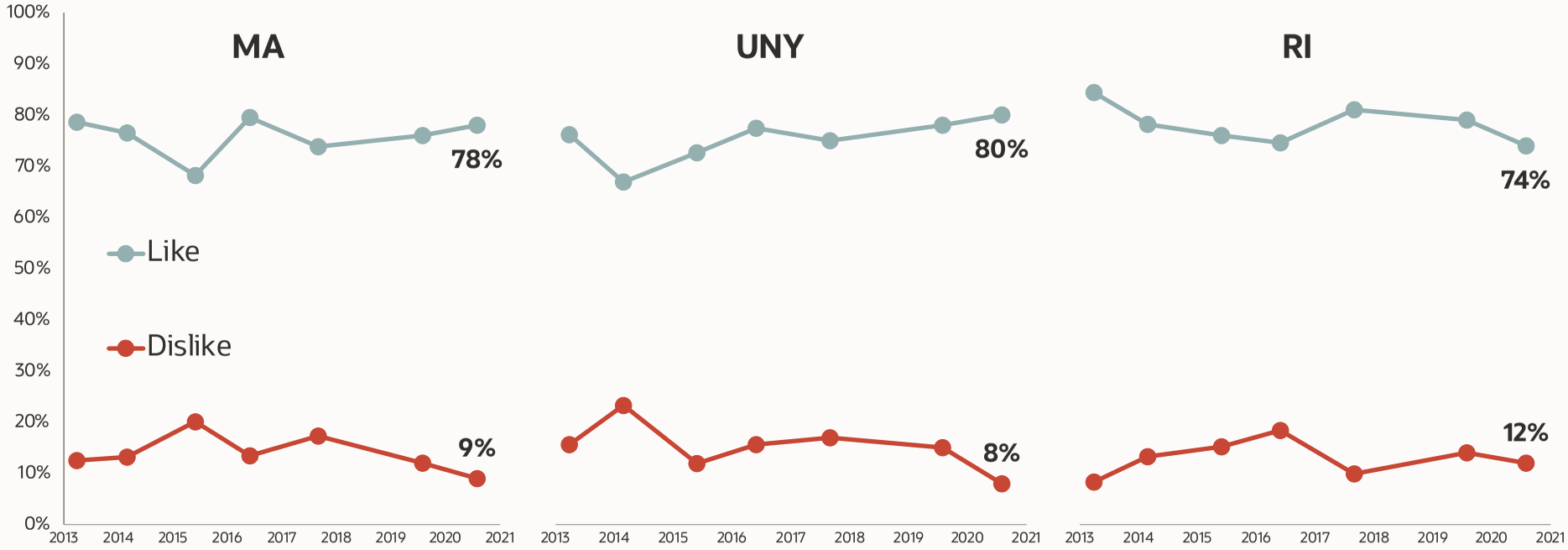


Thinking about the Home Energy Reports you've received, how much do you agree or disagree with each of the following statements: I like the Home Energy Reports

High levels of report liking sustained over time

Home Energy Report Liking Over Time

All customers who have read reports



Thinking about the Home Energy Reports you've received, how much do you agree or disagree with each of the following statements: I like the Home Energy Reports

“Likers” are saying…

It gives me a comparison with other similar homes in the area and whether I need to be doing things different especially because of winter.

I like the part where they compare me to my neighbors and I can see we are on the same wavelength or a little better.

I like to know how much energy I am using in comparison to my neighbors and then take whatever appropriate action to use less.

It is good. I don't know my neighbors but my bill is good right where it should be.

Easy to read. Comparisons seem hard to believe, surprised energy use is not more equal among neighbors.

[I like to] compare my energy usage month to month visually in a graph, but would like the report and other correspondence by email, Want to go completely paperless.

I like that they send it to my computer so that I don't have to wait on the mail.

I like the comparison between my usage and my neighbors and how much I save using solar.

“Neutrals” / “Dislikers” are saying…

I like the tips on savings and I like knowing how I compare to my neighbors even though it is not accurate. I am responsible for three apartments and my neighbors are single family homes or commercial buildings

The neighbors they have solar energy so naturally were going to use more

I would say to better outline ways I could actually save energy. I don't know if the comparison to my neighbors is accurate. I don't know if they are single homes with 1000 square feet or what.

I don't know… it makes me angry because I'm the one who uses the most energy in my neighborhood.

Waste of time and paper. They need use a website if they want help people

Maybe more tips on how to lower the energy usage. The graphs catch my eye but I don't see any tips that are useful.

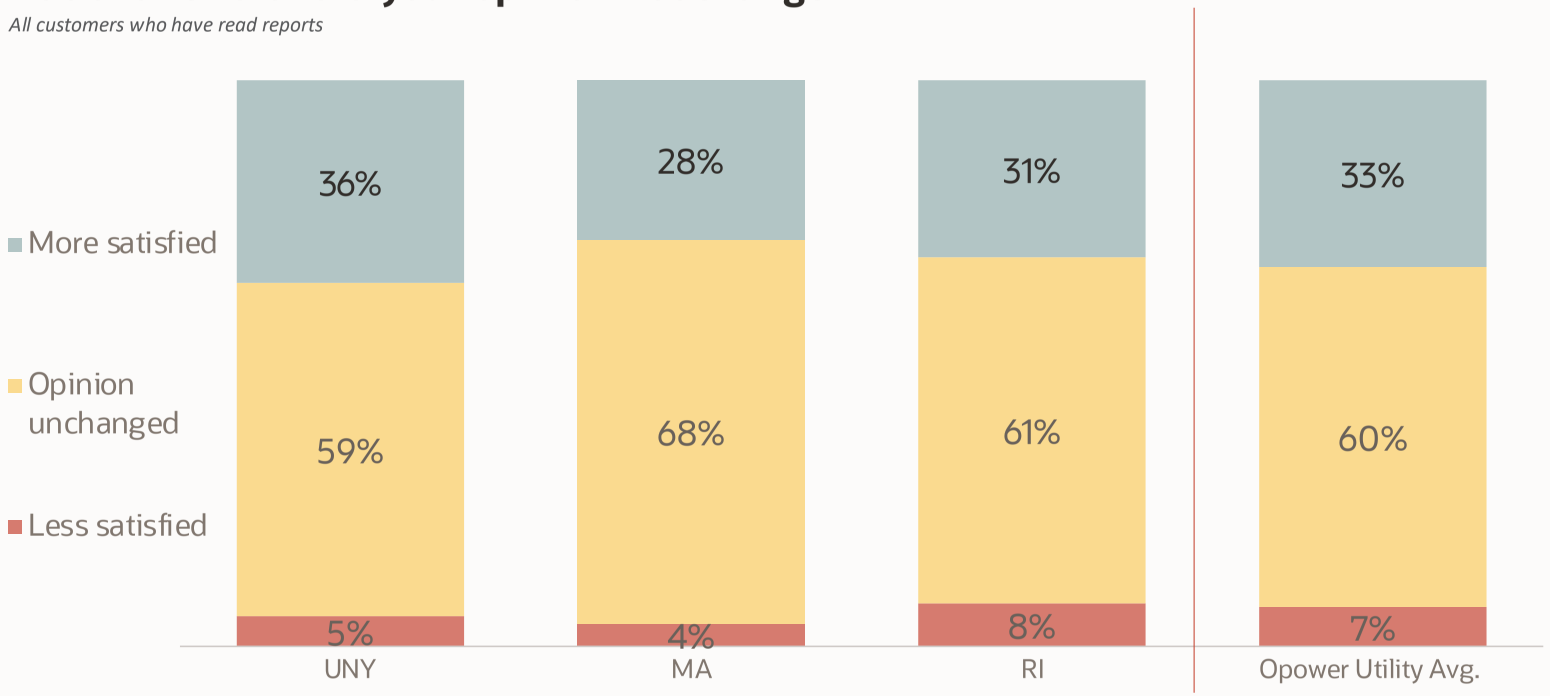
You should make a separate report for seasonal users

My energy usage is pretty acceptable and doesn't change much from month to month so the report isn't very useful.

Neutral to positive impact on self-reported satisfaction with National Grid for more than 90% of customers

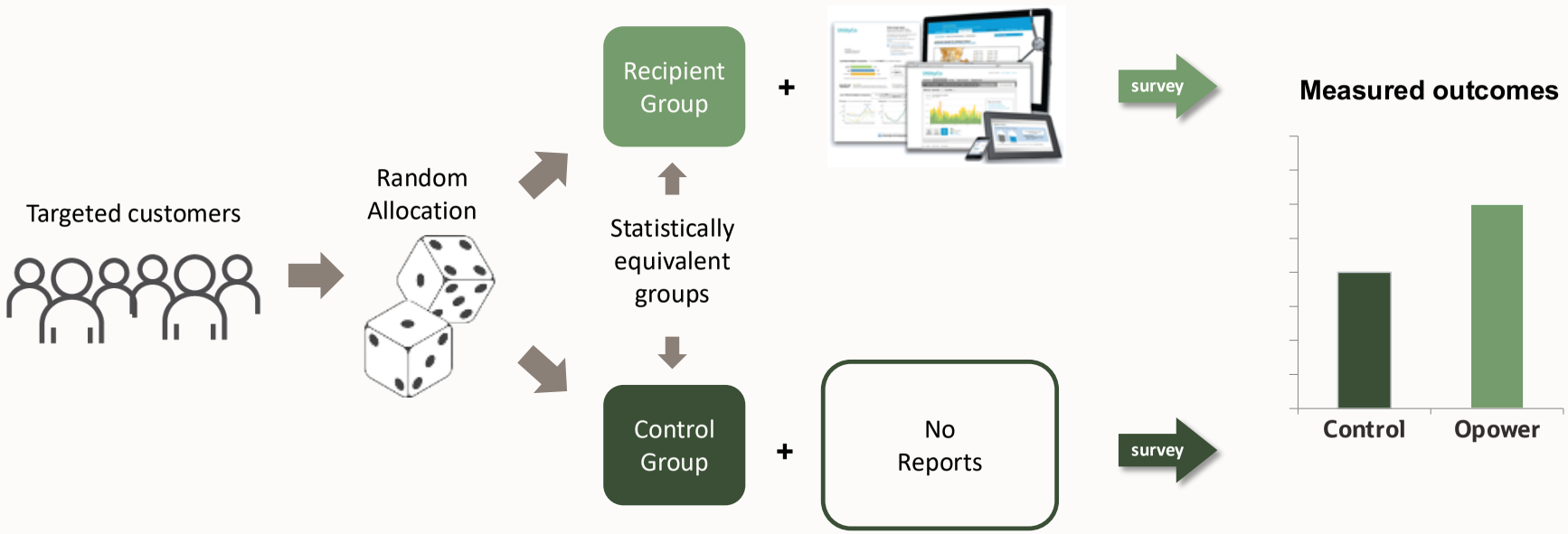
Did receiving the report make you more satisfied or less satisfied with National Grid or did your opinion not change?

All customers who have read reports



12 *Did receiving the report make you more satisfied or less satisfied with National Grid or did your opinion not change?*

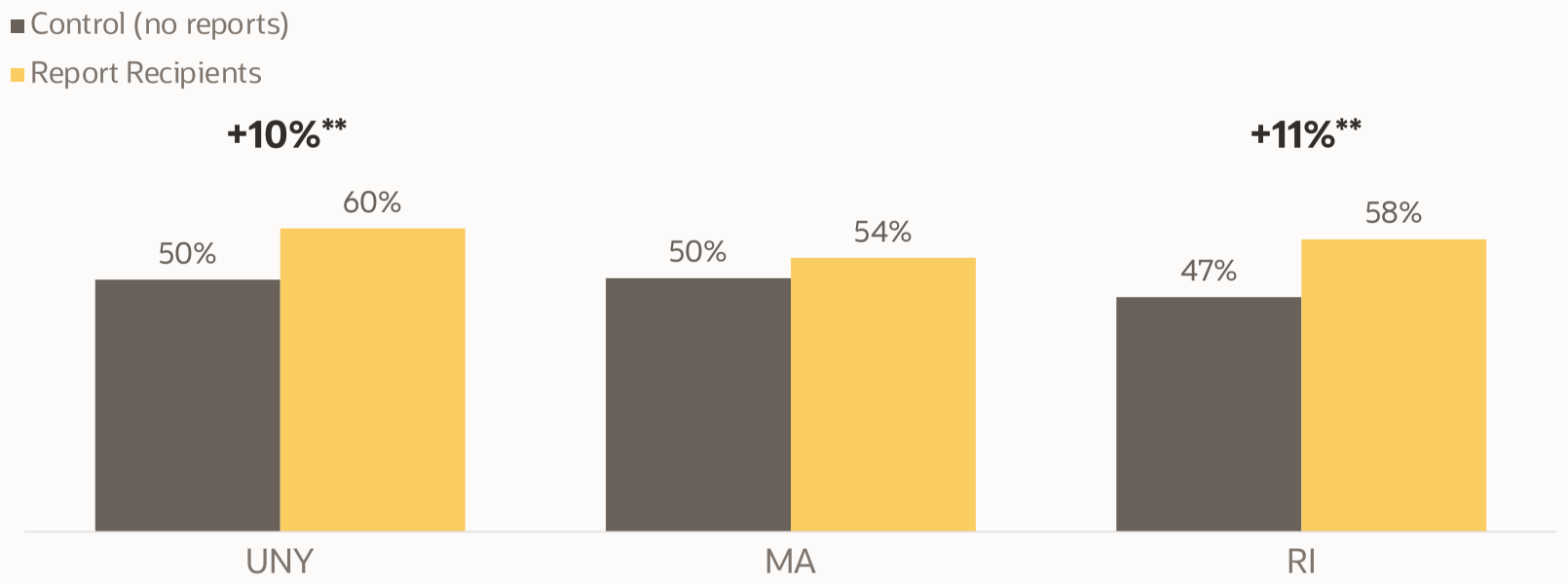
Experimental design enables other measurement of impact of key outcomes



Report recipients significantly more likely to view National Grid as an active partner in energy management, a model JD Power “Price” metric

Statement Agreement: National Grid helps me manage my monthly energy usage

Top 2 Box; 5pt scale



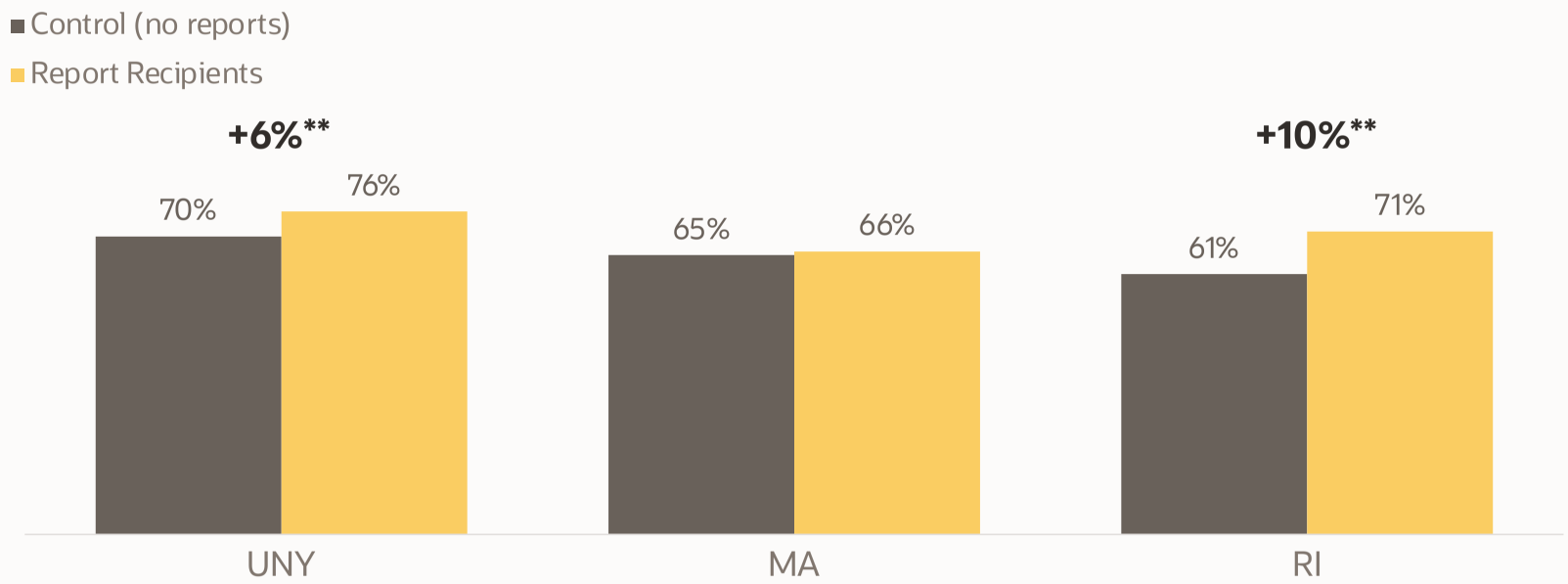
Thinking about National Grid, tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statements: National Grid helps me manage my monthly energy usage

**90% significant difference

Report recipients significantly more likely to view National Grid energy suggestions as useful, a model JD Power “Communications” metric

Statement Agreement: National Grid provides useful suggestions on ways I can reduce my energy usage and lower my monthly bills

Top 2 Box; 5pt scale

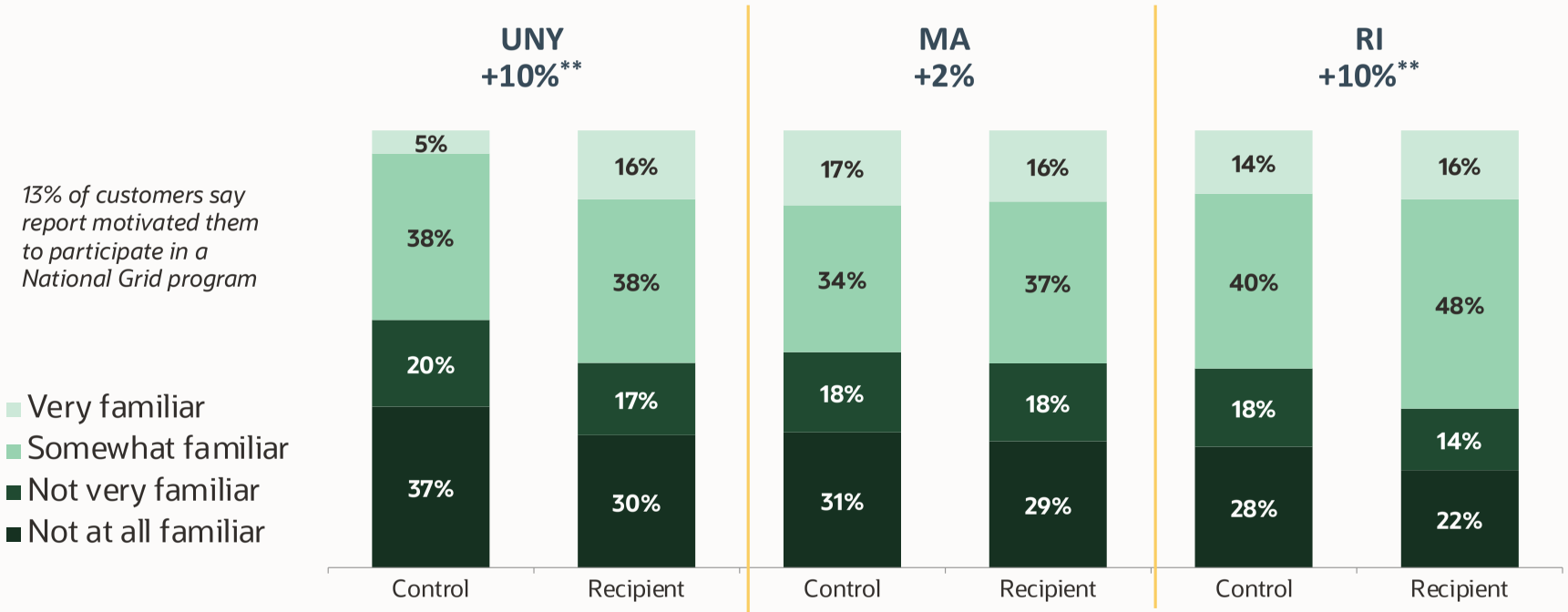


Thinking about National Grid, tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statements

**90% significant difference

Reports leading to greater familiarity with other National Grid EE programs

How familiar are you with energy efficiency or conservation programs from National Grid that help you with ways to use less energy?



16 *How familiar are you with energy efficiency or conservation programs from National Grid that help you with ways to use less energy?*

**90% significant difference

Summary of observed program impacts

Impact on Brand Perceptions of National Grid: Difference Between Report Controls and Treatments

Top 2 Box; 5pt. agreement scale or Top4 Box; 10pt agreement scale

	UNY	MA†	RI
Feel about National Grid overall	2%	-3%	1%
Trust National Grid to provide advice	-1%	-4%	1%
National Grid wants to help me save money	8%**	-3%	3%
National Grid helps me manage my monthly energy usage	10%**	4%	11%**
National Grid provides useful suggestions on ways I can reduce my energy usage and lower my monthly bills	6%**	1%	10%**
National Grid creates messages that get my attention	6%	-3%	4%
During COVID-19, National Grid is helping customers by providing information and tools to better manage their energy	5%	2%	4%
Familiarity with National Grid programs	10%**	2%	10%**

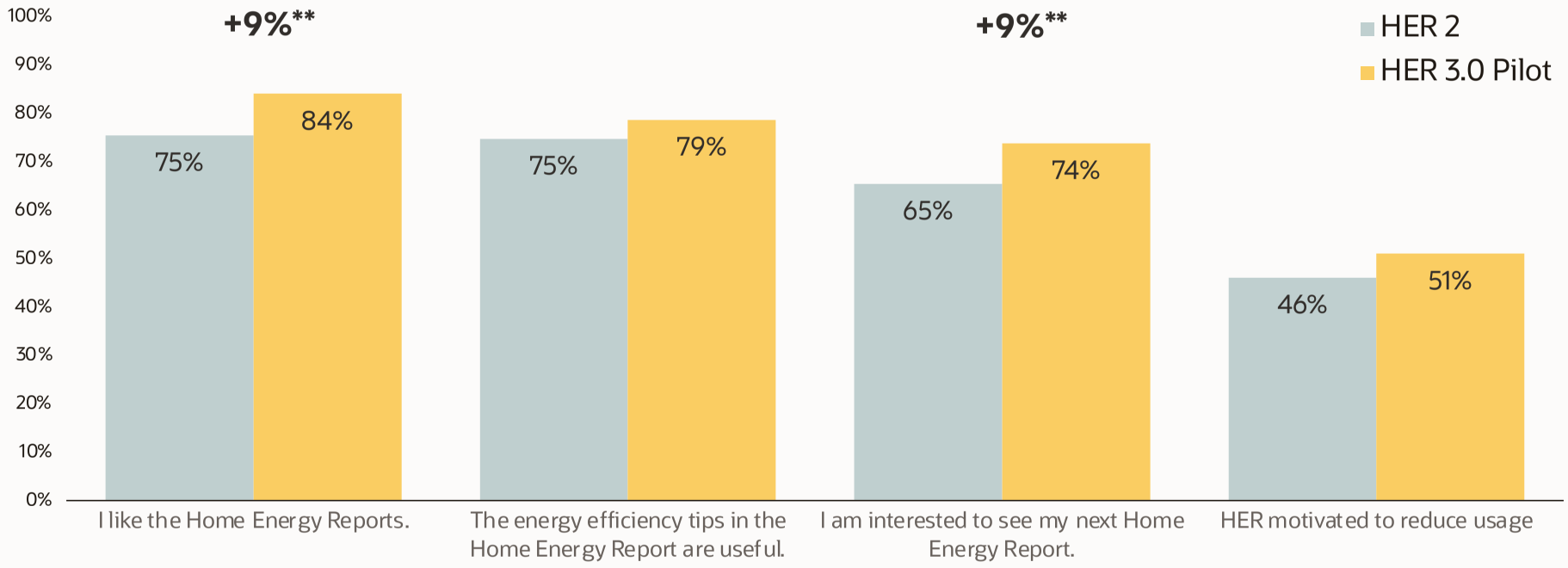
17

How familiar are you with energy efficiency or conservation programs from National Grid that help you with ways to use less energy?
†Outcomes may be impacted by relatively new 100k gas wave launched during survey fielding

**90% significant difference

HER 3.0 Pilot

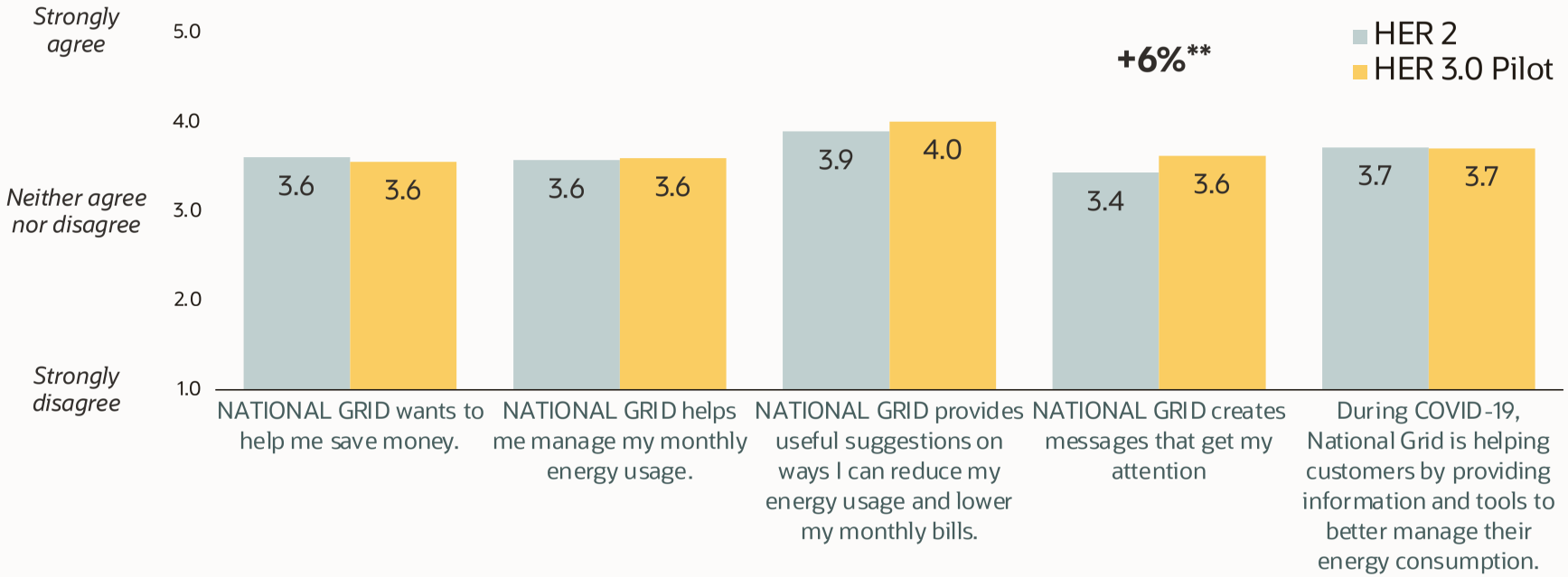
Refreshed experience appears to be better received by customers



**90% significant difference

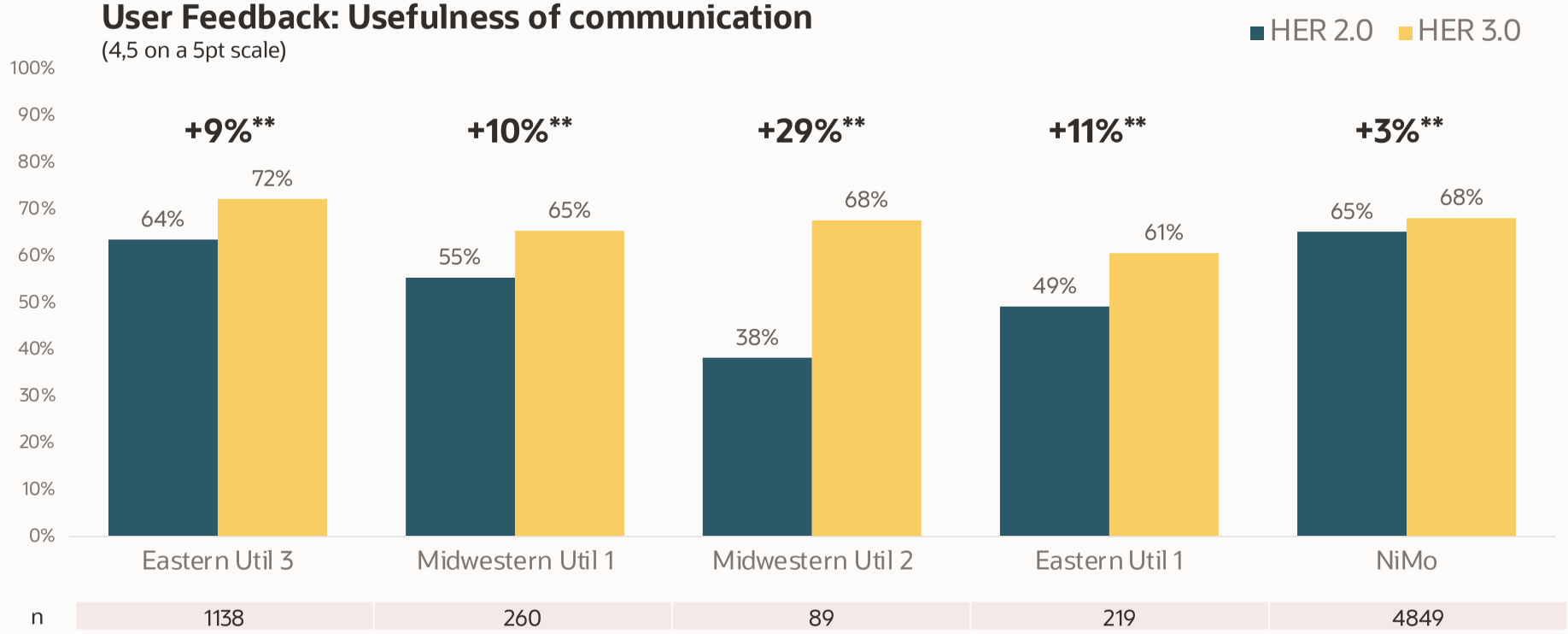
Some evidence that the refreshed experience improving broader feelings about National Grid communications

Perceptions of National Grid: Average Rating



**90% significant difference

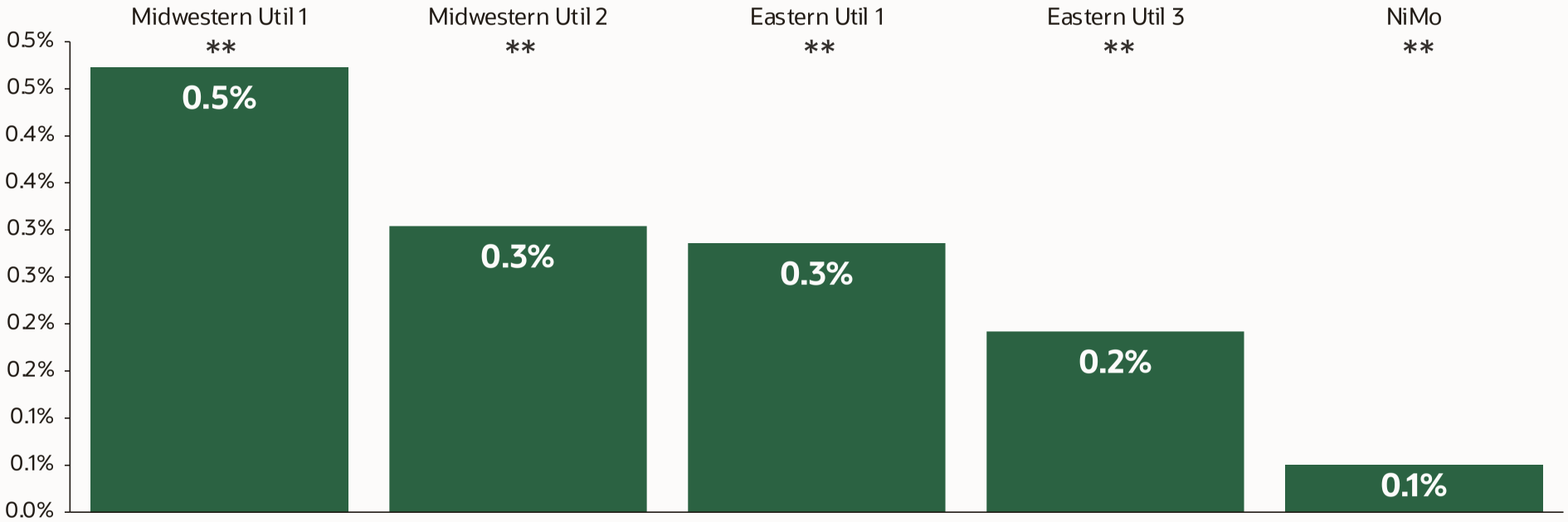
Feedback from refreshed digital Home Energy Report experience yield similar story across client deployments



**90% significant difference

Higher clickthrough rates for HER 3.0 Pilot recipients across clients

Percentage Point Difference in Clickthrough Rate in HER 3.0 Pilot (vs HER 2.0)



**90% significant difference

0

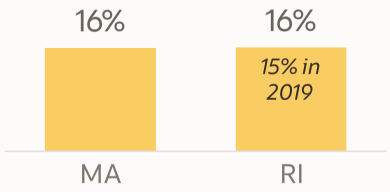
High Usage Alerts, WAMIs, Conservation Days, Web Tools

High Bill Alerts

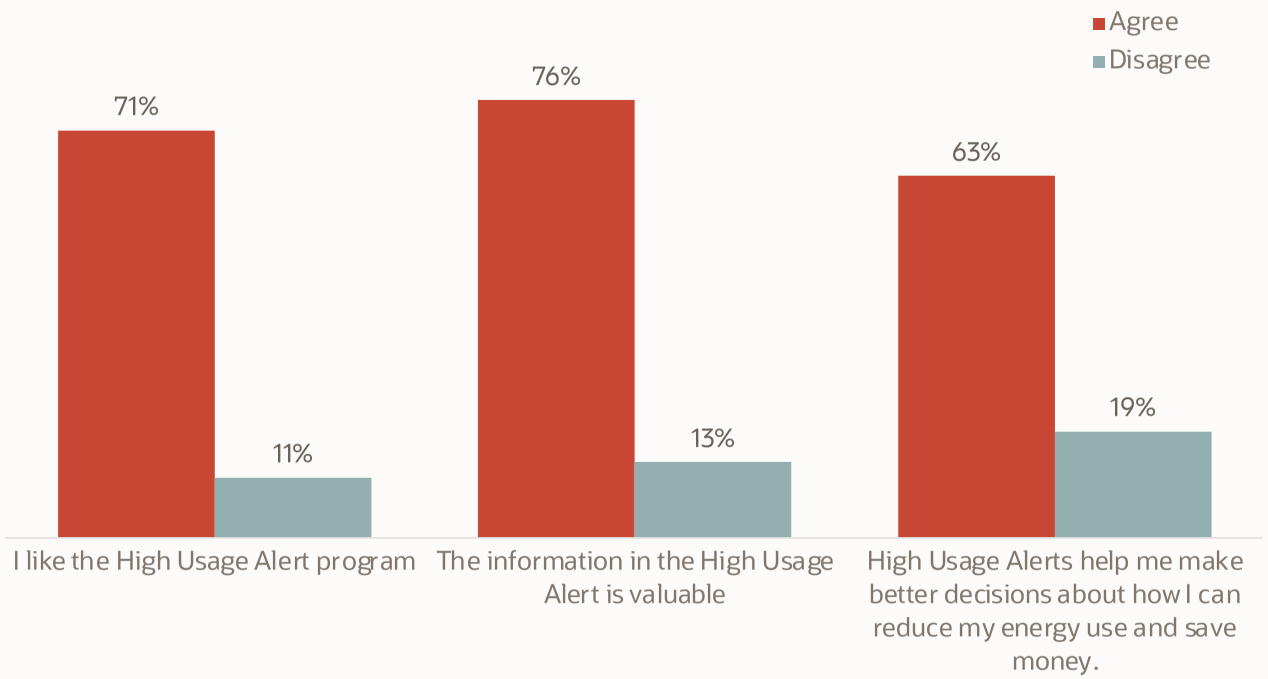
High Bill Alert Recall

n=241

Lower recall due to timing & frequency of these communications, and may have been impacted by COVID-19 shutoff



Statement Agreement: High Bill Alerts



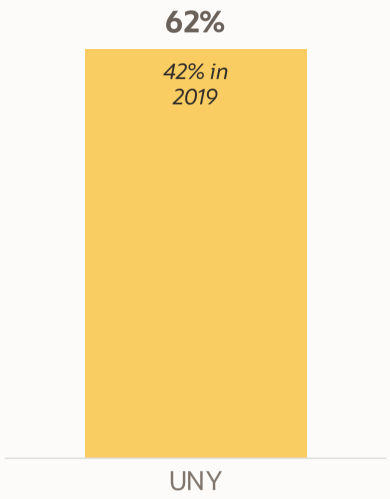
24 National Grid sends some customers High Usage Alerts when their usage is higher than normal. These alerts are sent by email when a customer is trending to have a higher than normal bill compared to the previous month. Have you ever received a High Usage Alert?

Weekly Electricity Reports

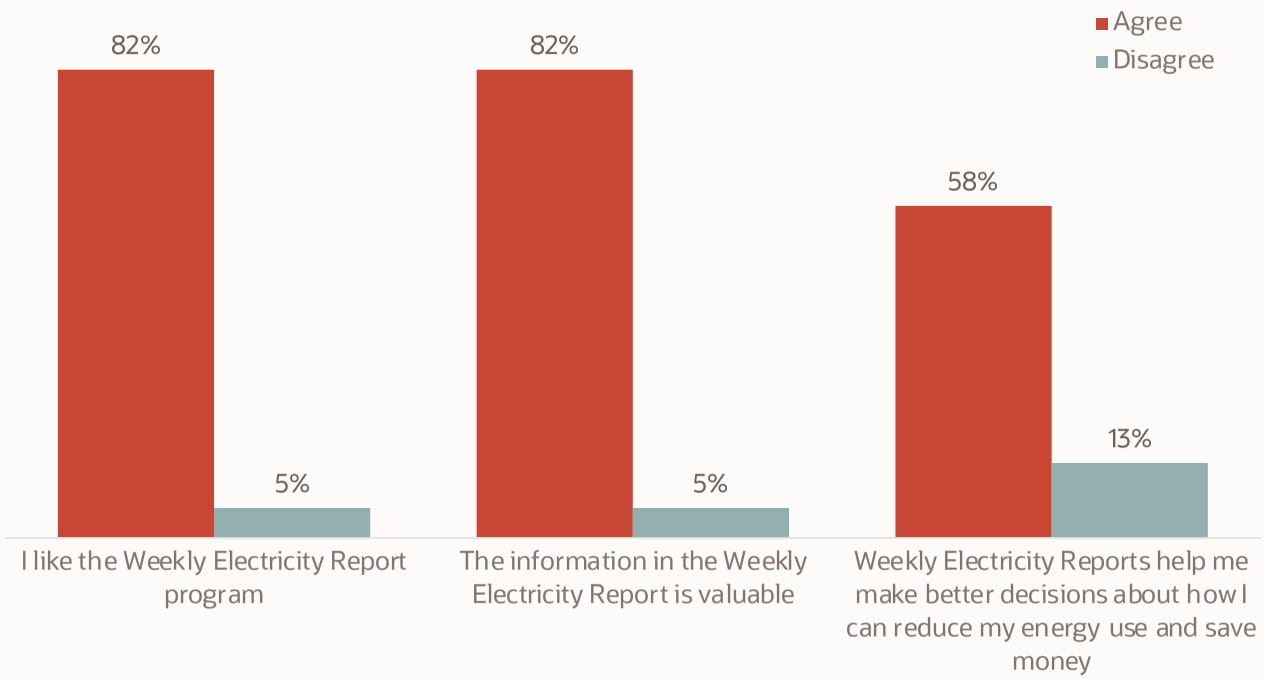
Weekly Electricity Report Recall

n=61

Recall may have been impacted by COVID-19 shutoff



Statement Agreement: Weekly Electricity Reports



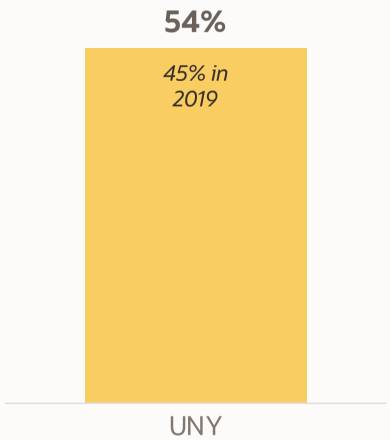
25 National Grid emails Weekly Electricity Reports to some customers that have chosen to receive them. These reports are emailed each week and contain a comparison of your usage in the current week compared to the previous week. Have you received Weekly Electricity Reports like this?

Conservation Day Communications

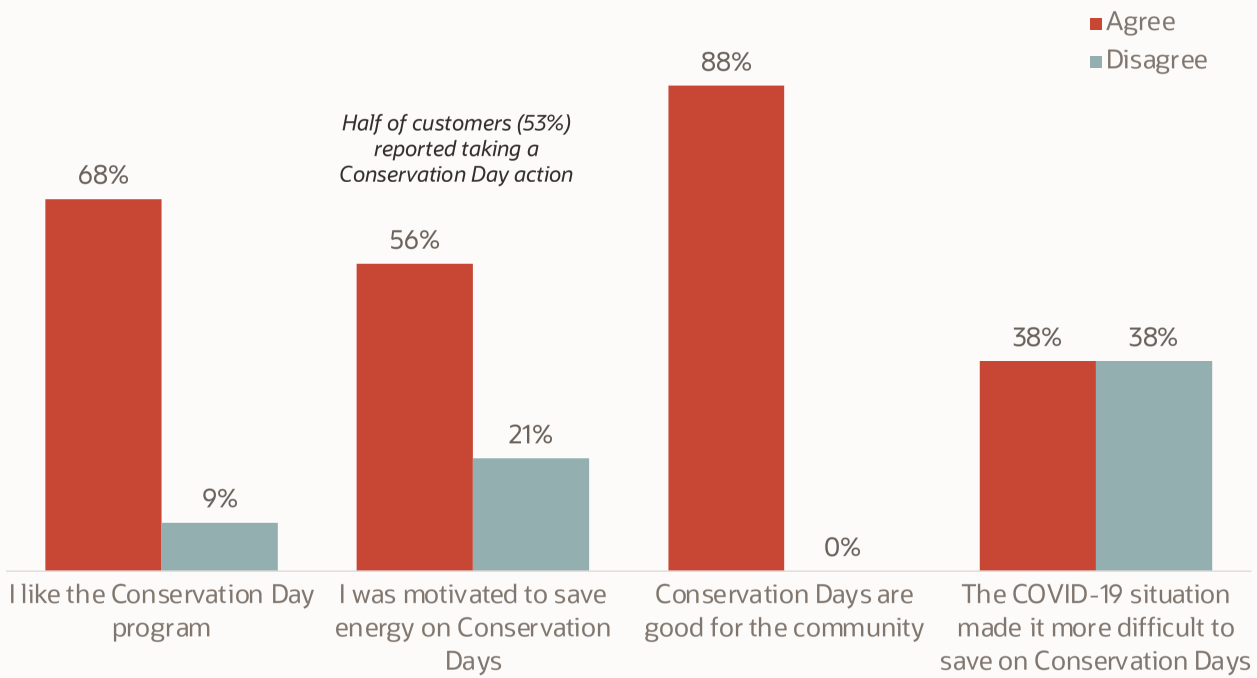
Conservation Day Communication Recall

n=63

Awareness likely declined between summer and survey fielding in winter



Statement Agreement: Conservation Days

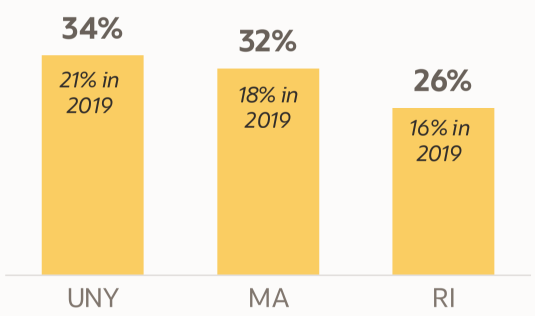


26 Between June and August of this year, some customers with central AC were sent communications about upcoming Conservation Days, where individuals could earn points as part of National Grid's Points and Rewards program by saving energy during certain days and times. Do you remember receiving these Conservation Day communications?

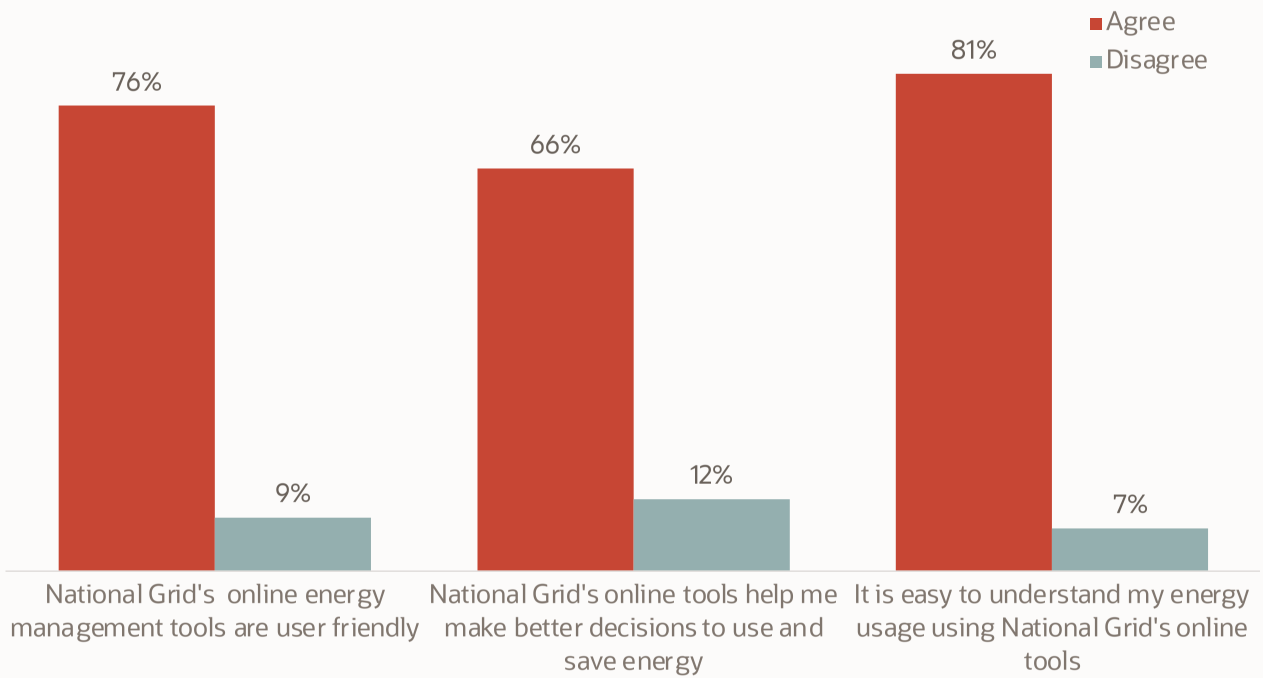
Online energy management tool awareness up significantly since previous year

Online Energy Management Tool Recall

n=2062



Statement Agreement: Energy Management Tools

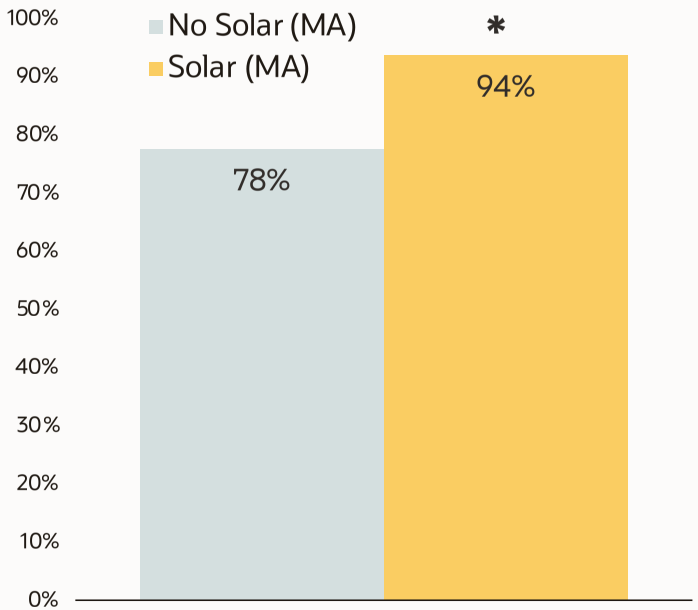


27 Are you aware of National Grid's online energy management tools, such as graphs that show changes in your usage when you're logged in to National Grid's website?

Solar customers show considerably higher levels of receptivity to both reports and online energy management web tools

Home Energy Report Liking

n=21 Solar customers; Top 2 Box



Metric	No Solar (MA)	Solar (MA)
HER recall	74%	76%
HER motivated to save	54%	69%
HER Liking	78%	94%*
Online tool awareness	31%	34%
Online tools help make better decisions to use energy	64%	90%*
Easy to understand energy usage using online tools	85%	90%

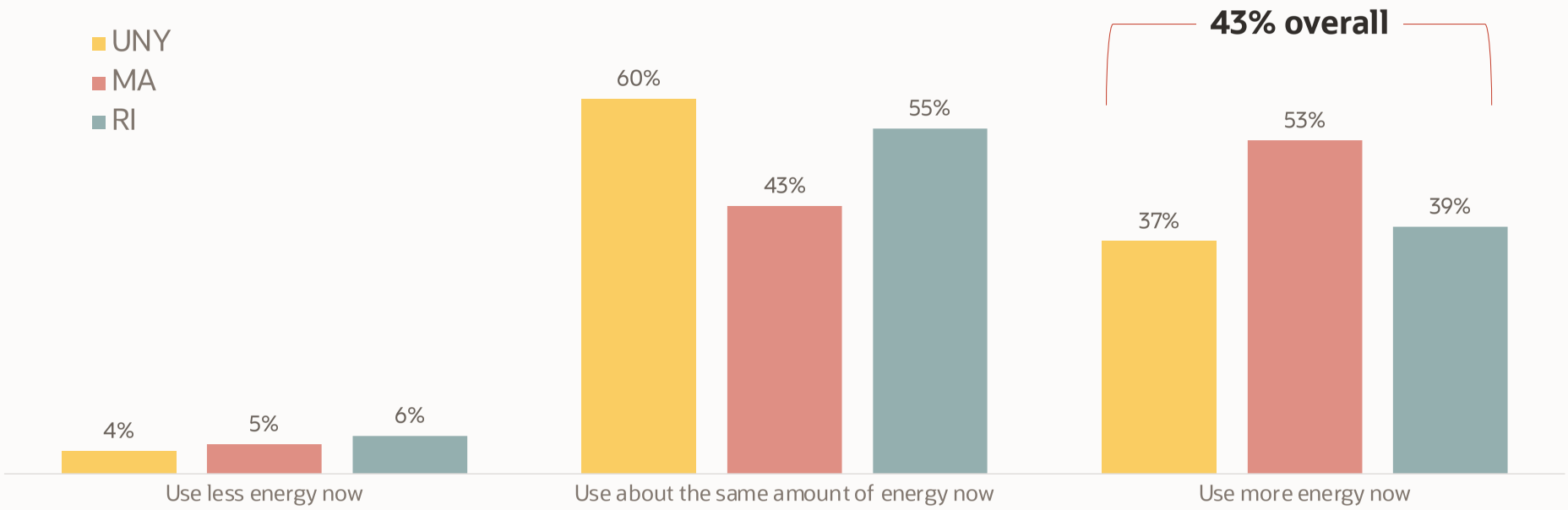
*85% significant difference (reduced for low n group)

0

COVID-19

Many Grid customers perceive increased usage due to COVID-19, including half of customers in MA

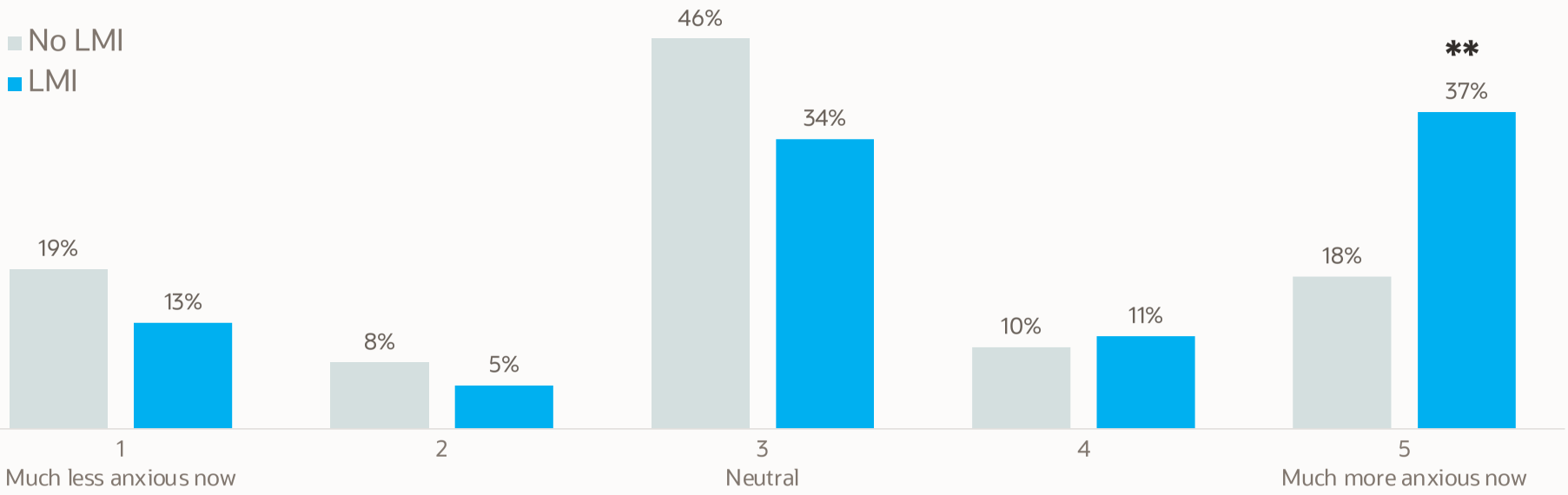
As a result of the COVID-19 situation, have you experienced any change in the amount of energy that your household uses?



30 *As a result of the COVID-19 situation, have you experienced any change in the amount of energy that your household uses?*

Overall, this impact on bill anxiety runs in both directions. However, an outsized effect is observed for projected LMI customers

How has the COVID-19 situation impacted your level of concern about your utility bill?

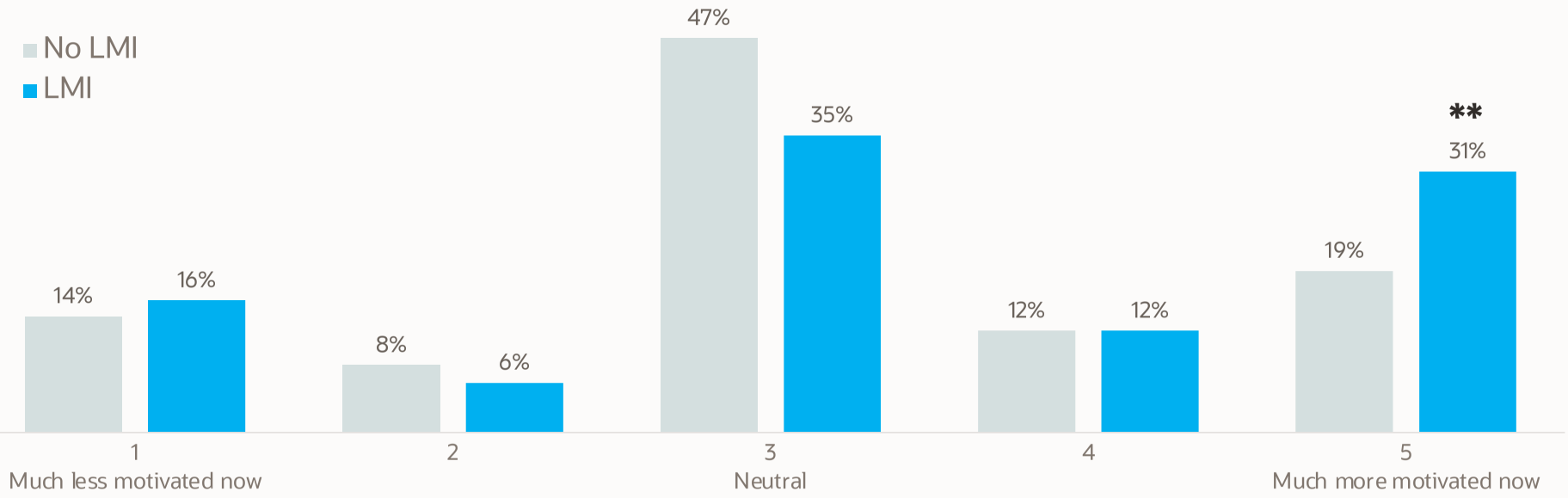


31 *How has the COVID-19 situation impacted your level of concern about your utility bill?*

**90% significant difference

Accordingly, increases in motivation to save are primarily observed among the LMI population

How has the COVID-19 situation influenced your motivation to increase your energy efficiency?

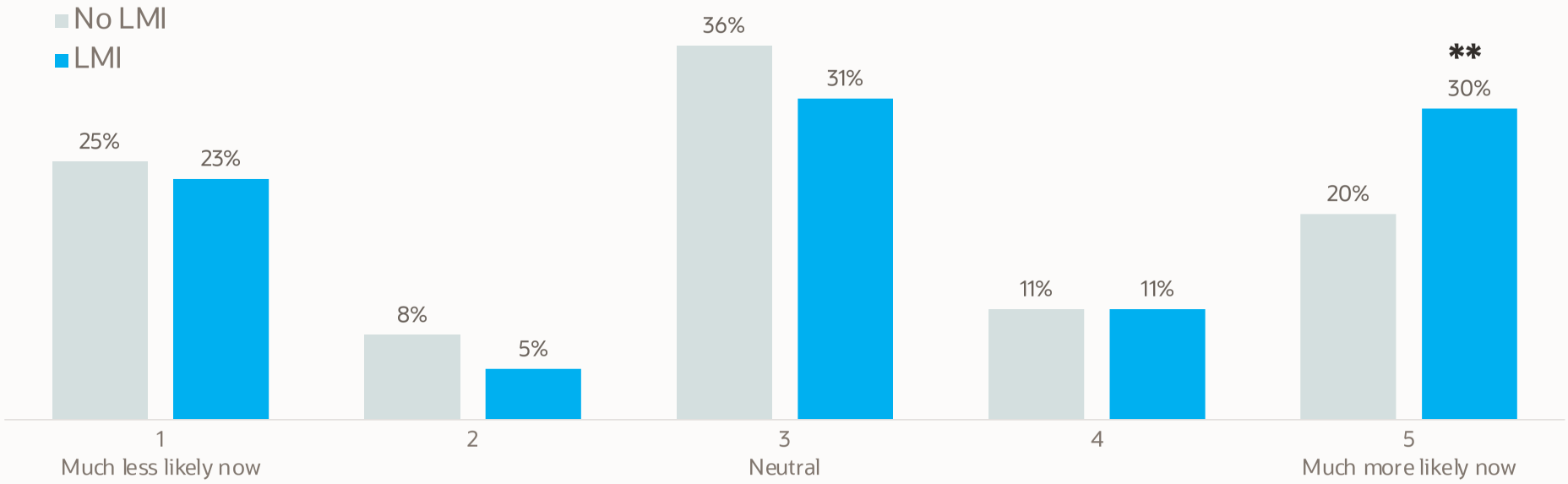


32 *How has the COVID-19 situation influenced your motivation to increase your energy efficiency?*

**90% significant difference

Similarly, stated likelihood to make energy efficiency improvements is higher among the LMI population

As a result of the COVID-19 situation, are you more or less likely to make energy efficiency home improvements or purchases?



33 *As a result of the COVID-19 situation, are you more or less likely to make energy efficiency home improvements or purchases?*

**90% significant difference

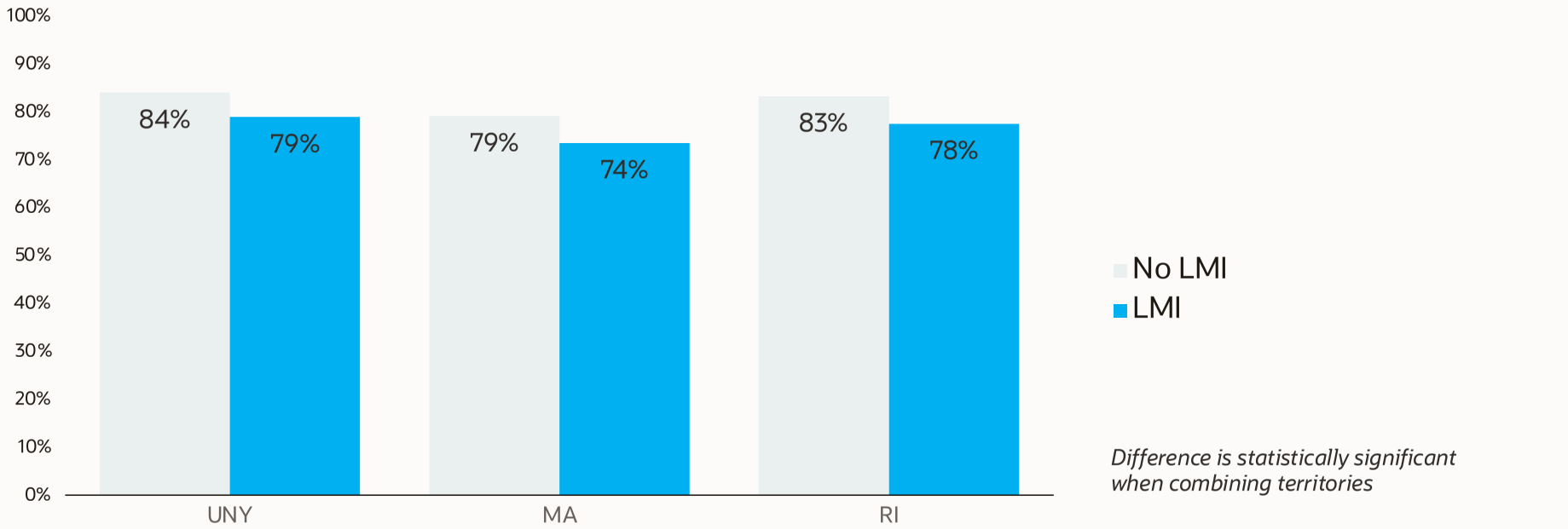
0

Low Income Customers

In aggregate, customers identified as LMI are slightly less likely to remember communications

Home Energy Report Recall

199 LMI report recipients



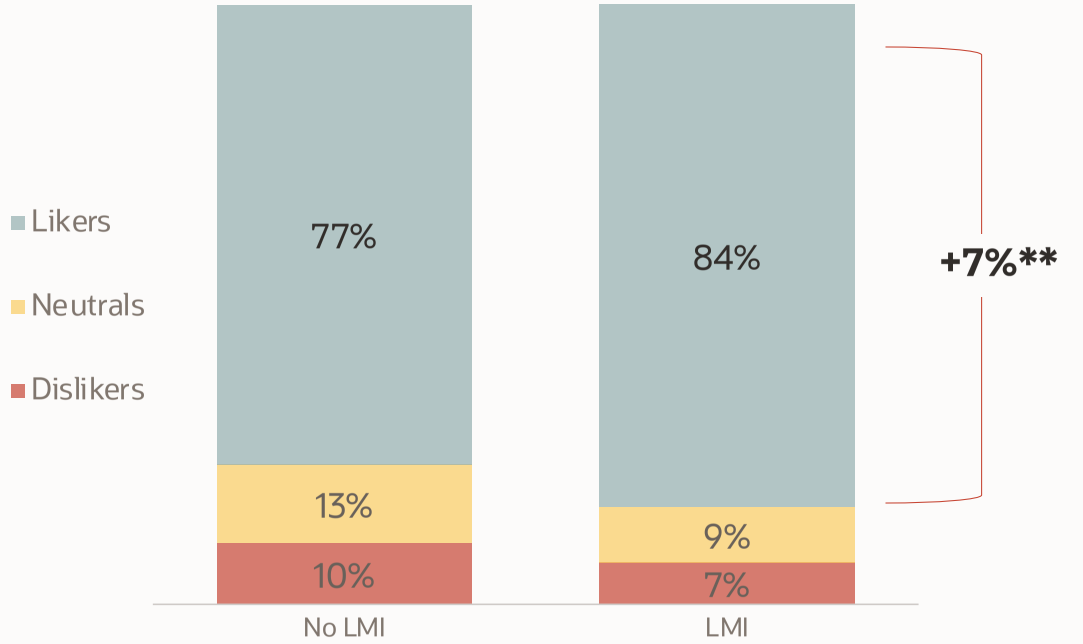
Difference is statistically significant when combining territories

**90% significant difference

However, across territories LMI customers the most positive about report experience—consistent with previous Grid surveys.

Home Energy Report Liking

199 LMI report recipients



UNY	+14%**
MA	+0%
RI	+9%

**90% significant difference

LMI Comparison Summary

310 respondents identified as likely low income due to census tract designation

Metric	No LMI	LMI	
Favorable towards National Grid	79%	82%	
Familiarity with EE programs	54%	51%	
HER Recall	82%**	76%	
HER Motivated to Save	47%	59%**	RI largest difference
HER Liking	77%	83%**	UNY, RI largest differences
Online tool awareness	31%	31%	
Online tools help make better decisions to use energy	64%	64%	
Easy to understand energy usage using online tools	87%	81%	

**90% significant difference

EJ Zip Code Comparison Summary

52 respondents identified as being in zip codes designated as EJ communities in MA and NY

Metric	No EJ (MA & NY)	EJ
Favorable towards National Grid	81%	82%
Familiarity with EE programs	51%	60%
HER Recall	81%	83%
HER Motivated to Save	50%	52%
HER Liking	79%	77%
Online tool awareness	34%	29%
Online tools help make better decisions to use energy	65%	53%
Easy to understand energy usage using online tools	81%	93%

No statistically significant differences observed between those who live in a zip code designated EJ community (MA/NY), however this may be due to sample size

**90% significant difference

Owner/Renter Comparison Summary

Self-identified owners and renters from survey data (554 renters; 1421 owners)

Metric	Owner	Renter
Favorable towards National Grid	78%	82%**
Familiarity with EE programs	54%	52%
HER Recall	85%**	75%
HER Motivated to Save	46%	55%**
HER Liking	75%	84%**
Online tool awareness	28%	36%**
Online tools help make better decisions to use energy	62%	72%**
Easy to understand energy usage using online tools	79%	86%**

**90% significant difference

0

Personas

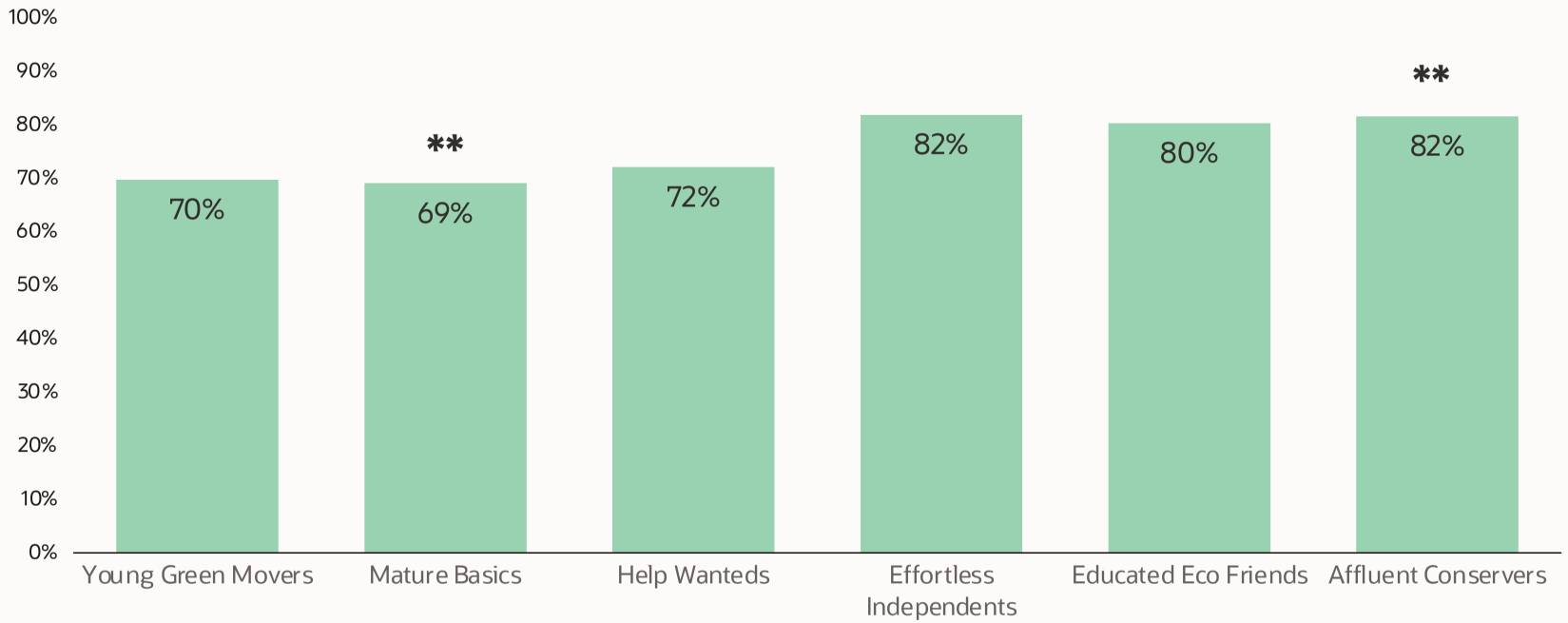
Several personas identified at National Grid

Analysis uses gas persona as primary persona (due to winter survey, with electric persona as backup where no gas persona exists.

	YOUNG GREEN MOVERS	MATURE BASICS	HELP WANTED	EFFORTLESS INDEPENDENTS	EDUCATED ECO FRIENDS	AFFLUENT CONSERVERS
Survey n	218	284	128	126	220	276
% Homeowner	40%	85%	49%	55%	85%	91%
% College Degree	53%	40%	39%	48%	58%	68%
% LMI	36%	10%	34%	17%	11%	7%

High readership across customer types, although Affluent Conservers appear more aware than Mature Basics

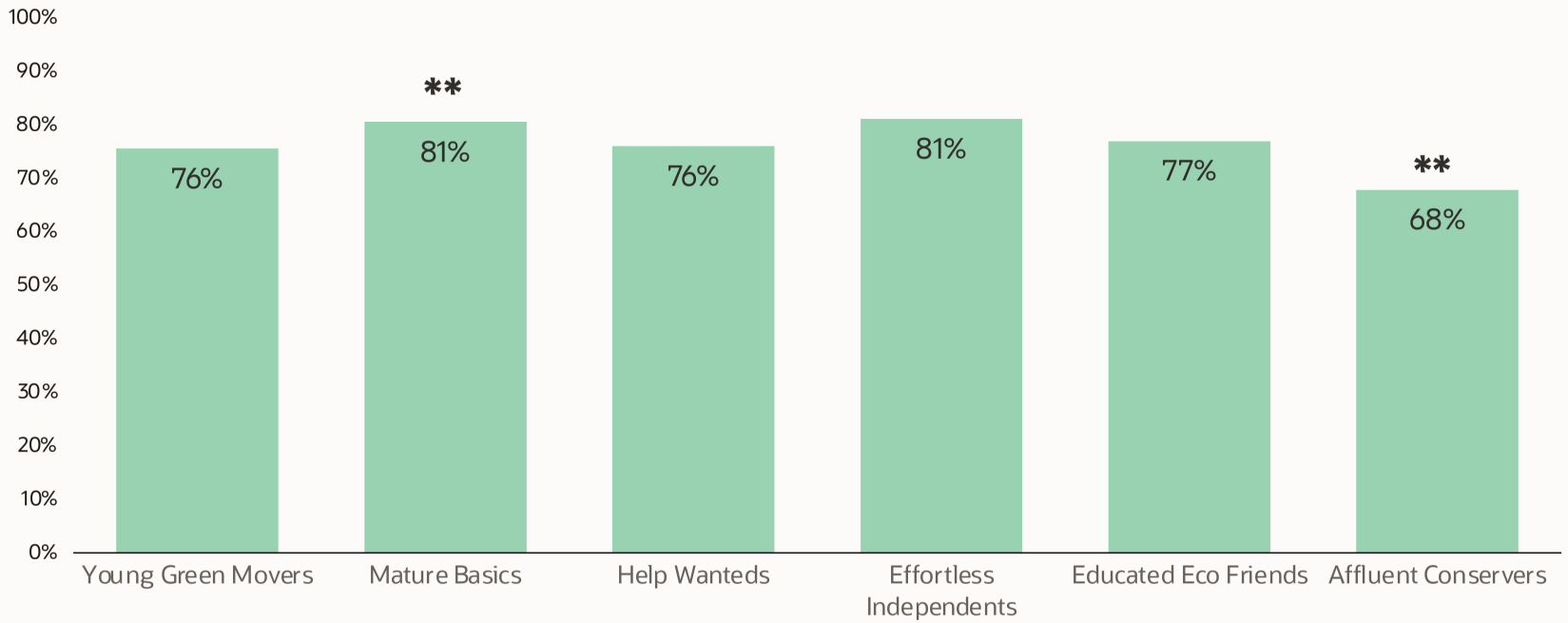
Home Energy Report Readership



**90% significant difference
*85% significant difference

Relationship reversed when evaluating report experience

Home Energy Report Liking (Top 2 Box)



**90% significant difference

Persona Comparison Summary

METRIC	YOUNG GREEN MOVERS	MATURE BASICS	HELP WANTED	EFFORTLESS INDEPENDENTS	EDUCATED ECO FRIENDS	AFFLUENT CONSERVERS
Favorable towards National Grid	77%	81%	79%	85%	77%	73%
Familiarity with EE programs	51%	52%	54%	58%	61%	60%
HER Readership	70%	69%	72%	82%	80%	82%
HER Motivated to Save	41%	50%	57%	53%	46%	49%
HER Liking	76%	81%	76%	81%	77%	68%
Online tool awareness	37%	16%	32%	30%	33%	27%
Use more due to COVID-19	50%	36%	51%	38%	45%	47%
Increased bill anxiety due to COVID-19	39%	30%	51%	33%	25%	32%
National Grid helping customers during COVID with information and tools	57%	54%	65%	58%	57%	46%

Mature Basics: Relatively lower HER readership, online activity but positive reception to those experiences. Good candidate for additional promotion outreach about web tools.

Hep Wanted: Relatively higher impact/motivation due to COVID-19, good candidate for continued messaging around this.

Affluent Conservers: Lower valuation of Grid but higher engagement with communications/tools.

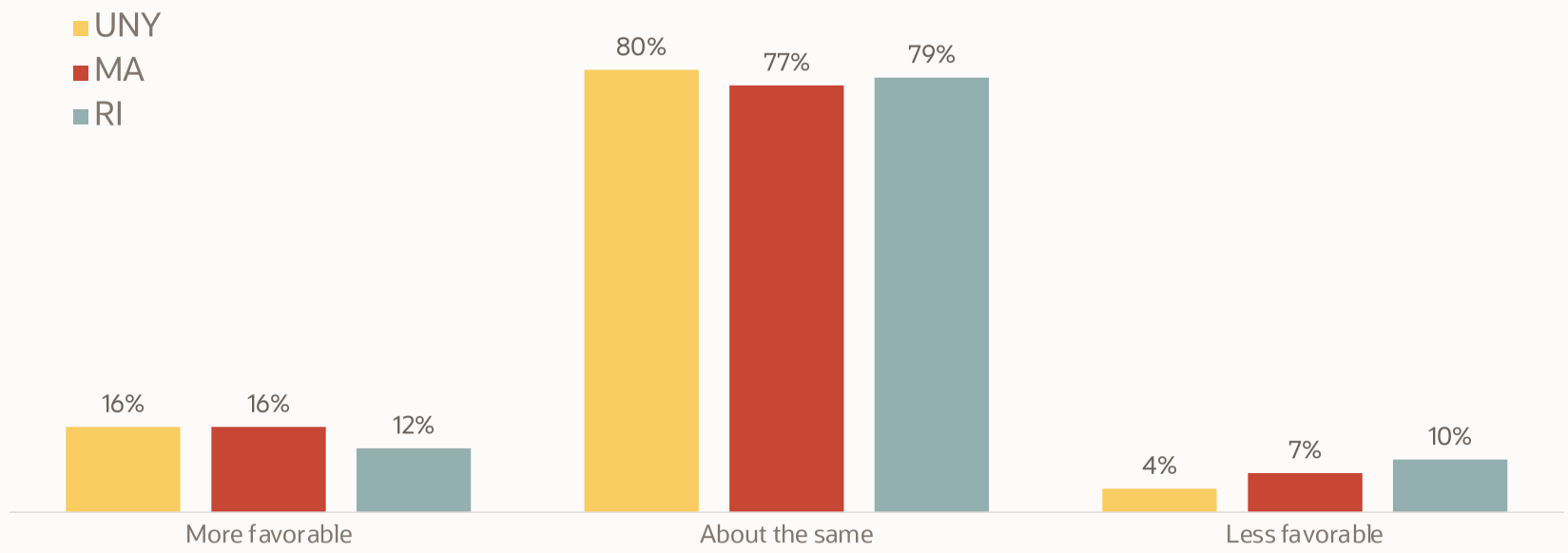
Highlighted cells indicate statistically significant difference at the 90% level

Appendix

Similar continued engagement observed when customers evaluate perceptions compared to previous year

Over the past year, how has your opinion about the Home Energy Report changed?

All customers who have read reports



46 Over the past year, how has your opinion about the Home Energy Report changed?

Specific program awareness gains harder to measure

Which of the following programs are you familiar with?

Metric	UNY Control	UNY Treatment	UNY Diff	MA Control	MA Treatment	MA Diff	RI Control	RI Treatment	RI Diff
General EE Program Familiarity	43%	53%	10%**	51%	53%	3%	54%	64%	10%**
No-Cost Energy Assessments	18%	22%	4%	37%	39%	2%	33%	29%	-4%
Heating and Cooling rebates	18%	25%	7%**	25%	24%	-1%	25%	30%	5%
Payment assistance programs	25%	30%	5%	30%	33%	2%	29%	33%	4%
ConnectedSolutions smart thermostat program	17%	20%	3%	20%	20%	-1%	18%	19%	1%
Marketplace for energy savings products	21%	22%	1%	18%	22%	4%	22%	24%	2%
SOLAR: ConnectedSolutions battery storage program	n/a	n/a	n/a	13%	24%	11%	n/a	n/a	n/a

47 *How familiar are you with energy efficiency or conservation programs from National Grid that help you with ways to use less energy?*

**90% significant difference

Data weights correct for oversample on Solar (MA) and Clifton Park (UNY)

MA

Solar	HER	Sample	Population	Weight
Yes	Control	4%	3%	0.794
Yes	Recpiient	5%	3%	0.579
No	Control	97%	97%	1.007
No	Recipient	95%	97%	1.021

UNY

Clifton Park	HER	Sample	Population	Weight
Yes	Control	8%	1%	0.12
Yes	Recpiient	15%	1%	0.06
No	Control	92%	99%	1.08
No	Recipient	85%	99%	1.16

National Grid
2019 Customer Engagement Tracker

February 2020

Research Methodology

Survey responses from 2,411 National Grid customers in Home Energy Report program

- ~800 customer responses from each territory: **MA, NY, and RI**
- **1509 total responses** from Home Energy Report recipient customers
- **902 total responses** from control customers (non-recipients to be used as baseline)

Stratified random sample of customers from across all Home Energy Report deployments in each territory

- Oversample of NY respondents in Clifton Park: for overall results for NY, weights are used to correct for this
- Contains individuals across all six "personas" defined by National Grid (RI and MA)
- Results compared to similar survey effort in 2018 (some data from surveys going back to 2013)
- Where applicable, questions also included regarding High Usage Alerts, Weekly Electricity Reports, Conservation Days, and online energy management tool usage

Telephone survey fielded between Nov 18, 2019 and Jan 13, 2020

- Interviews conducted by CASRO/ESOMAR provider, ISA
- Fielding paused across Thanksgiving and winter holidays
- Questionnaire designed in conjunction with National Grid, aligned with previous survey questionnaires

Survey Key Findings

Strong continued engagement with the Home Energy Report and related communications

- 80% of customers actively reading communications, with half of these reading the content thoroughly.
- Readership has steadily increased since 2013 (from 63%) and appears to have stabilized
- 79% of customers like the communications (13% disliking), an increase over previous years that greatly exceeds performance of other utility programs.
- Similarly high levels of liking for High Usage Alerts (89%), Weekly Electricity Reports (83%), and Conservation Day communications (80%) indicate broad demand for more energy usage information

Gains seen in customer perceptions of National Grid

- Third of customers say they are more satisfied with Grid due to the HER, compared to only 5% reporting lower satisfaction
- Compared to customers who do not receive reports, statistically significant improvements were observed, including:
  +8% National Grid wants to help me save money (NGRI)
  +9% National Grid helps me manage my monthly energy usage (NGRI)
  +6% National Grid creates messages that get my attention (NGMA)
  +7% Familiarity with National Grid efficiency or conservation programs (NGMA)

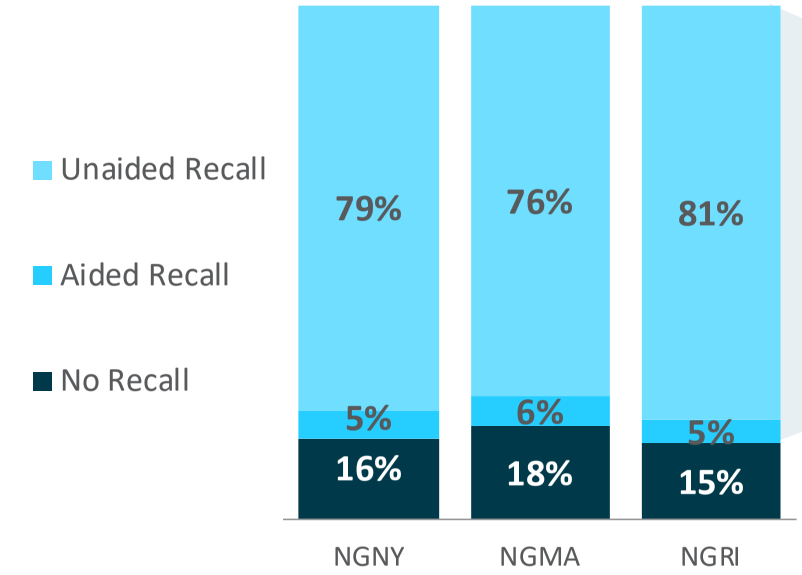
Opportunities to optimize program based off different customer segment responses to content

- Low-income rate customers show lower levels of report awareness but significantly higher levels of satisfaction
- Lower online energy management tool awareness for Help Wanted persona indicates opportunity to promote digital resources
- Relatively lower HER readership for Effortless Independent persona despite highest levels of program satisfaction may be a signal that it would effective to engage population through multiple channels to expand messaging reach

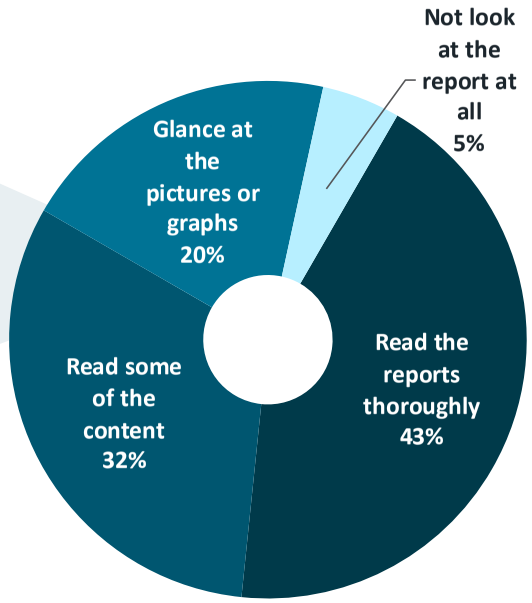
79% of recipients reading reports in some way

Home Energy Report Recall

1493 HER or eHER recipients



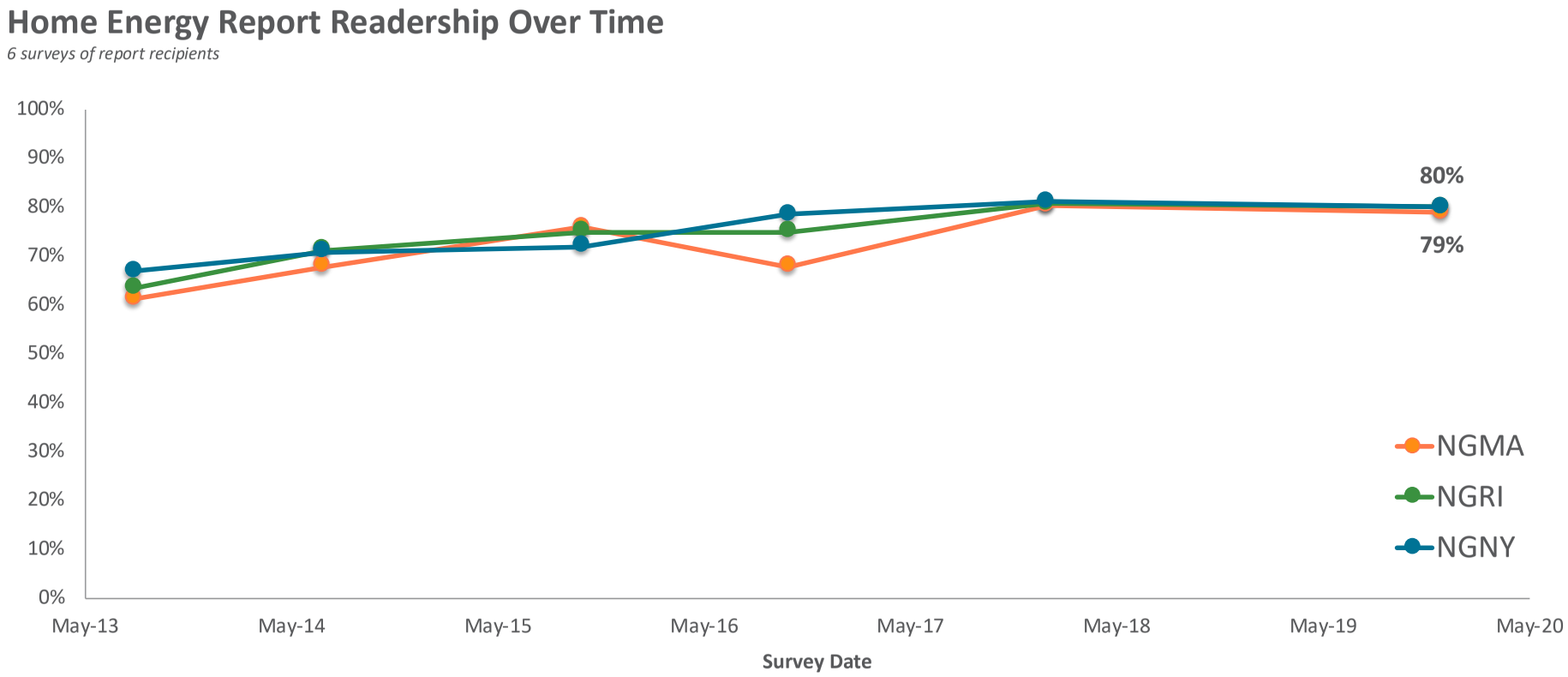
Home Energy Report Reading



80% Overall Readership

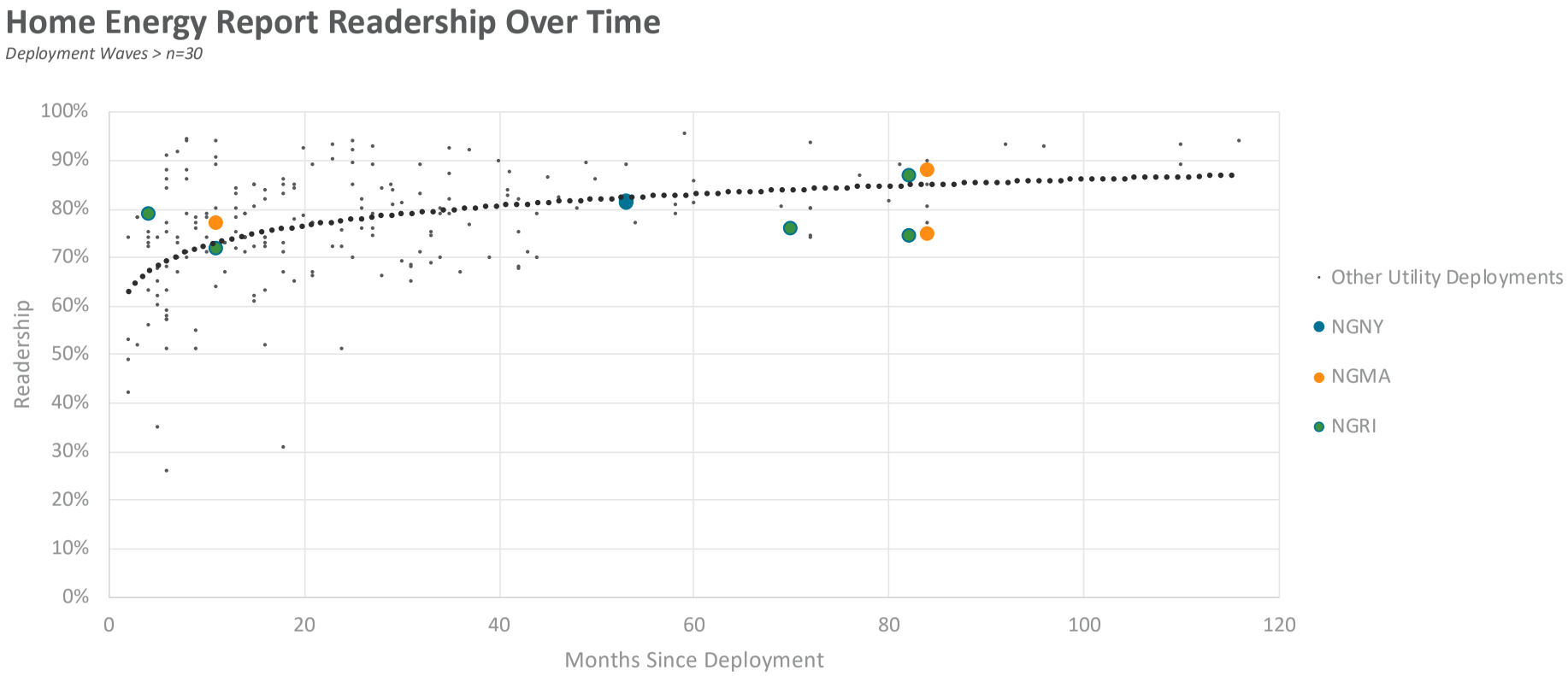
In the past six months, do you remember receiving a Home Energy Report from National Grid about your in-home energy use?

Overall readership sustained at high levels



In the past six months, do you remember receiving a Home Energy Report from National Grid about your in-home energy use?

Engagement level tends to stabilize deep in program

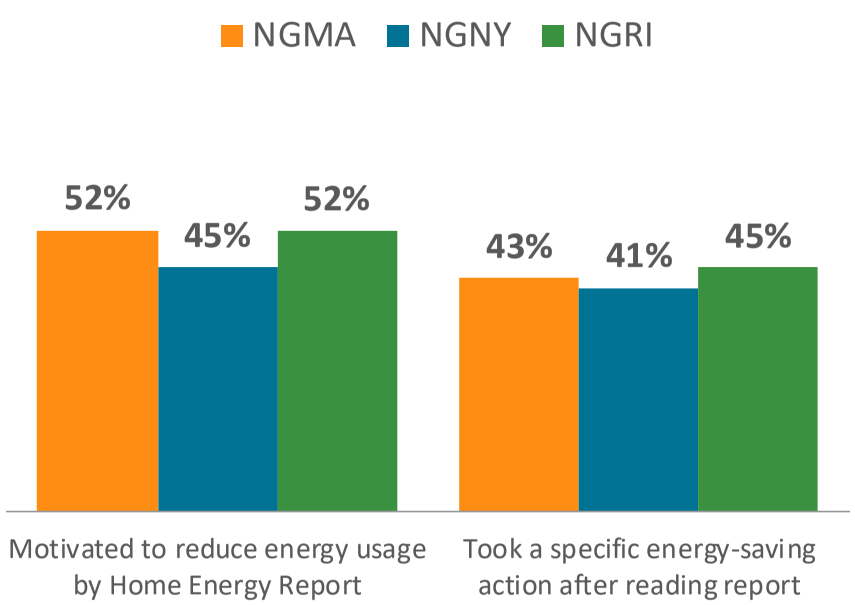


In the past six months, do you remember receiving a Home Energy Report from National Grid about your in-home energy use?

Half of customers motivated to reduce usage

Energy-Saving Actions

1137 recalling and reading Home Energy Report recipients



Which actions did you take? [Sample responses]

I have gone and purchased LED light bulbs and during the summer set the ac at a more moderate temperature and was opening windows. I got new windows.

I turned the heat off when I wasn't home and significantly reduced the temperature of the heater from 80 down to 70. I started using less hot water for the laundry.

We got nest thermostats. We have energy efficient light bulbs. We did insulation in my attic. We did weather stripping on all my doors.

I had a home assessment done: the MassSave deal

Got an energy audit done twice, changed bulbs for energy savings, take other steps/measures as advised in the reports.

Being aware and turning out the lights after my husband.

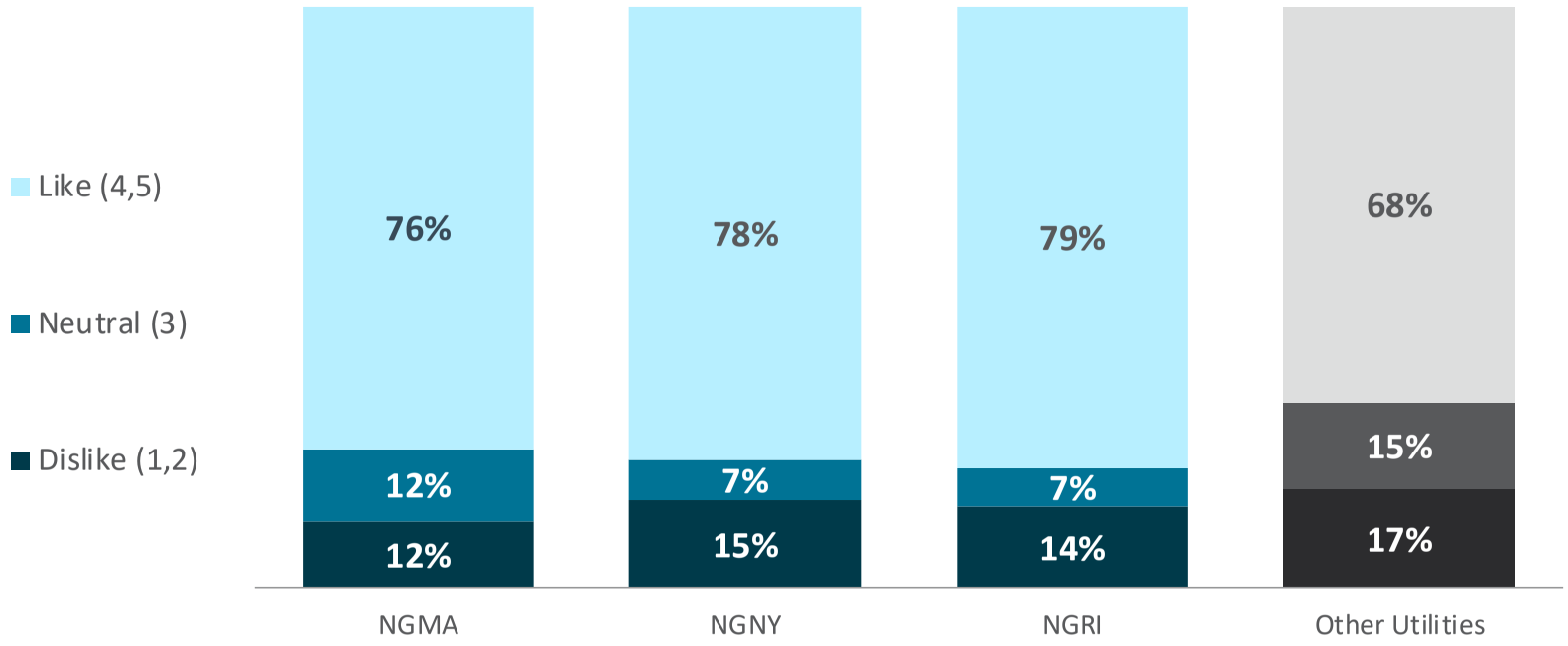
ORACLE

Did the Home Energy Report motivate you to reduce your energy usage? After reviewing your report, have you taken a specific energy-saving action?

78% of recipients like experience, outpacing peer programs

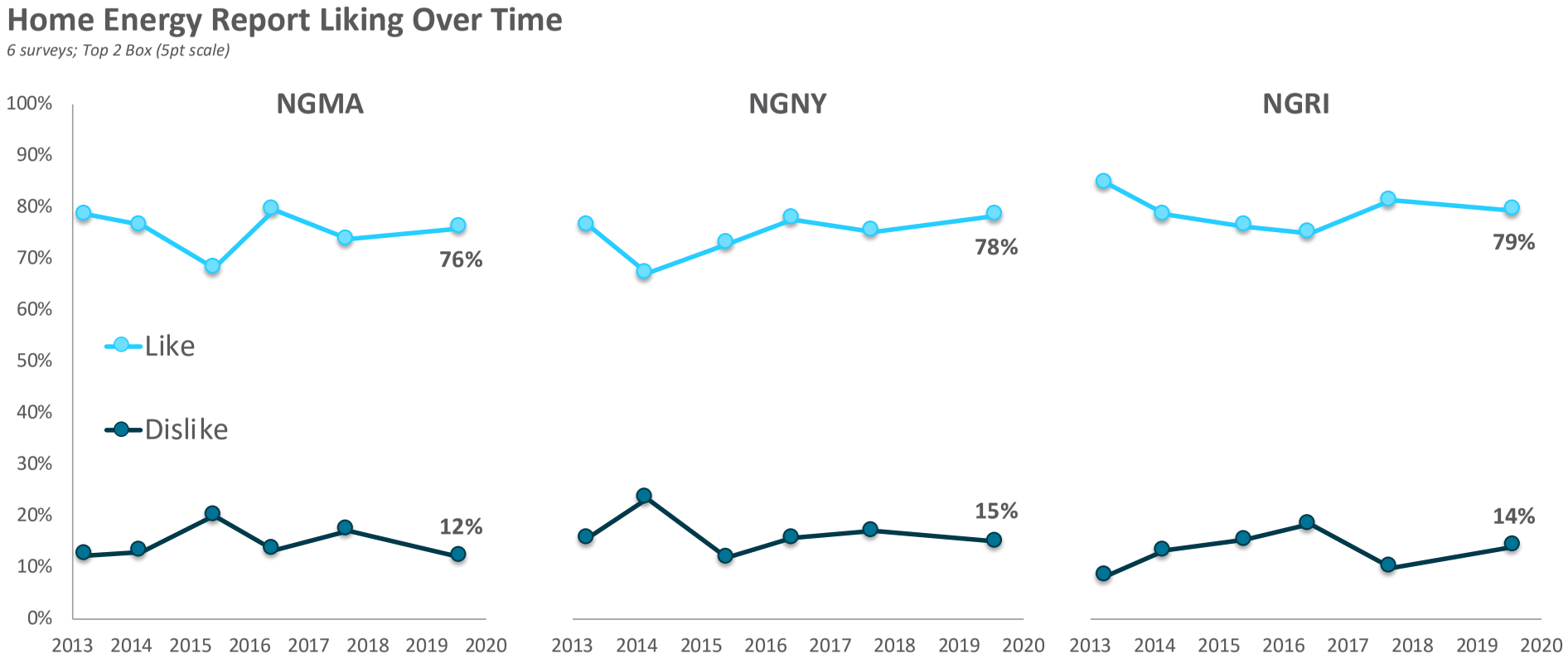
Home Energy Report Liking

1169 recalling Home Energy Report recipients; 5pt scale



Tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statement: I like the Home Energy Reports.

Report reception sustained at high levels over time as readership has increased

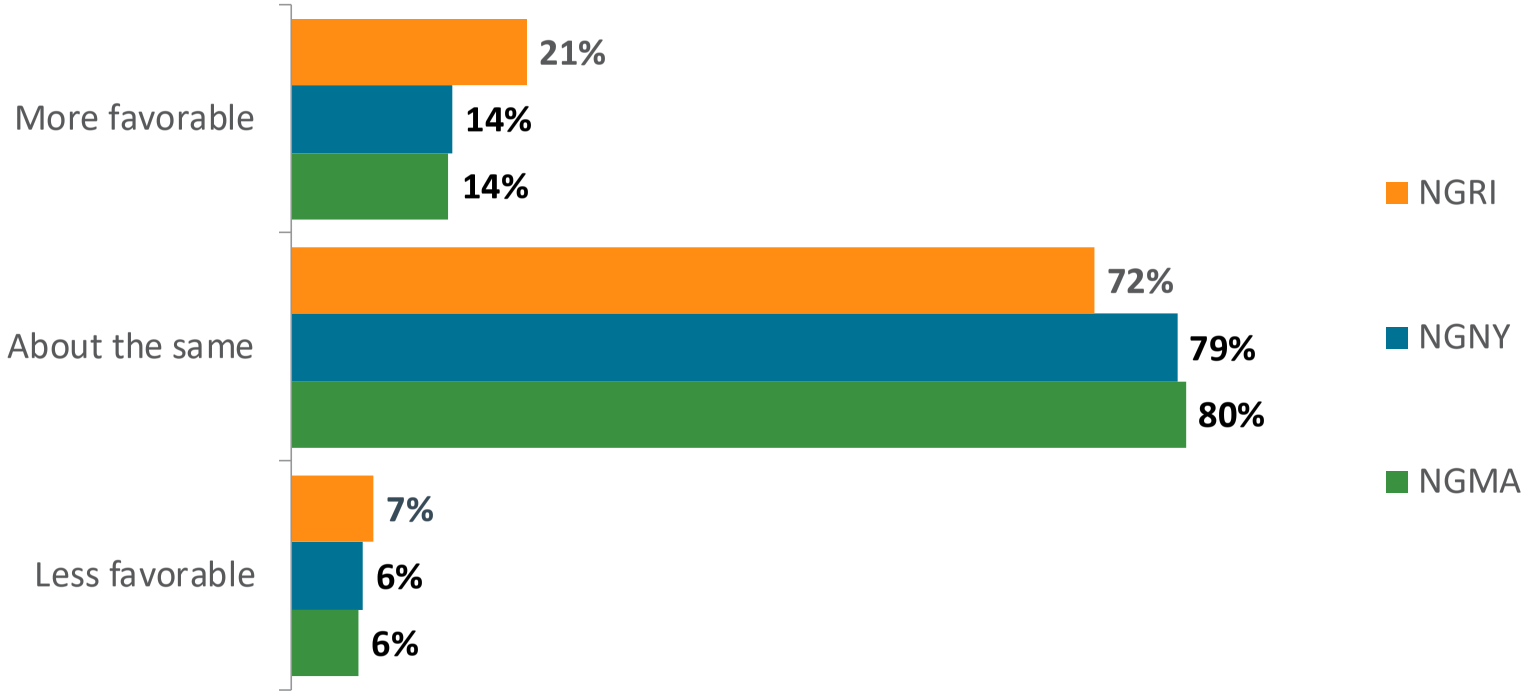


ORACLE

Tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statement: I like the Home Energy Reports.

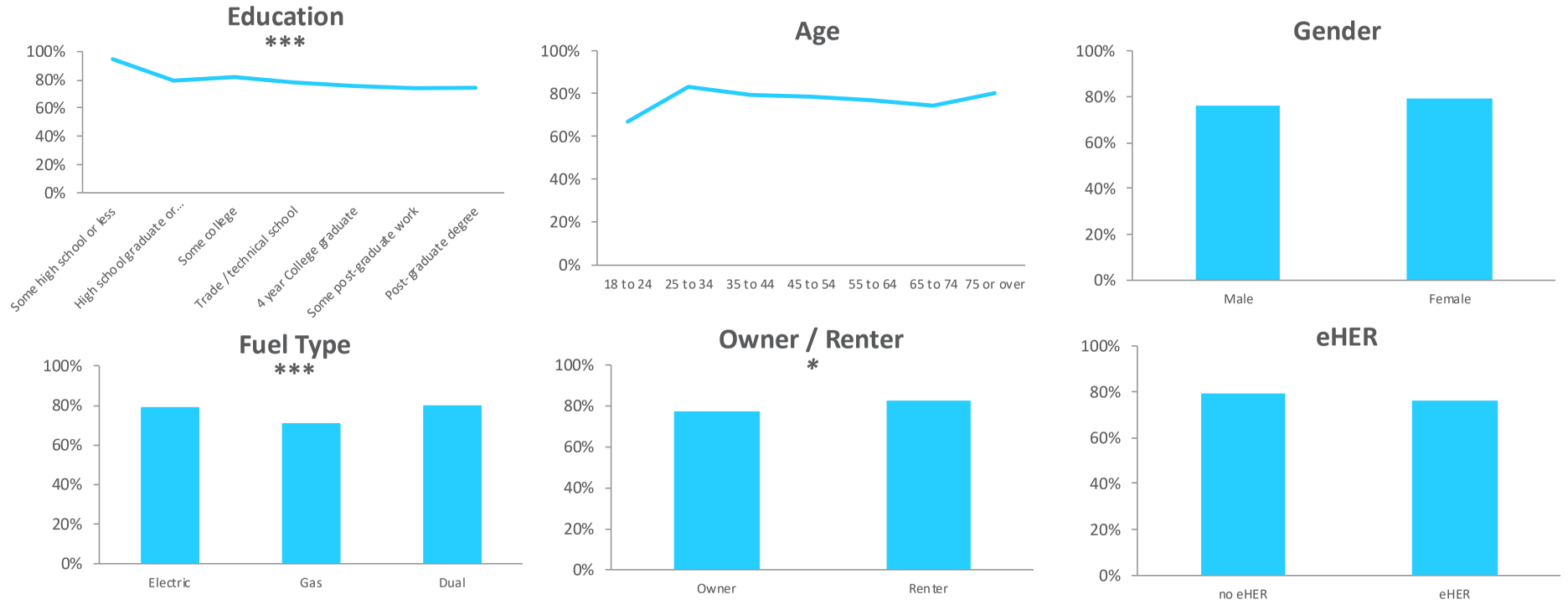
Response to content sustained or improving in past year

Over the past year, how has your opinion about the Home Energy Report changed?



Customers at lower levels of educational attainment appear to like reports relatively more

Home Energy Report Liking by Characteristic



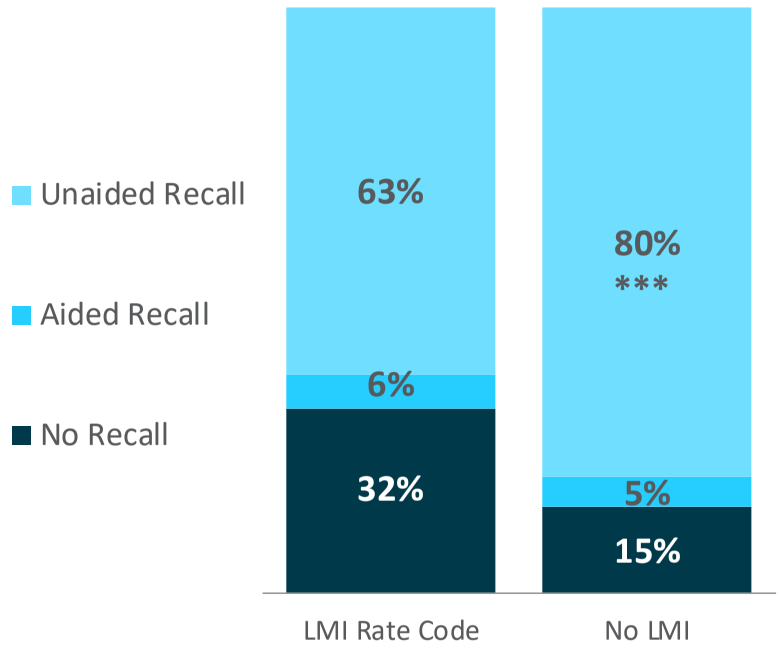
Tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statements: I like the Home Energy Reports.

***95% significant difference
**90% significant difference
* 85% significant difference

Relatively harder for messages to reach LMI rate customers, but those customers value content significantly more

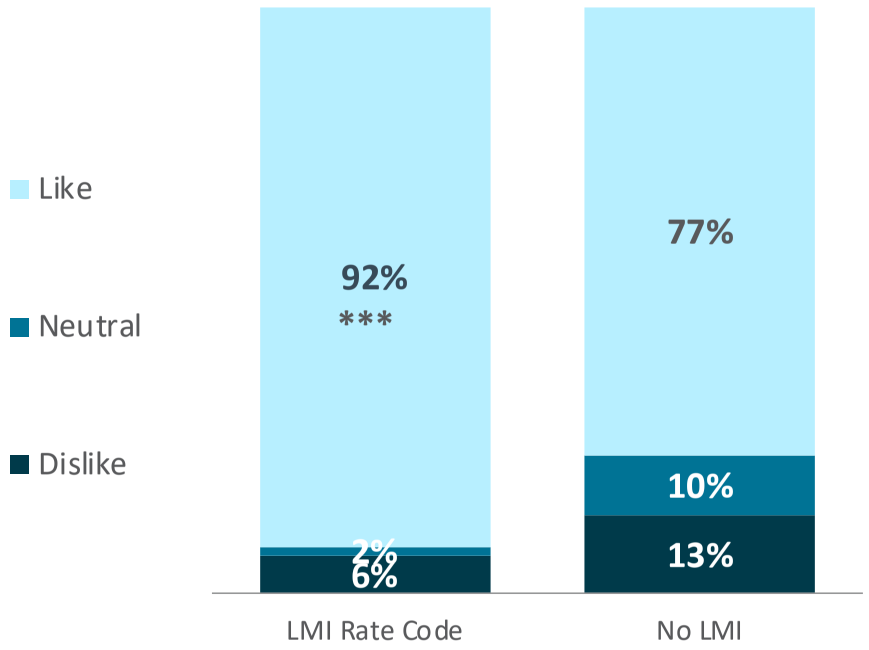
Home Energy Report Recall

104 LMI report recipients



Home Energy Report Liking

63 recalling LMI Home Energy Report recipients; 5pt scale



Tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statement: I like the Home Energy Reports.

***95% significant difference
**90% significant difference
* 85% significant difference

Likers are saying:

I like when they show us and compare the energy that we use against all the people around us and our neighbors. it motivates us to keep it going.

Well it may seem silly because it is competitive but [I like] seeing the comparison to my neighbors and trying to beat them. Plus there are points.

Getting off fossil fuel and it breaks down where I stand with my neighbors. It opens my eyes and makes me think more about it.

I like seeing how much I'm improving; sometimes the info is wonky; with the size of our home (16 rooms) some to the comparisons to the neighbor's homes may be a bit inaccurate due the smaller sizes of their homes.

Graphs comparison between this year and last year. Interesting reading. I think it's a good thing.

The little hints are helpful. What pertains to me and my house is important.

[I like] The part showing month to month usage. Would like to see two or three years usage altogether to compare.

Dislikers are saying:

Well we are thrown in with permanent residents and seasonal residents and people who have electric heat and people who have kerosene.

Our house is larger than our neighbors. They say we use more but it is not equal in size to their homes.

My problem is size of the neighboring houses are not the same with mine. My house is double the size of our neighbors. I would not mind a comparison with houses of the same size that are not near by.

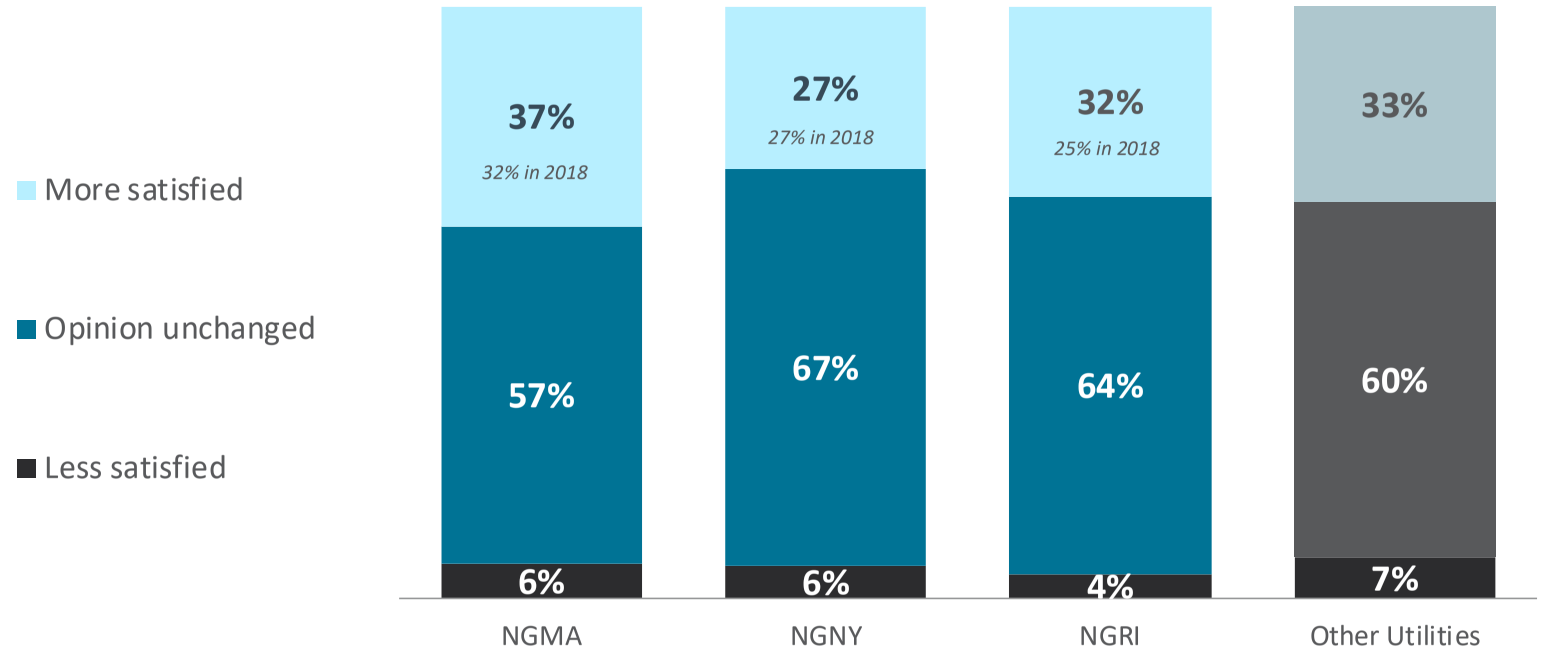
The accuracy of the neighbor comparisons... where do they get their information? I can't use any less energy than I already do.

It shows my neighbors are cheap. They don't turn on the air conditioning even if it's really hot outside.

It's not specific for my situation, in other words averages are not going to help me. I need specifics for my situation. I have a hot tub. I'd like to know how i stack up for other people who have hot tubs.

Third of customers more satisfied with Grid due to reports, compared to 5% reporting lower satisfaction

Did receiving the report make you more satisfied or less satisfied with National Grid or did your opinion not change?

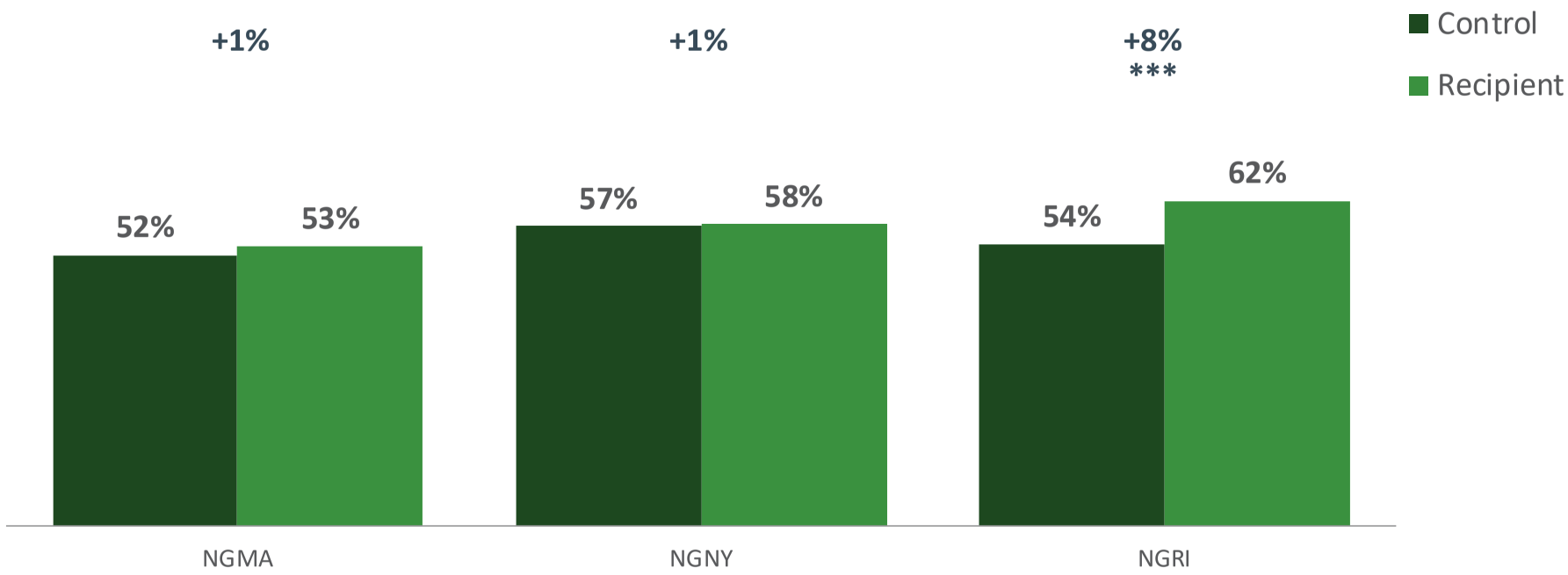


Did receiving the report make you more satisfied or less satisfied with National Grid or did your opinion not change?

Reports driving perception that National Grid wants to help customers save money in Rhode Island

Statement Agreement: National Grid wants to help me save money

Top 2 Box; 5pt. agreement scale

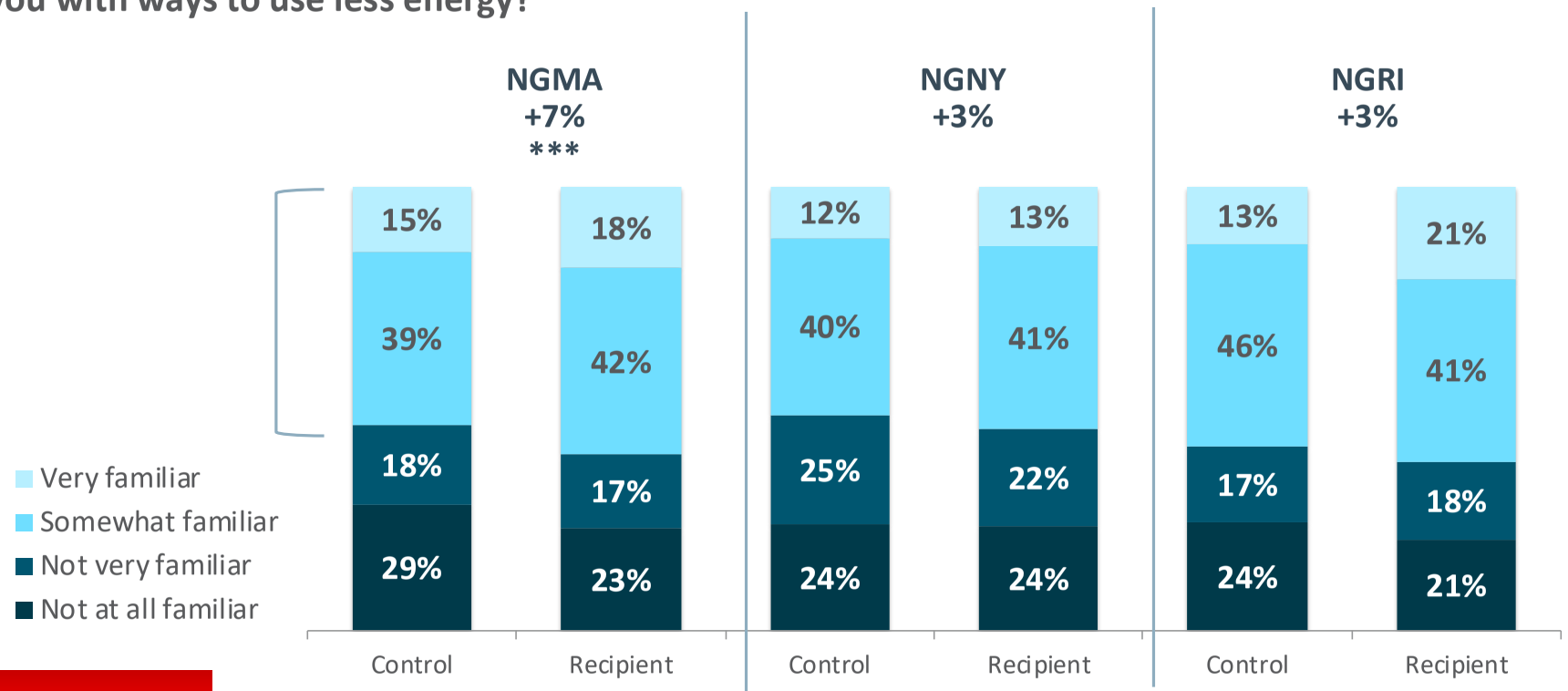


Thinking about National Grid, tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statements:

***95% significant difference
**90% significant difference
* 85% significant difference

Gains in other EE program familiarity, particularly in MA

How familiar are you with energy efficiency or conservation programs from National Grid that help you with ways to use less energy?



How familiar are you with energy efficiency or conservation programs from National Grid that help you w ways to use less energy?

***95% significant difference
**90% significant difference
* 85% significant difference

Gains most concentrated among NGRI customers; may be room to improve environmental messaging

Impact on Brand Perceptions of National Grid

Difference between control and recipient customers
Top 2 Box; 5pt. agreement scale or Top4 Box; 10pt agreement scale

	NGMA	NGNY	NGRI
Favorability towards National Grid	+1%	-1%	+3%
Trust National Grid advice on energy decisions	+0%	-3%	+2%
Ease of doing business with National Grid	+5% *	+1%	+1%
National Grid wants to help me save money	+2%	+0%	+8% ***
National Grid helps me manage my monthly energy usage	+4%	-4%	+9% ***
National Grid provides useful suggestions on ways I can reduce my energy usage and lower my monthly bills	+3%	+0%	+2%
National Grid creates messages that get my attention	+6% **	+0%	+2%
National Grid takes actions to help the environment	+5%	-5%	+5%
Familiarity with National Grid efficiency or conservation programs	+7% ***	+3%	+3%

Thinking about National Grid, tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statements:

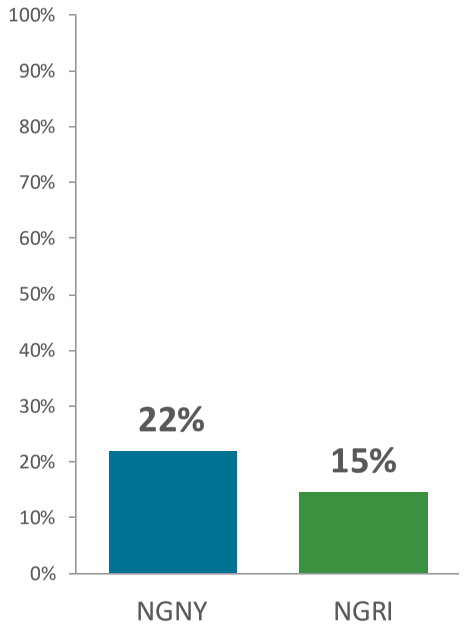
***95% significant difference
**90% significant difference
* 85% significant difference

Other comms

Lower levels of high usage alert recall, likely due to timing and no regular cadence of communication

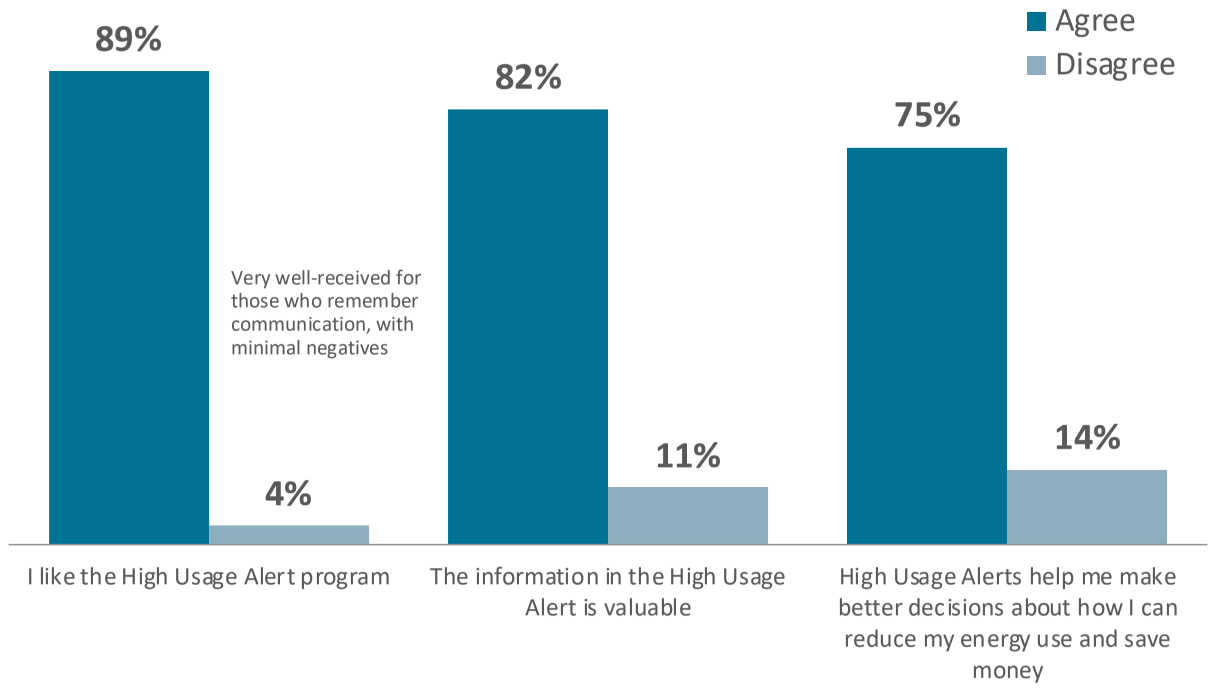
High Usage Alert Recall

165 alert recipients (unweighted)



High Usage Alert Reception

Bottom/Top 2 Box; 5pt. agreement scale (unweighted)

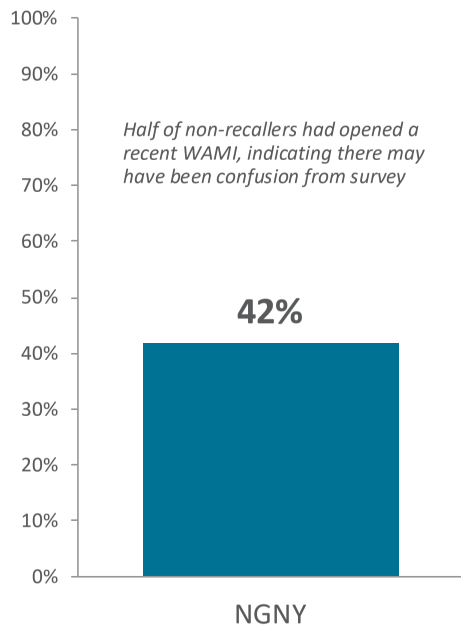


National Grid sends some customers High Usage Alerts when their usage is higher than normal…
Have you ever received a High Usage Alert?

Weekly Electricity Reports also well-received by customers, with greater recall due to frequency of delivery

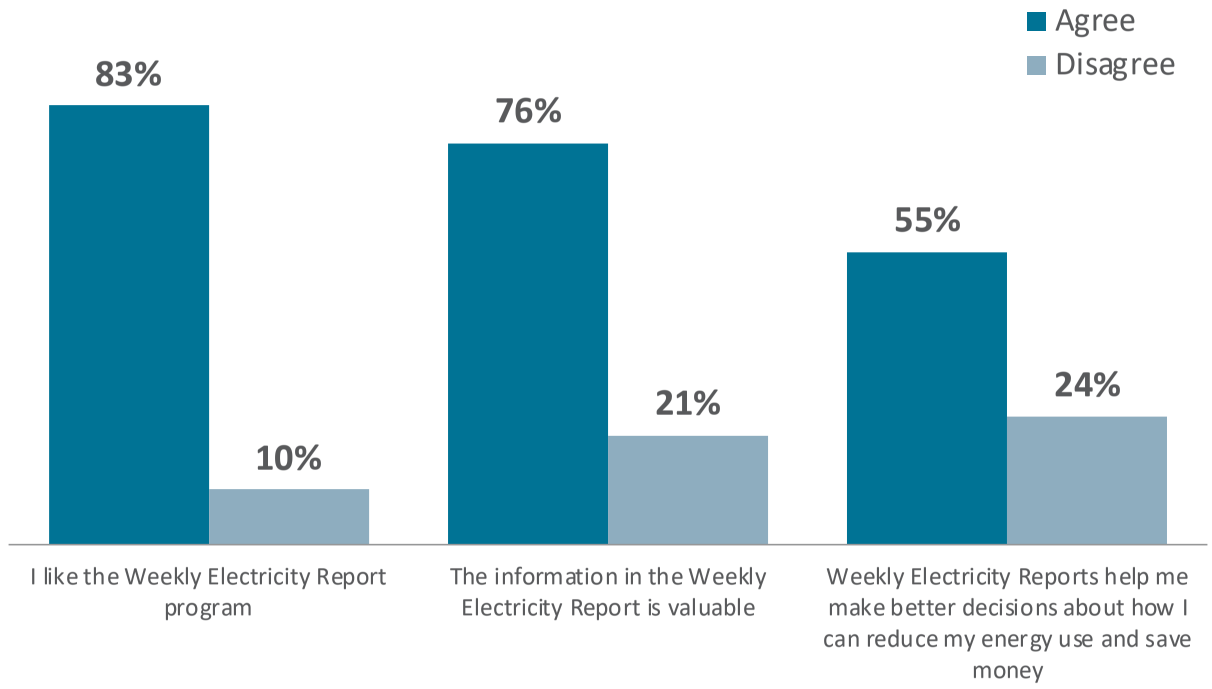
Weekly Electricity Report Recall

72 report recallers (unweighted)



Weekly Electricity Report Reception

Bottom/Top 2 Box; 5pt. agreement scale (unweighted)



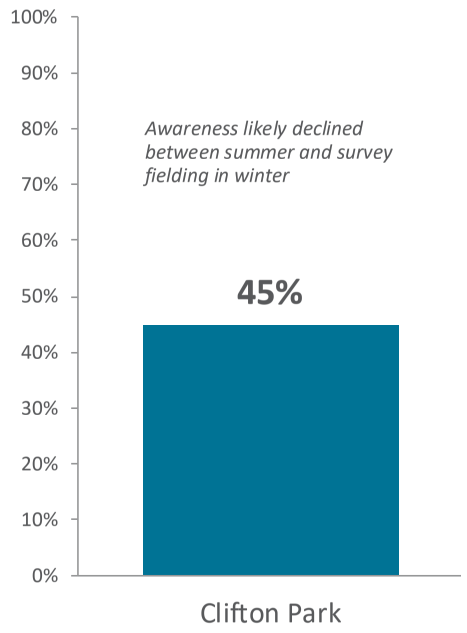
ORACLE

National Grid emails Weekly Electricity Reports to some customers that have chosen to receive them...
Have you received Weekly Electricity Reports like this?

Customer liking of conservation days exceeds motivation to save

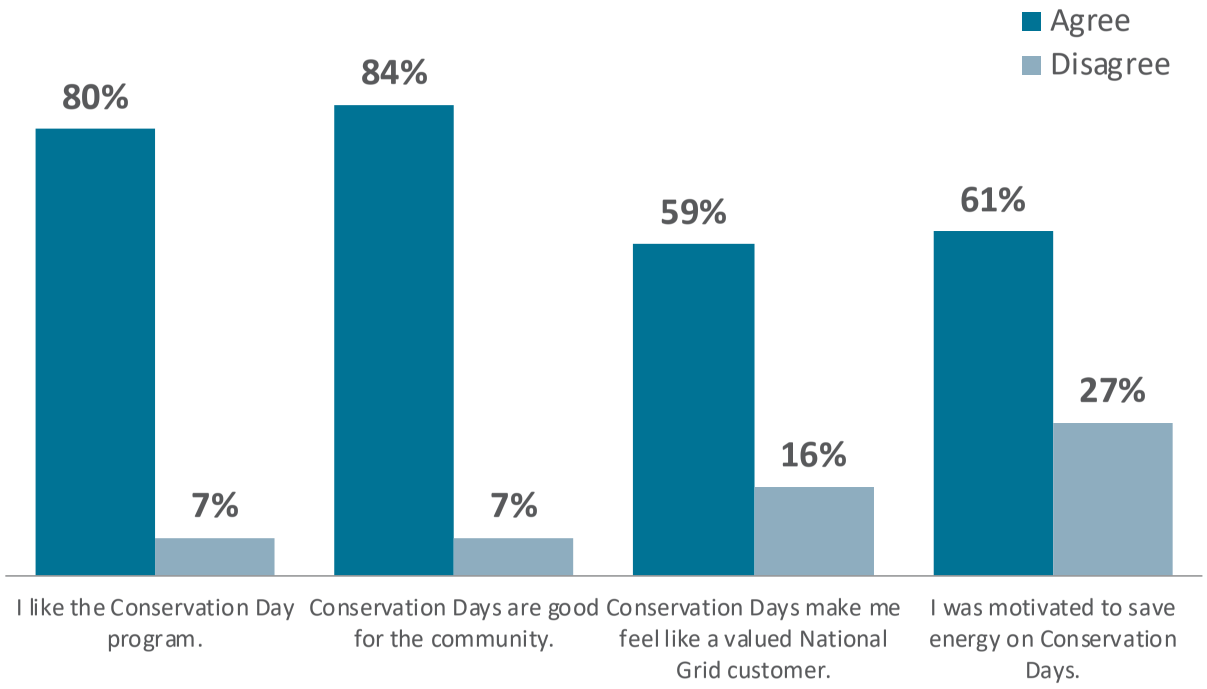
Conservation Day Recall

98 Clifton Park customers (unweighted)



Conservation Day Reception

Bottom/Top 2 Box; 5pt. agreement scale (unweighted)



This summer, some customers with central AC were sent communications about upcoming Conservation Days…
Do you remember receiving these Conservation Day communications?

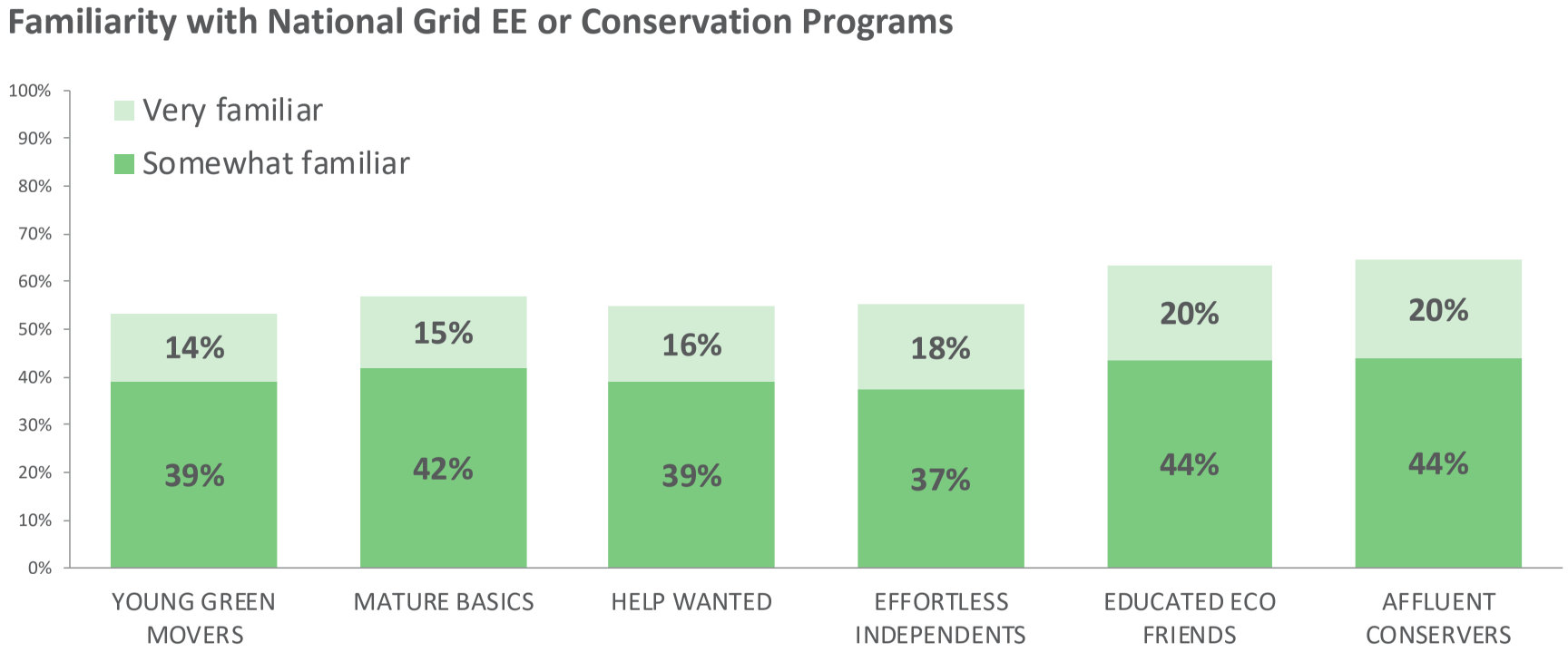
National Grid Personas

Several “Personas” identified by National Grid

Analysis uses gas persona as primary persona (due to winter survey, with electric persona as backup where no gas persona exists.

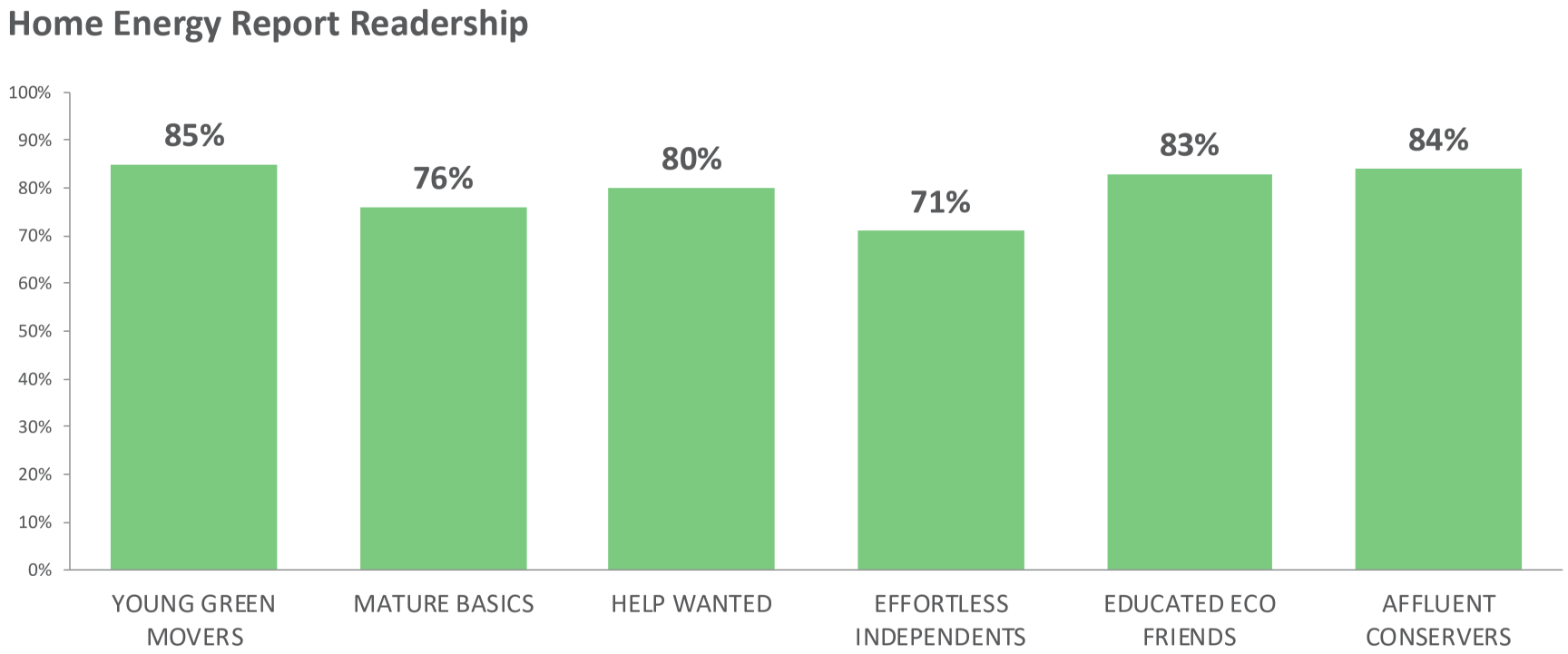
	YOUNG GREEN MOVERS	MATURE BASICS	HELP WANTED	EFFORTLESS INDEPENDENTS	EDUCATED ECO FRIENDS	AFFLUENT CONSERVERS
Survey n	182	443	134	141	338	348
Avg. Daily Winter Gas Usage	2.6	5.7	5.9	1.8	4.2	7.1
Avg. Daily Winter Elec Usage	9.2	21.6	24.8	9.4	16.9	30.2
% Homeowner	48%	85%	57%	54%	84%	95%
% College Degree	57%	55%	46%	55%	65%	73%

Affluent Conservers, Educated Eco Friends most familiar with National Grid programs



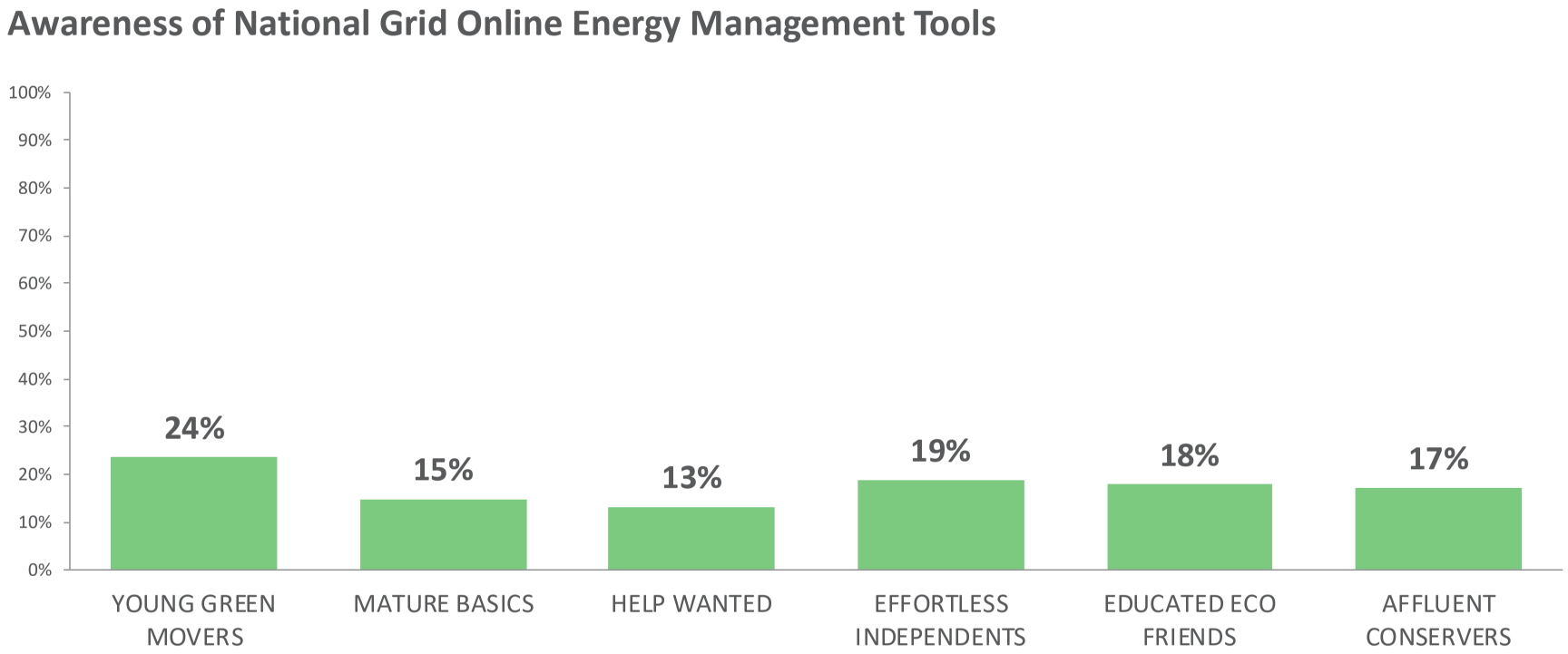
How familiar are you with energy efficiency or conservation programs from National Grid that help you with ways to use less energy?

Report readership relatively lower for Effortless Independents, Mature Basics



How familiar are you with energy efficiency or conservation programs from National Grid that help you with ways to use less energy?

Young Green Movers the most aware of online web tools; Help Wanteds the least



ORACLE

Are you aware of National Grid's online energy management tools?

Persona Outcome Summary

	YOUNG GREEN MOVERS	MATURE BASICS	HELP WANTED	EFFORTLESS INDEPENDENTS	EDUCATED ECO FRIENDS	AFFLUENT CONSERVERS
Favorable towards National Grid	74%	74%	74%	73%	75%	71%
National Grid wants to help me save	60%	52%	58%	58%	59%	55%
Familiarity with EE programs	53%	57%	55%	55%	64%	64%
HER Readership	85%	76%	80%	71%	83%	84%
HER Motivated to Save	54%	49%	55%	51%	51%	55%
HER Liking	79%	73%	80%	87%	81%	76%
HER made more satisfied with Grid	48%	28%	27%	47%	34%	31%
Online tool awareness	24%	15%	13%	19%	18%	17%

YGM: Strongest HER readership and online awareness. Consider targeting with more program marketing modules as EE program familiarity is low.

MB: Relatively lower levels of report motivation and reception. Possibly adjusting messaging could lead to improved outcomes.

HW: Opportunity to promote online energy management tools in outbound communications to improve familiarity with those options.

EI: Lower HER readership, although highest levels of program satisfaction. Consider engaging further across multiple channels to expand message reach.

Appendix

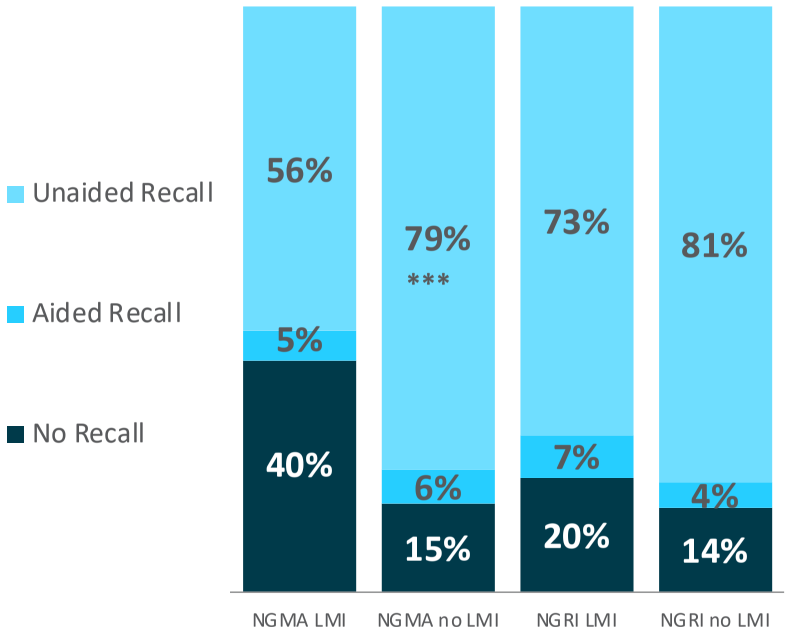
NGNY weights applied due to Clifton Park oversample when reporting overall territory results

Clifton Park	Population	Sample	Weight
YES	0.92%	12.23%	0.08
NO	99.1%	87.77%	1.13

LMI recall differences mainly observed in MA

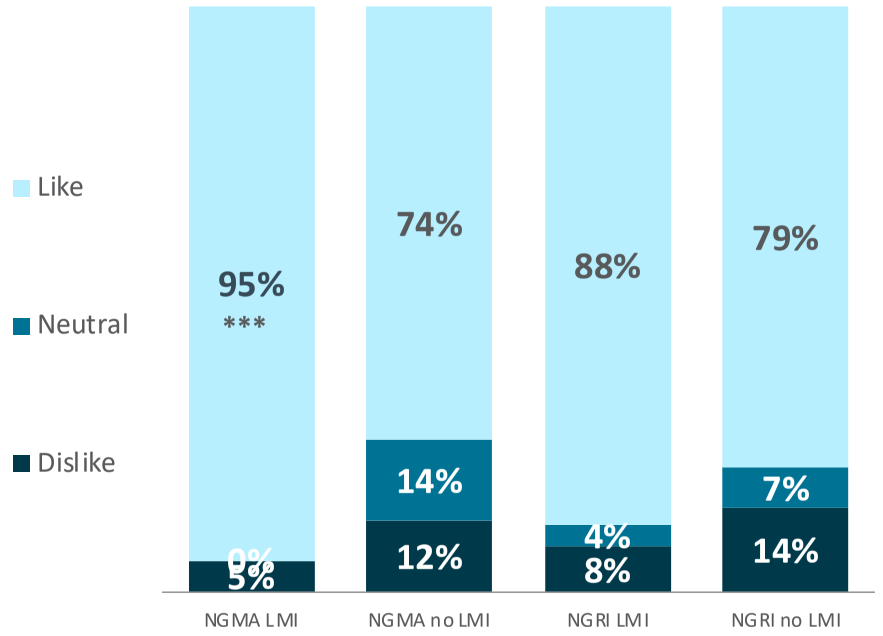
Home Energy Report Recall

63 LMI report recipients at NGMA
41 LMI report recipients at NGRI



Home Energy Report Liking

37 recalling LMI Home Energy Report recipients at NGMA
26 recalling LMI Home Energy Report recipients at NGRI; 5pt scale

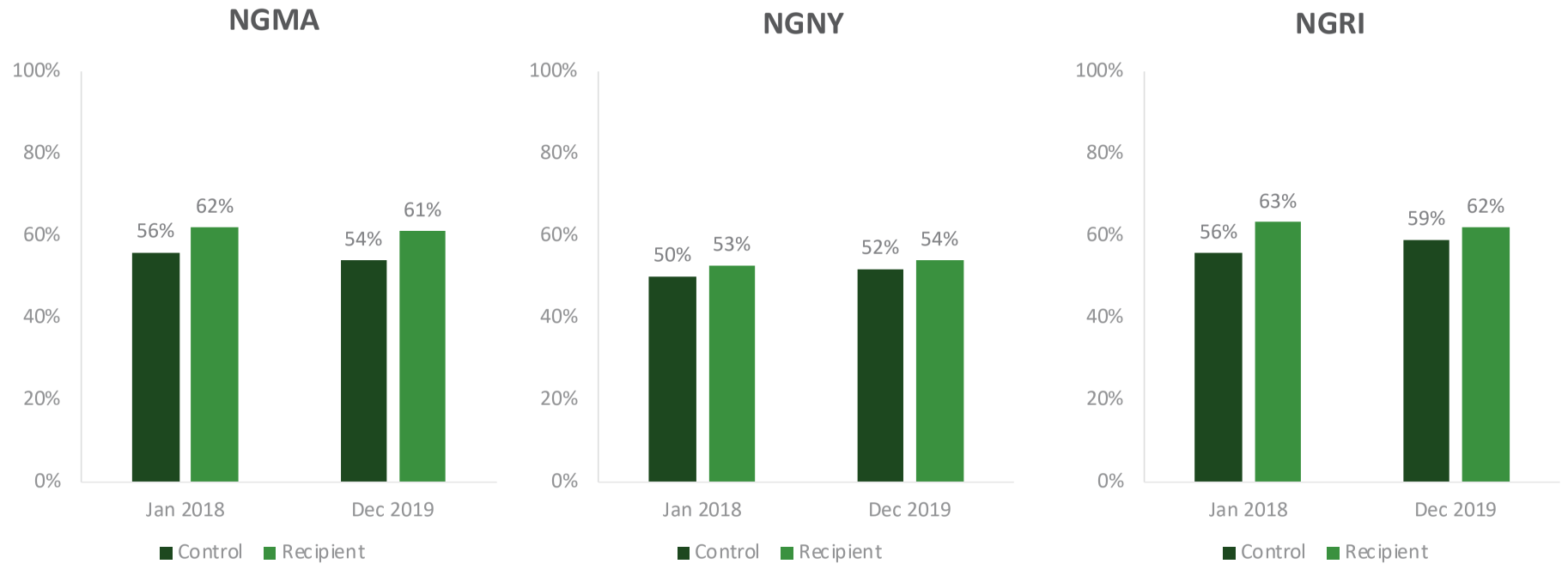


Tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statement: I like the Home Energy Reports.

***95% significant difference
**90% significant difference
* 85% significant difference

Similar levels of program familiarity compared to 2018

How familiar are you with energy efficiency or conservation programs from National Grid that help you with ways to use less energy? (Familiar & Very Familiar)



Gains most concentrated among MA/RI customers; may be room to improve environmental messaging

Impact on Brand Perceptions of National Grid

Difference between control and recipient customers
Top 2 Box; 5pt. agreement scale or Top4 Box; 10pt agreement scale

	MA		NY		RI	
	Jan 2018	Dec 2019	Jan 2018	Dec 2019	Jan 2018	Dec 2019
Favorability towards National Grid	-1%	1%	-5% *	-1%	2%	3%
Trust National Grid advice on energy decisions	-2%	0%	-5% *	-3%	-4%	2%
Ease of doing business with National Grid	2%	5% *	-3%	1%	-4%	1%
National Grid wants to help me save money	4%	2%	7% ***	0%	9% ***	8% ***
National Grid helps me manage my monthly energy usage	-1%	4%	0%	-4%	10% ***	9% ***
National Grid provides useful suggestions on ways I can reduce my energy usage and lower my monthly bills	2%	3%	0%	0%	5% *	2%
National Grid creates messages that get my attention	0%	6% **	0%	0%	3%	2%
National Grid takes actions to help the environment	-6% **	5%	-8% ***	-5%	6% *	5%
Familiarity with National Grid efficiency or conservation programs	6% **	7% ***	3%	3%	7% **	3%

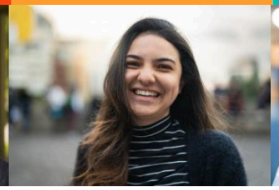
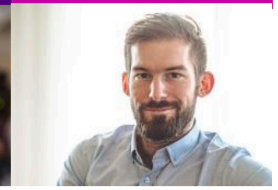
ORACLE

Thinking about National Grid, tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statements:

***95% significant difference
**90% significant difference
* 85% significant difference

Residential Needs-Based Segments (Personas)

Segments influence strategic and tactical efforts, including strategy, marketing, branding, and product/service offerings

EDUCATED ECO-FRIEND	AFFLUENT CONSERVER	HELP WANTED	YOUNG GREEN MOVER	MATURE BASIC	EFFORTLESS INDEPENDENT
					
"Prove to me you care about the environment"	*"Help me save with informed energy decisions"*	*"Provide me personalized ways to lower my bill"*	*"Show me you care about our communities"*	*"Make it easy to reach you and provide simple communications"*	*"Be transparent and provide a seamless way to interact with you"*
• Highly educated • Socially responsible • Dislikes inefficiency	• Highest income • Large home & energy bills • Seeks advice to make decisions	• Lowest income • Deal oriented • Wants savings, easy-to-use apps	• Urban renter • Socially conscious • Minimize expenses	• Empty nester • Longest customers • Simple needs	• Personal comfort over conservation • Desire ease, reliability

* Provided by National Grid

Customer Engagement Tracker Results

Prepared for National Grid MA & RI

February 26th, 2018

Research Methodology

Telephone survey of 1,613 National Grid Massachusetts and Rhode Island customers

- **1010 interviews** with Home Energy Report program recipients
- **603 interviews** with Home Energy Report controls
- Simultaneous separate outreach to NGNY customers

Randomized selection of customers within MA and RI report programs

- Sample includes 509 eHER recipients; 127 customers in "Low Income" group
- Slight oversample for RI "Low Income" customers; data weights applied for overall results

Survey fielded between Dec 19, 2017 and Jan 23, 2018 (pausing Dec 22 to Jan 1)

- Survey conducted by third party research provider ISA
- Semi-standard questionnaire, designed in conjunction with National Grid
- 5% overall response rate (33% upon successful contact)

Key Findings

Continued strong engagement with Home Energy Reports at National Grid MA & RI

- Readership increasing: 81% of customers actively reading communications, up from 75% in late 2015
- EE action sustained: 40% of recipients report taking some form of energy-savings action
- Report reception above benchmark; stable over time: 77% of customers like reports (14% disliking)

Gains seen in customer brand perception and program awareness

- Net impact improving over time: 29% say reports make them more satisfied with Grid; 5% less satisfied
- +6% National Grid wants to help me save money, compared to control
- +5% National Grid provides a variety of energy efficiency programs, compared to control
- +7% general familiarity with National Grid energy efficiency programs, compared to control

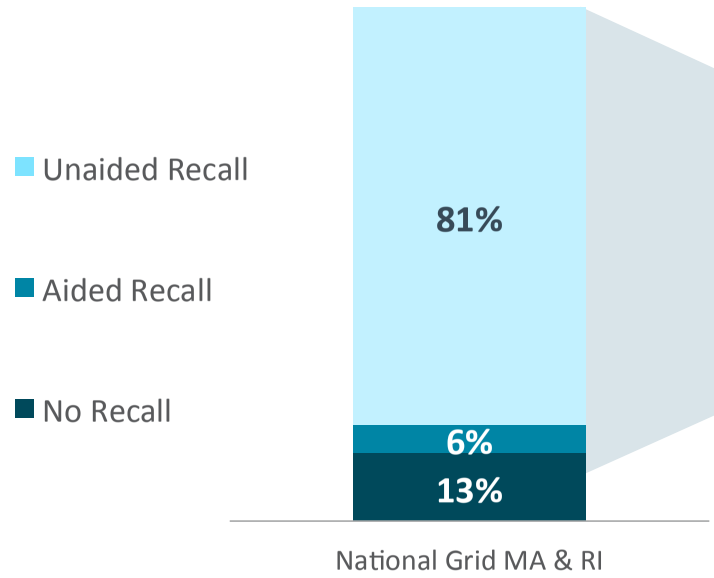
Opportunities to further program impact

- Increasing or providing targeted on-report environmental messaging may yield improvement: MA recipients rate Grid lower on this metric

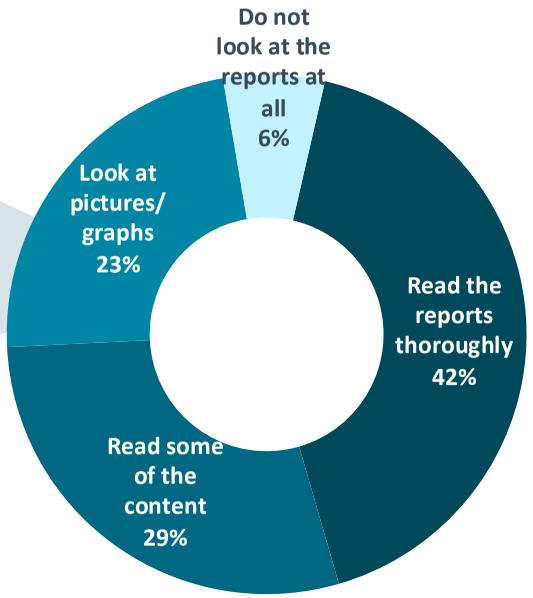
81% of New England customers engaging with content

Home Energy Report Recall

1006 Home Energy Report recipients



Home Energy Report Reading



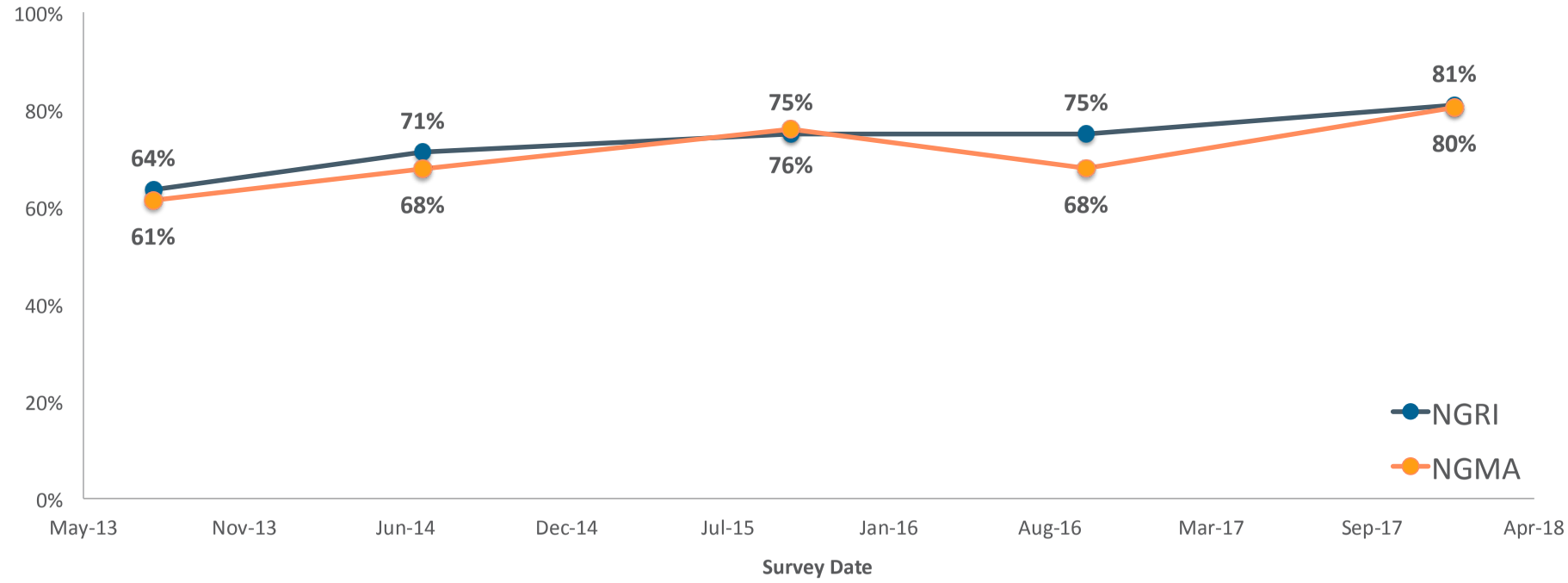
81% Overall Readership

In the past three months, do you remember receiving a Home Energy Report from National Grid about your in-home energy use? Thinking of all the reports you have received, in general, what have you done with them? Did you…

Overall report readership steadily increasing over time

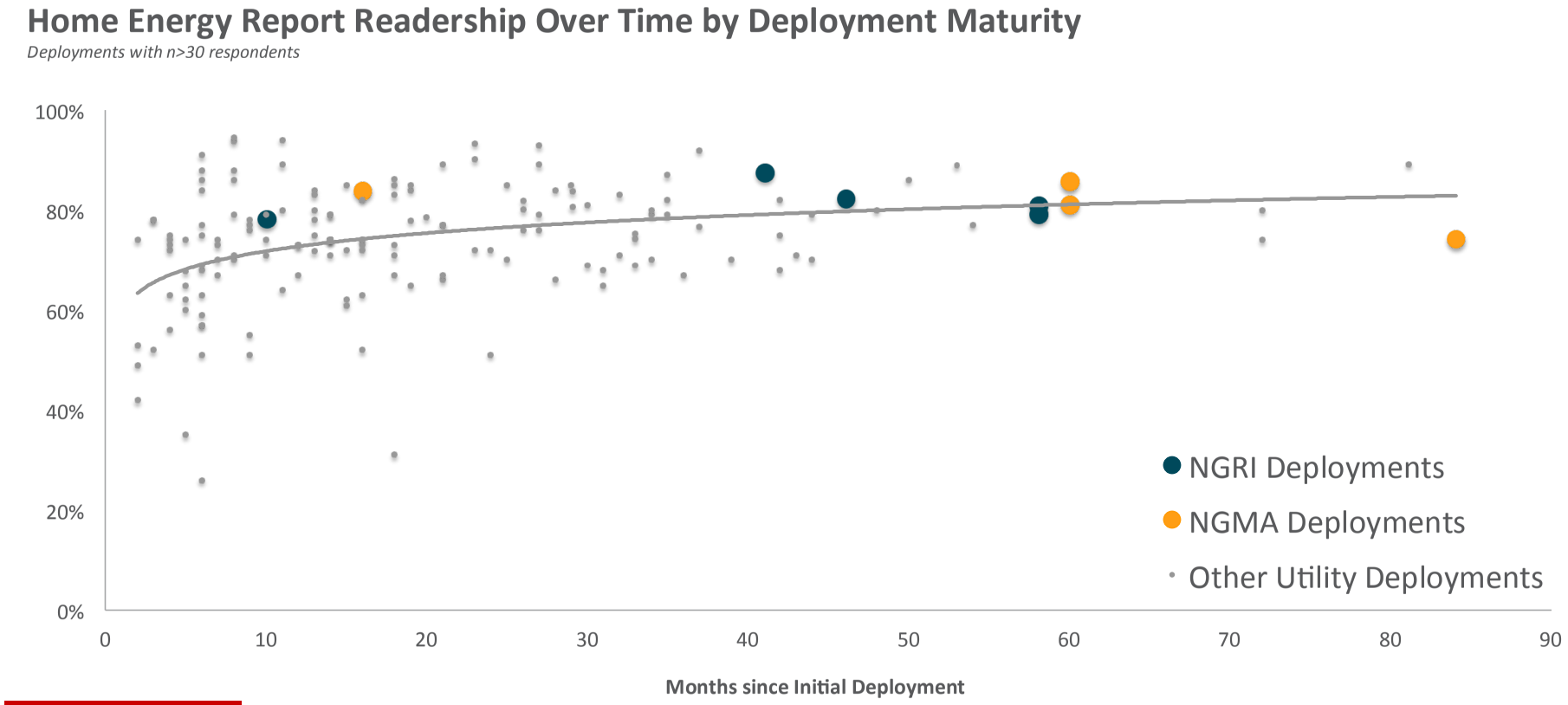
Home Energy Report Readership Over Time

5 surveys of NGMA and NGRI report recipients



In the past three months, do you remember receiving a Home Energy Report from National Grid about your in-home energy use? Thinking of all the reports you have received, in general, what have you done with them? Did you…

At different stages of program maturity, readership is in line with similar utility programs

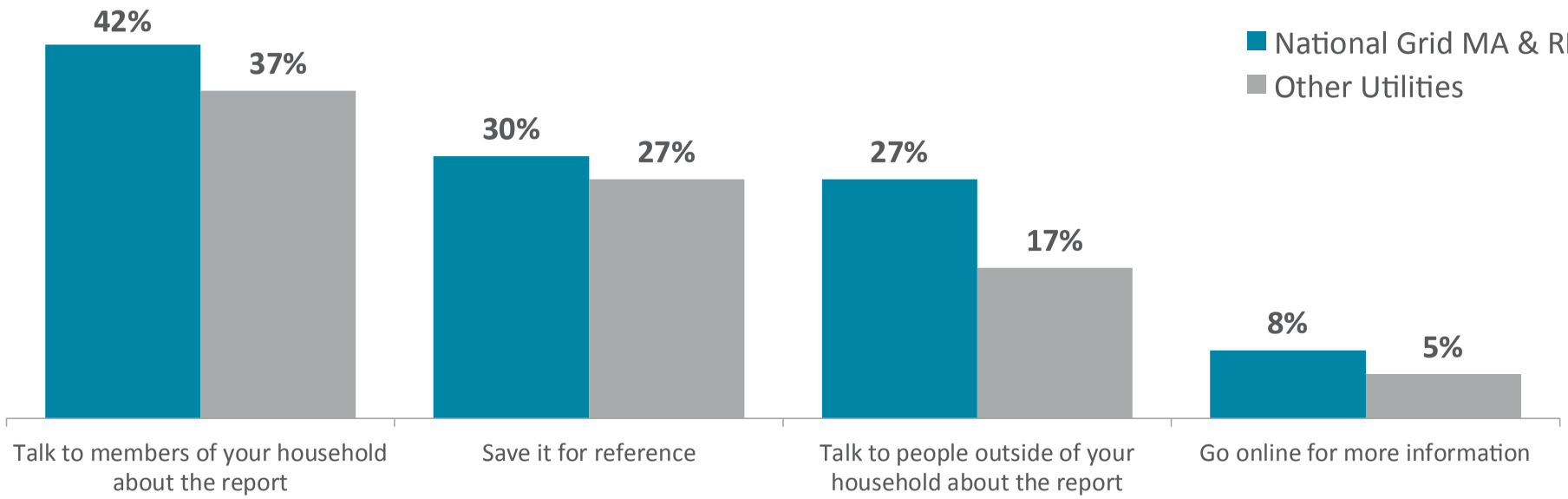


In the past three months, do you remember receiving a Home Energy Report from National Grid about your in-home energy use? Thinking of all the reports you have received, in general, what have you done with them? Did you…

Levels of report sharing exceed other utility deployments

Home Energy Report Interaction

812 recalling and reading Home Energy Report recipients



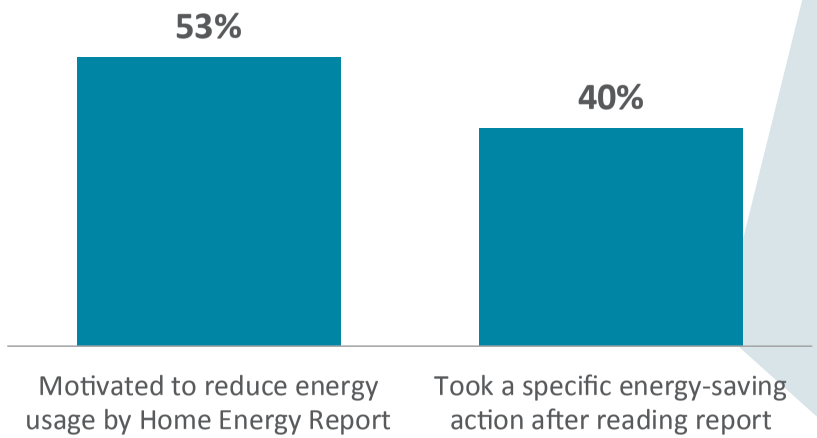
ORACLE

After reviewing your report, what do you typically do with it?

53% of customers motivated to reduce usage

Energy-Saving Actions – National Grid MA & RI

800 recalling and reading Home Energy Report recipients



Which actions did you take? Examples

"I got on my landlord to make our home more energy efficient"

"I had the energy audit done, they came in we did great on it, and the only thing they could do was put in energy efficient light bulbs"

"I am having new windows installed as we speak. Had Mass Save come over and got new insulation"

"We did most of the things suggested, changed all the light bulbs to LED and purchased more efficient appliances"

"Try to reduce the gas and the heating but the weather has been crazy"

"I convinced my husband to turn off lights in empty rooms"

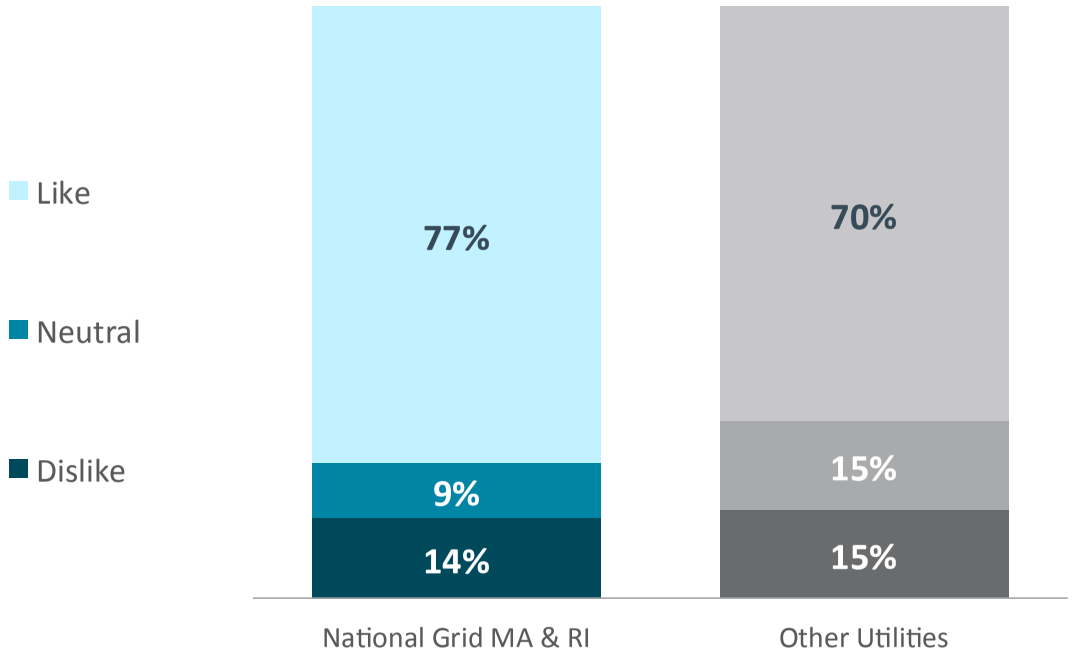
ORACLE

Did the Home Energy Report motivate you to reduce your energy usage? After reviewing your report, what do you typically do with it? …Take a specific energy-saving action? What actions did you take?

77% of customers like reports, exceeding benchmark

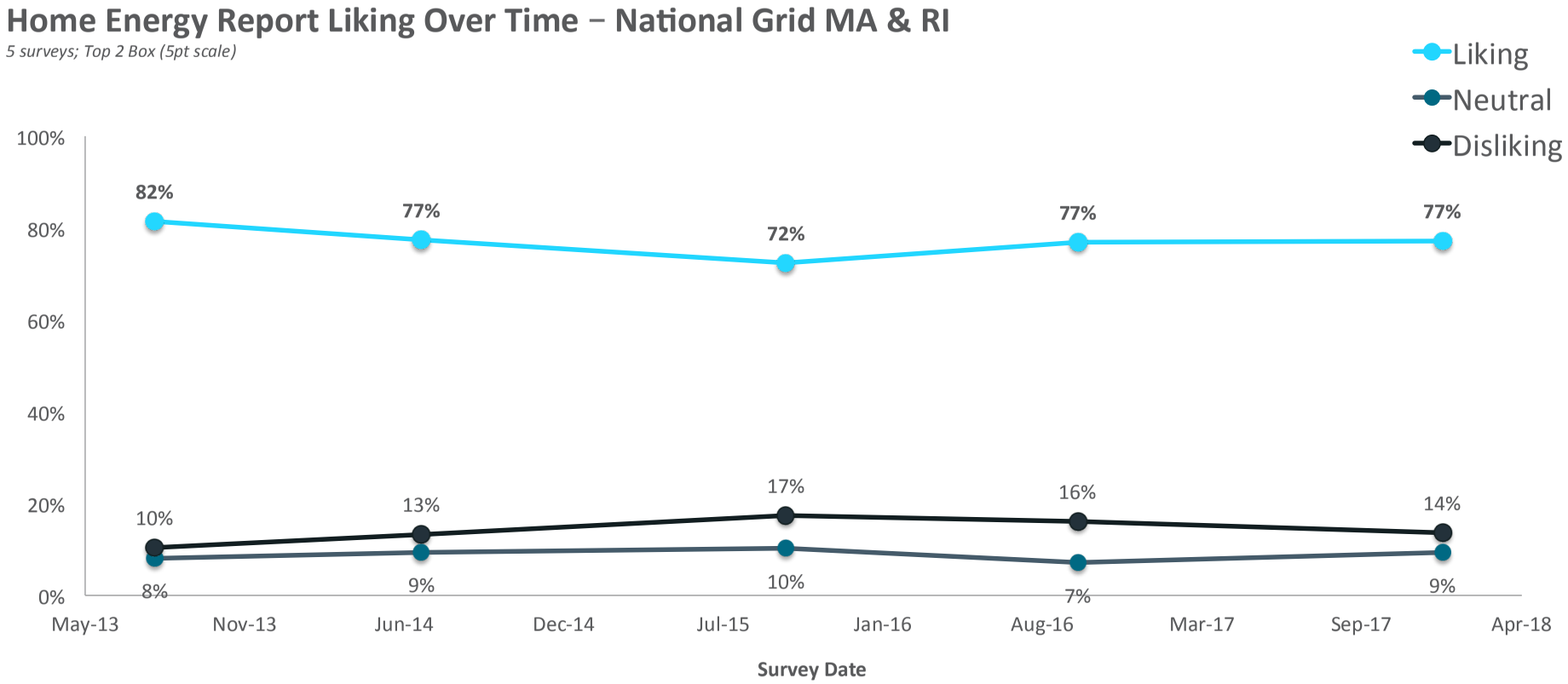
Home Energy Report Liking

808 recalling Home Energy Report recipients; 5pt scale



Tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statements: I like the Home Energy Reports.

As readership increases, overall report reception has been stable over time

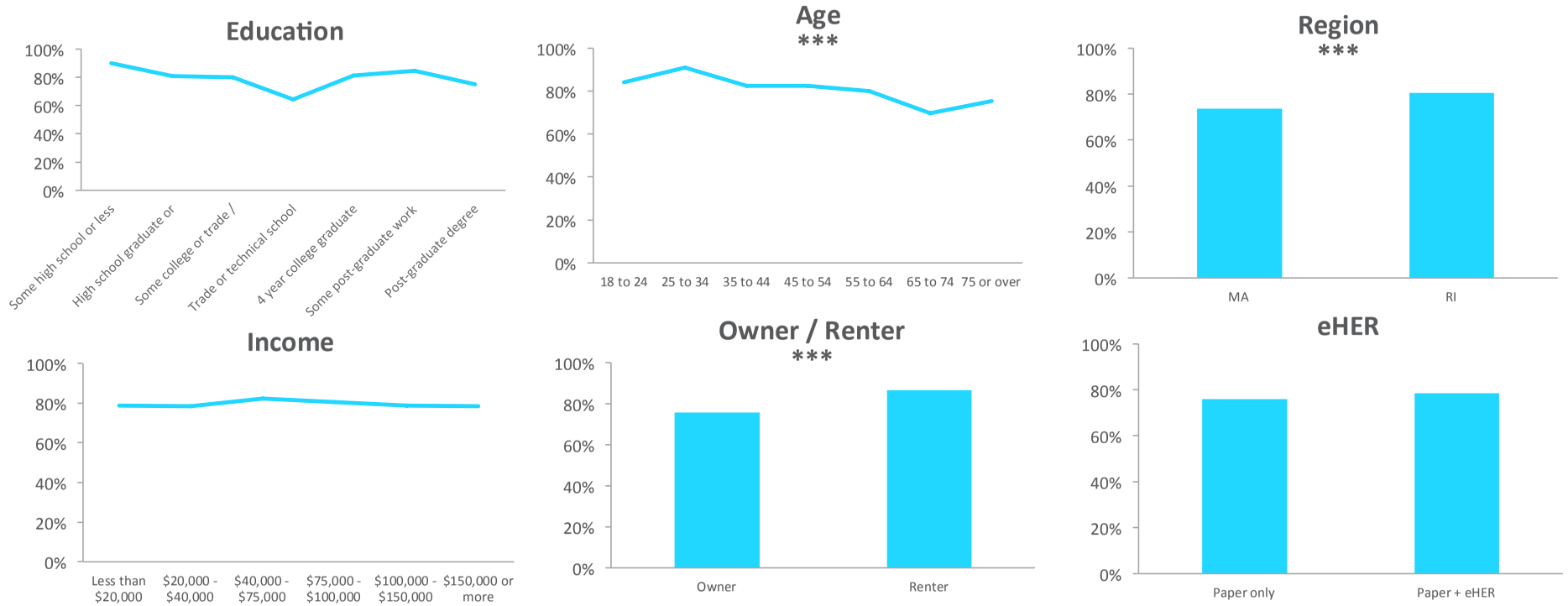


Tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statements: I like the Home Energy Reports.

Younger customers, renters most positive about experience. RI program in particular is well-received.

Home Energy Report Liking by Characteristic

808 recalling Home Energy Report recipients; 5pt scale



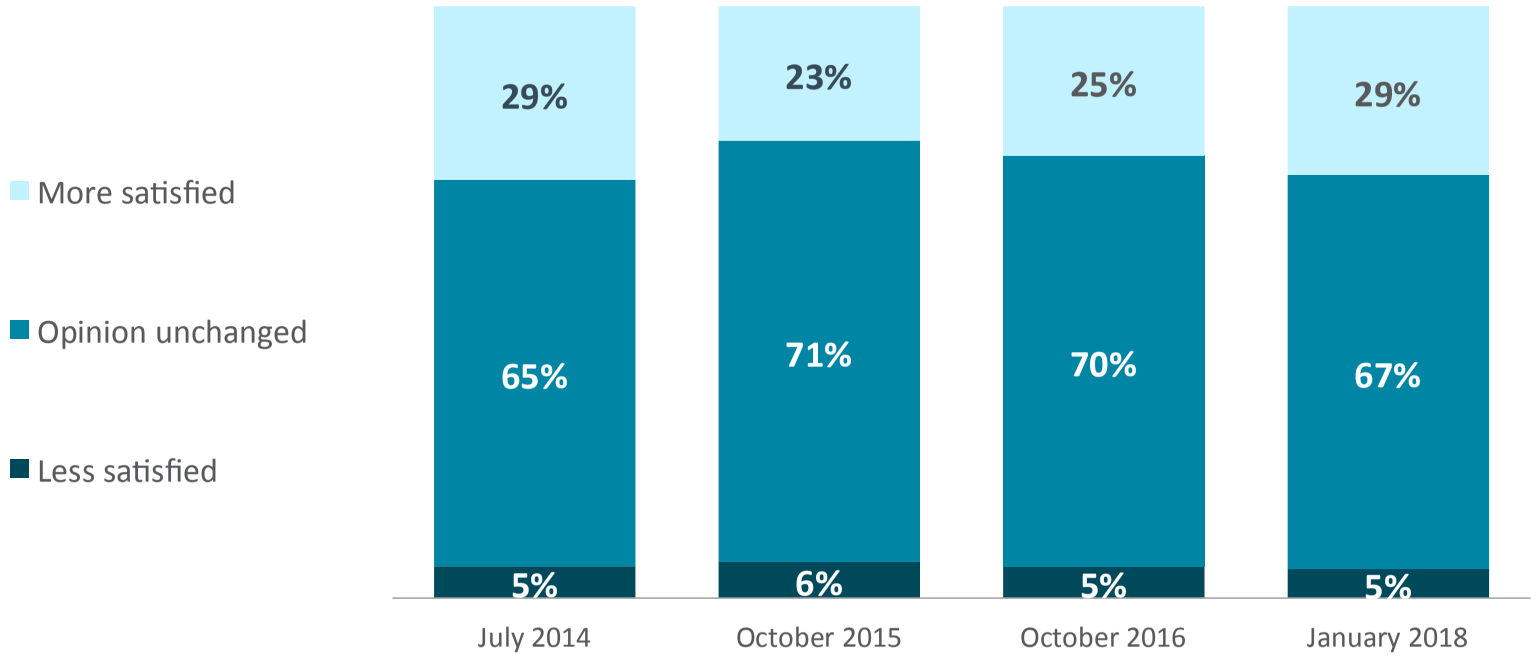
Tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statements: I like the Home Energy Reports.

***95% significant difference
**90% significant difference

Self-reported impact on customer satisfaction steadily increasing since 2015

Did receiving the report make you more satisfied or less satisfied with National Grid or did your opinion not change? – National Grid MA & RI

5 surveys over time



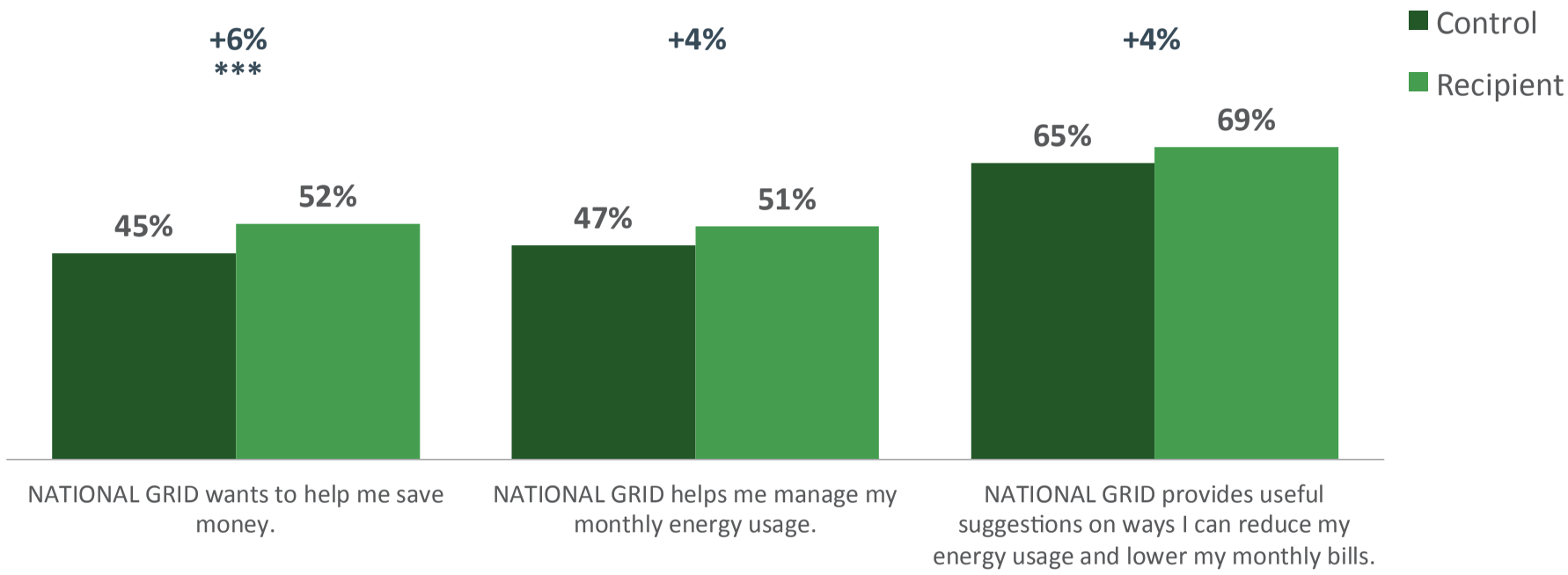
Did receiving the report make you more satisfied or less satisfied with National Grid or did your opinion not change?

***95% significant difference
**90% significant difference

Report recipients 6% more likely to believe National Grid wants to help them save money

Impact on Brand Perceptions of National Grid MA & RI

1010 Home Energy Report recipients; 603 Home Energy Report controls
Top 2 Box; 5pt. agreement scale



ORACLE

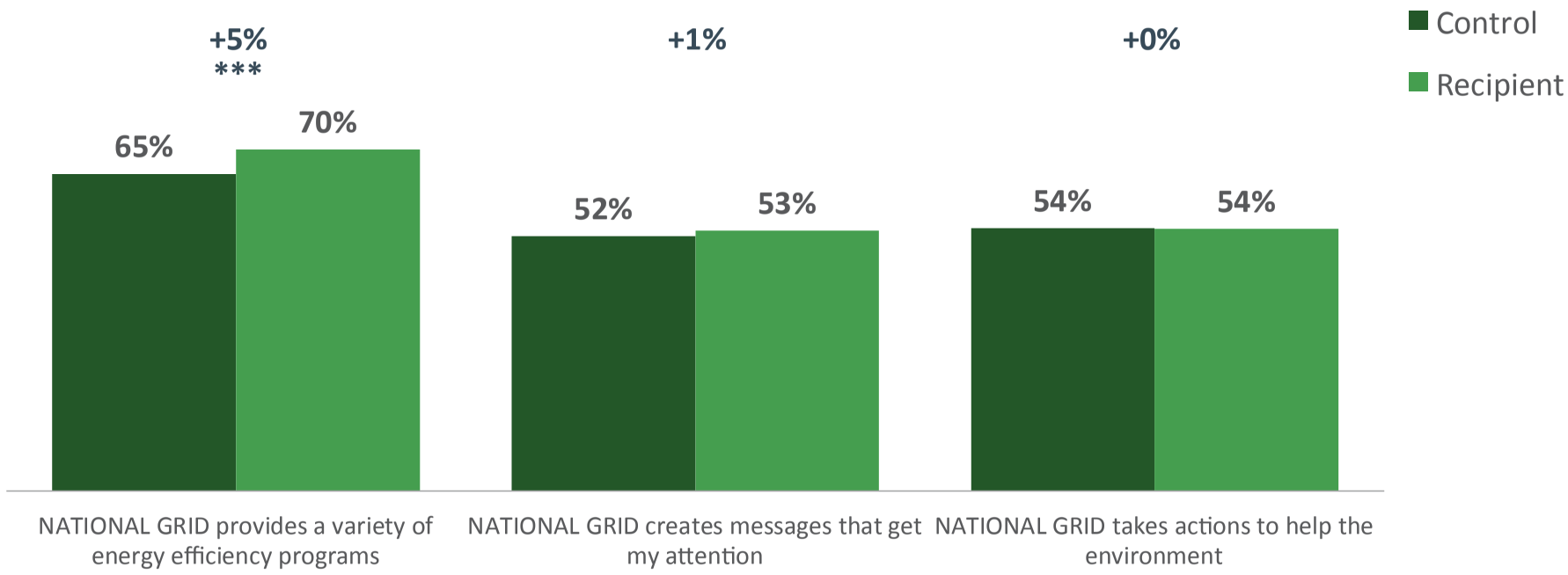
Thinking about National Grid, tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statements:

***95% significant difference
**90% significant difference

Recipients also perceive Grid as offering more EE programs

Impact on Brand Perceptions of National Grid MA & RI

1010 Home Energy Report recipients; 603 Home Energy Report controls
Top 2 Box; 5pt. agreement scale



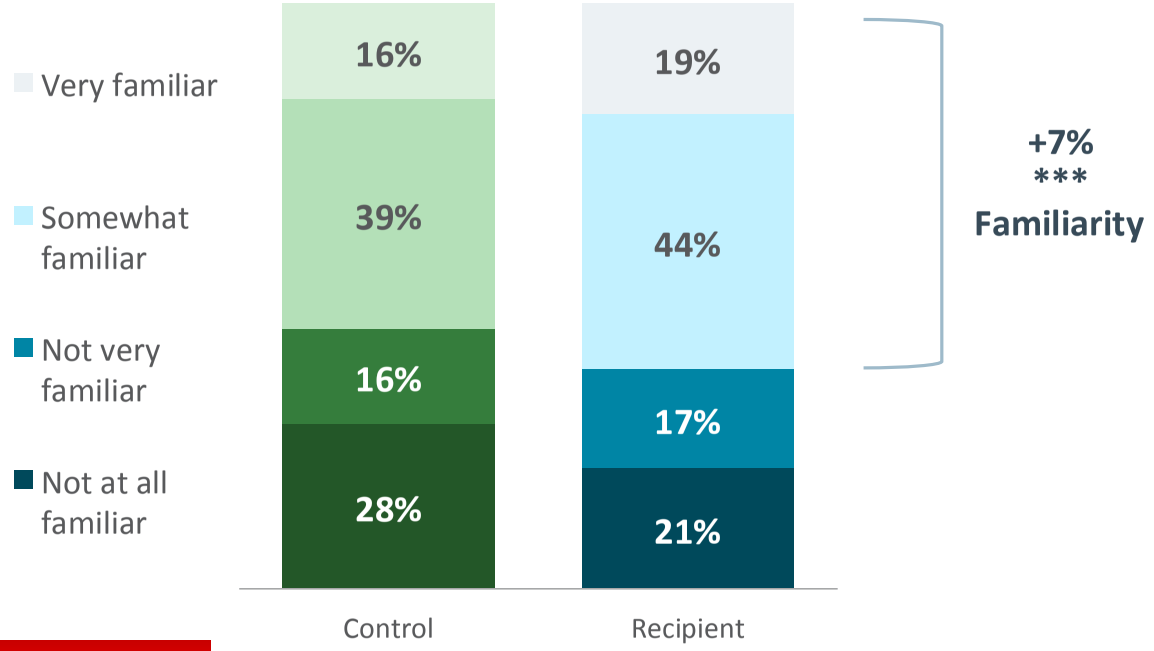
Thinking about National Grid, tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statements:

***95% significant difference
**90% significant difference

Report recipients more likely to be familiar with Grid efficiency programs

How familiar are you with energy efficiency or conservation programs from National Grid that help you with ways to use less energy?

1010 Home Energy Report recipients; 603 Home Energy Report controls



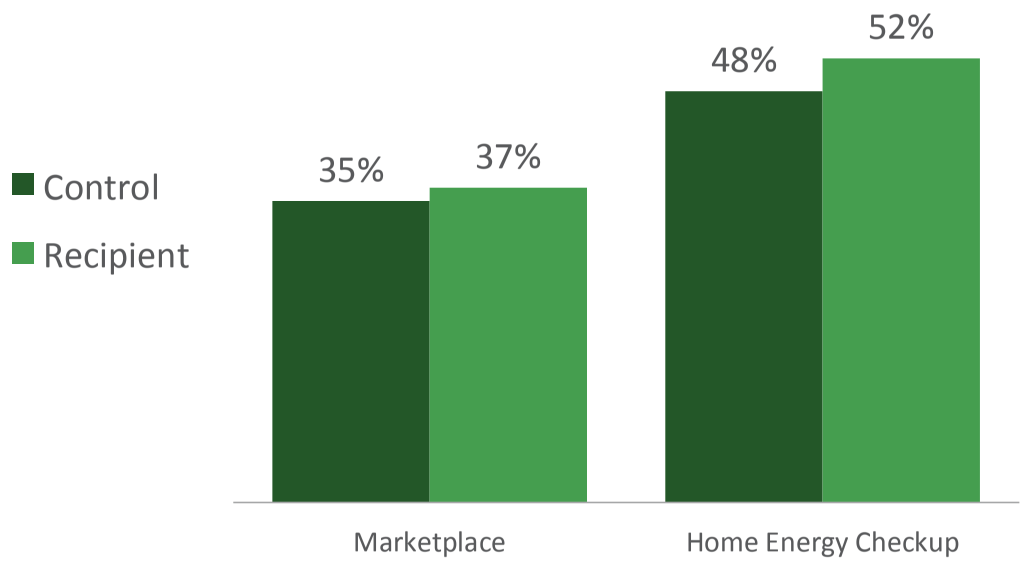
How familiar are you with energy efficiency or conservation programs from National Grid that help you with ways to use less energy?

***95% significant difference
**90% significant difference

However, no difference in familiarity with specific programs

Which of the following National Grid programs are you familiar with?

1010 Home Energy Report recipients; 603 Home Energy Report controls



ORACLE

Which of the following National Grid programs are you familiar with?

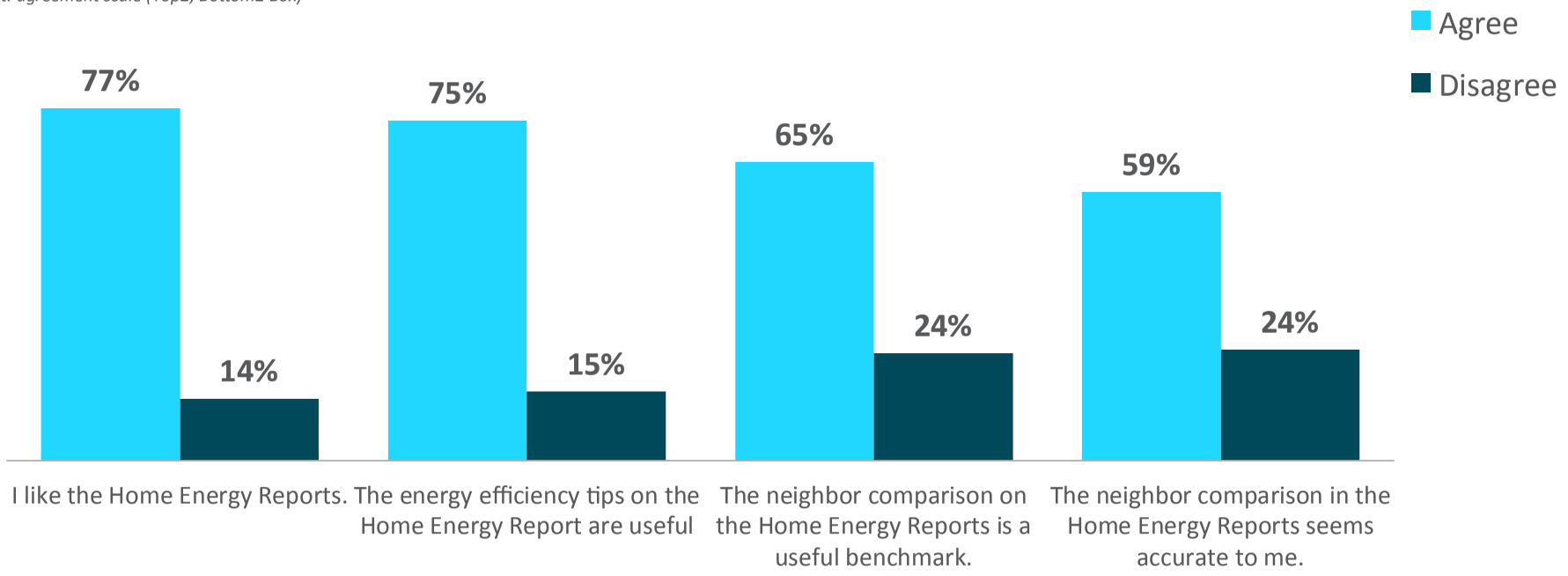
**95% significant difference
*90% significant difference

Appendix

Usefulness of the report outpaces perceptions of comparison

Home Energy Report Reception – National Grid MA & RI

808 recalling Home Energy Report recipients
5pt. agreement scale (Top2, Bottom2 Box)



Tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statements

Data weights applied to overall RI numbers due to slight oversample for “Low Income” customers

NGRI Recipients	Population %	Sample %	Weight
Low Income	11%	18%	0.59
Non Low Income	89%	82%	1.08

Gains most concentrated among NGRI customers; may be room to improve environmental messaging

Impact on Brand Perceptions of National Grid

Difference between control and recipient customers
Top 2 Box; 5pt. agreement scale

	NGMA	NGRI
NATIONAL GRID wants to help me save money.	4%	9% ***
NATIONAL GRID helps me manage my monthly energy usage.	-1%	10% ***
NATIONAL GRID provides useful suggestions on ways I can reduce my energy usage and lower my monthly bills.	2%	5%
NATIONAL GRID provides a variety of energy efficiency programs	6%	4%
NATIONAL GRID creates messages that get my attention	0%	3%
NATIONAL GRID takes actions to help the environment	-6%	6%

Thinking about National Grid, tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statements:

***95% significant difference
**90% significant difference

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Customer Engagement Tracker Survey – National Grid

Survey Objectives & Structure

The Customer Engagement Tracker (CET) survey is an instrument designed to explore utility customer reactions to the Home Energy Reports program and other related outreaches. The instrument incorporates a variety of standardized questions that enable applicable comparisons to other surveyed Opower utility deployments, representing over 170,000 customer interviews across 70 distinct utility partners.

At National Grid, the survey aims to accomplish the following high-level objectives, among others:

- Explore customer interaction with and reception of the Home Energy Report, for customers across all National Grid territories and deployments
- Gauge overall impact of the program on the National Grid customer relationship, both via self-reported influence and by measuring differences in engagement between program participants and non-participants (controls)
- Compare results between National Grid deployments and those of other utility partners, with an eye towards potential program improvements
- Compare results to previous survey efforts at National Grid
- Segment results by key customer groups, such as Personas and LMI status
- Explore reactions to other experiences, including: High Usage Alerts, Weekly AMI emails, Demand Response Reward, Target Rank, and Solar customers

Survey Methodology

- Phone survey of randomly-selected National Grid customers across all territories:
  - Massachusetts:
    - 300 HER controls
    - 500 HER recipients
      - Oversample: High usage Alerts
      - Oversample: Solar customers
  - New York
    - 300 HER controls
    - 500 HER recipients
      - Oversample: Clifton Park (WAMIs/DRR)
  - Rhode Island
    - 300 controls

    - 500 recipients
        - Oversample: High Usage Alerts
        - Oversample: Target Rank

- Phone calls to be conducted with California-based provider Interviewing Service of America, an AMA and CASRO-certified research vendor
- Randomized selection of interviewees, excluding opt-out and inactive customers
- Interviews conducted over a three-week period in mid/late November 2020 (timeline can be adjusted according to National Grid's capacity and goals), with a pause over Thanksgiving break.
- Overall target interview length: ~10 minutes for recipients and ~7 minutes for controls

Survey Questionnaire Script

Script: Hello, I'm [FNAME] from Interviewing Services of America, calling with a survey on behalf of your utility, National Grid. I have some questions about communications you might have received from National Grid. We are only gathering information on your opinions and experiences. The survey will take no more than 10 minutes of your time, and your answers will remain confidential.

Do you have some time to help us out?

- Yes
- No

Thank you. As we all continue navigating the many challenges surrounding the COVID-19 pandemic, please know that National Grid is continually working to protect their customers and employees as they deliver essential services to our communities. National Grid is grateful to have you as a customer, and appreciate you taking the time to offer your feedback.

Screeners and Identification [all customers]

S1. Did I reach you on a cell phone?
- Yes
- No [SKIP TO S4]

S2. Are you driving a vehicle at the moment?
- Yes
- No [SKIP TO S4]

S3. Is there a more convenient time to reach you?
- Yes [SCHEDULE CALLBACK]
- Yes, and please call this alternate number -- [SCHEDULE CALLBACK]
- No, I don't wish to participate -- [THANK AND TERMINATE]

S4. Do you or any member of your household work for National Grid?
- Yes [THANK and TERMINATE]
- No

S5. Are you the person in your household who typically pays your energy bill?
- Yes [SKIP TO Q1]
- No

S5. Is the person responsible for paying your energy bill available?
- Yes [TRANSFER TO THIS PERSON IF AVAILABLE, RE-READ INTRO, THEN BEGIN AT Q1]
- No

S6. Is there a better time for me to call them back and reach them?
- Yes [SCHEDULE CALL BACK]

- No [THANK AND TERMINATE]

Overall Satisfaction and Engagement [all customers]

1. Considering everything you have experienced, read or heard, how would you say you ***feel*** about National Grid overall. That is, how favorable are you toward the company? Please use a scale from ONE TO TEN, where ONE means 'Dislike National Grid Very Much' and TEN means 'Like National Grid Very Much'. You can use any number from 1-10.

2. Next, considering everything you may know about National Grid, how much do you ***trust*** National Grid to provide you the advice you need to make good energy decisions? Please use a scale from ONE TO TEN, where ONE means 'Do Not Trust Advice at All', and TEN means 'Trust Advice Completely'. You can use any number from 1-10.

3. Thinking about National Grid, tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statements: [RANDOMIZE STATEMENTS]
    a. National Grid wants to help me save money
    b. National Grid helps me manage my monthly energy usage
    c. National Grid provides useful suggestions on ways I can reduce my energy usage and lower my monthly bills
    d. National Grid creates messages that get my attention
    e. During COVID-19, National Grid is helping customers by providing information and tools to better manage their energy consumption.

4. How familiar are you with energy efficiency or conservation programs from National Grid that help you with ways to use less energy?
    - Not at all familiar
    - Not very familiar
    - Somewhat familiar
    - Very familiar
    - [DO NOT READ] Don't Know / Refused

4a. [IF Q4<> Not at all familiar] Which of the following programs are you familiar with?

a. No-Cost Energy Assessments
b. Heating and Cooling rebates
c. Payment assistance programs
d. ConnectedSolutions smart thermostat program
e. Marketplace for energy savings products
f. [IF SOLAR] ConnectedSolutions battery storage program

Home Energy Report Recall [HER RECIPIENT]

5. In the past six months, do you remember receiving a Home Energy Report from National Grid about your in-home energy use?
    - Yes
    - No
    - [DO NOT READ] I don't know/I am not sure

6. The Home Energy Report is a printed report sent by mail or email, separate from your bill. It includes a breakdown of your energy use and that of your neighbors. Your neighbors are 100 nearby, occupied homes with similar characteristics. The report also includes tips on how to save energy.
   [IF Q5=Don't Know or No] Did you receive this Home Energy Report?
   [IF Q5=Yes] Does this describe what you received?
   - Yes
   - No
   - [DO NOT READ] Don't Know / Refused

Home Energy Report Interaction [if Q6 = Yes]

7. Thinking of all the reports you have received, in general, what have you done with them? Did you…
   - Read the reports thoroughly
   - Read some of the content
   - Glance at the pictures or graphs
   - Do not look at the reports at all [SKIP to Q17]

8. Did the Home Energy Report motivate you to reduce your energy usage?
   - Yes
   - No
   - [DO NOT READ] Don't Know / Refused

9. After reviewing your report, have you taken a specific energy-saving action?
   - Yes
   - No
   - [DO NOT READ] Don't Know / Refused

10. [If Q9 = Yes] What actions did you take? [OPEN]

11. Have the Home Energy Reports motivated you to participate in another National Grid energy efficiency program?
    - Yes
    - No

12. Tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statements:
    a. I like the Home Energy Reports.
    b. The energy efficiency tips in the Home Energy Report are useful.
    c. I am interested to see my next Home Energy Report.

13. Did receiving the report make you more satisfied or less satisfied with National Grid or did your opinion not change?
    - More satisfied
    - Less satisfied

- Opinion unchanged
- [DO NOT READ] Don't Know / Refused

14. Over the past year, how has your opinion about the Home Energy Report changed?
    - More favorable
    - About the same
    - Less favorable
    - [DO NOT READ] Don't Know / Refused

15. [IF Q12a>3] What aspect of the Home Energy Reports do you like the most? [OPEN]

16. [IF Q12a<4] What aspect of the Home Energy Reports should be improved? [OPEN]

High Usage Alerts [HBA recipients only]

17. National Grid sends some customers High Usage Alerts when their usage is higher than normal. These alerts are sent by email when a customer is trending to have a higher than normal bill compared to the previous month. Have you ever received a High Usage Alert?
    - Yes
    - No [SKIP TO Q19]
    - [DO NOT READ] Don't Know / Refused [SKIP TO Q19]

18. Tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statements:
    a. I like the High Usage Alert program.
    b. The information in the High Usage Alert is valuable.
    c. High Usage Alerts help me make better decisions about how I can reduce my energy use and save money.

Weekly Electricity Reports [WAMI recipients only]

19. National Grid emails Weekly Electricity Reports to some customers that have chosen to receive them. These reports are emailed each week and contain a comparison of your usage in the current week compared to the previous week. Have you received Weekly Electricity Reports like this?
    - Yes
    - No [SKIP TO Q21]
    - [DO NOT READ] Don't Know / Refused [SKIP TO Q21]

20. Tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statements:
    a. I like the Weekly Electricity Report program.
    b. The information in the Weekly Electricity Report is valuable.
    c. Weekly Electricity Reports help me make better decisions about how I can reduce my energy use and save money.

Demand Response Rewards [DRR recipients only]

21. Between June and August of this year, some customers with central AC were sent communications about upcoming Conservation Days, where individuals could earn points as part of National Grid's Points and Rewards program by saving energy during certain days and times. Do you remember receiving these Conservation Day communications?
    - Yes
    - No [SKIP TO Q24]
    - [DO NOT READ] Don't Know / Refused [SKIP TO Q24]

22. Did you take any action to reduce your energy usage on Conservation Days?
    - Yes
    - No
    - [DO NOT READ] Don't Know / Refused

23. Tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statements:
    a. I like the Conservation Day program
    b. I was motivated to save energy on Conservation Days
    c. Conservation Days are good for the community
    d. Conservation Days make me feel like a valued National Grid customer
    e. The COVID-19 situation made it more difficult to save on Conservation Days

Web Engagement [all customers]

24. Are you aware of National Grid's online energy management tools, such as graphs that show changes in your usage when you're logged in to National Grid's website?
    - Yes
    - No [SKIP TO Q26]
    - [DO NOT READ] Don't Know / Refused [SKIP TO Q26]

25. Tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statements:
    a. National Grid's online energy management tools are user friendly
    b. National Grid's online tools help me make better decisions to use and save energy.
    c. It is easy to understand my energy usage using National Grid's online tools

COVID-19

26. As a result of the COVID-19 situation, have you expeienced any change in the amount of energy that your household uses? Do you:
    - Use less energy now
    - Use about the same amount of energy now
    - Use more energy now
    - [DO NOT READ] Don't Know / Refused

27. How has the COVID-19 situation impacted your level of concern about your utility bill? Please use a scale of 1 to 5 where 5 is “Much more anxious now” and 1 is “Much less anxious now”.

28. How has the COVID-19 situation influenced your motivation to increase your energy efficiency? Please use a scale of 1 to 5 where 5 is “Much more motivated now” and 1 is “Much less motivated now”

29. As a result of the COVID-19 situation, are you more or less likely to make make energy efficiency home improvements or purchases? Please use a scale of 1 to 5 where 5 is “Much more likely now” and 1 is “Much less likely now.”

30. Since COVID-19, have you made any energy efficiency home improvements or purchases?
    - Yes
    - No
    - [DO NOT READ] Don’t Know / Refused

Demographics [all customers]

The final following questions are **optional** and will help us make sure we are talking to lots of different people. It is okay if you prefer not to answer.

31. [INTERVIEWER RECORDS, DO NOT ASK THIS QUESTION]
    - Male
    - Female

32. Which of the following categories best describes your age?
    - 18 to 24
    - 25 to 34
    - 35 to 44
    - 45 to 54
    - 55 to 64
    - 65 to 74
    - 75 or over
    - [DO NOT READ] Don’t Know/Refused

33. Do you own or rent your residence?
    - Owner
    - Renter
    - [DO NOT READ] Don’t Know/Refused

34. What is the highest level of education you have achieved? Just stop me when I get to the category that describes you. [READ LIST IN ORDER]
    - Some high school or less
    - High school graduate or GED
    - Some college or trade / technical school
    - Trade / technical school / 2 year college graduate
    - 4 year college graduate

- Some post-graduate work
- Post-graduate degree
- [DO NOT READ] Don’t Know/Refused

Closing [all customers]

This concludes the survey. Thank you very much for your time!

Your input is very valuable and will allow us to improve your experience as a customer with National Grid.

Division 3-8
Customer Feedback

Request:

At Bates 181, the Company reports that in each Home Energy Report, there are multiple options for the customer to contact the Company to learn more or opt-out of the reports.

a. Does the Company advise customers via any other messaging on how customers can opt-out of these reports?
b. How many customers have opted out of these reports? Please distinguish between A-60 and A-16 customers?
c. Please provide a list of zip codes with the number of customers that have opted out per zip code and the total number of customers within that zip code.

Response:

a. Customers can opt out of reports via an Unsubscribe link in the footer of the email Home Energy Reports, or by contacting the customer service call center by phone and making preference updates with the customer service representative.

b. The Company's Home Energy Report Vendor is working to provide this information. The Company will provide an updated response when the data becomes available.

c. The Company's Home Energy Report Vendor is working to provide this information. The Company will provide an updated response when the data becomes available.

Prepared by or under the supervision of: Angela Li

Division 3-8 - Supplemental, page 1
Customer Feedback

Request:

At Bates 181, the Company reports that in each Home Energy Report, there are multiple options for the customer to contact the Company to learn more or opt-out of the reports.

a. Does the Company advise customers via any other messaging on how customers can opt-out of these reports?
b. How many customers have opted out of these reports? Please distinguish between A-60 and A-16 customers?
c. Please provide a list of zip codes with the number of customers that have opted out per zip code and the total number of customers within that zip code.

Response:

a. Customers can opt out of reports via an Unsubscribe link in the footer of the email Home Energy Reports, or by contacting the customer service call center by phone and making preference updates with the customer service representative.

b. From January 2020 through October 2021, 354 participants have opted out of the Home Energy Report program. Follow are the Opt Outs by rate class.

Home Energy Reports 01/2020 - 10/2021 Opt Outs		
Fuel	Rate Class	Opt Outs
Electric	A-16 Residential Standard Offer	133
E&G	A-16 and 12	76
E&G	A-16 and 10	3
Electric	A-60 Resi Low Income Standard Offer	11
E&G	A-60 and 12	1
E&G	A-60 and 10	1
E&G	A-60 and 13	8
Gas	12	71
E&G	A-16 T&D Residential and 12	4
Gas	13	23
E&G	A-60 T&D Resi Low Income and 13	5
Electric	A-16 T&D Residential	18
	Total	**354**

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Division 3-8 - Supplemental, page 2
Customer Feedback

c. Following is a table with total number of participants and participant opt outs for January 2020 through October 2021.

Zip Code	Total Number of Participants by Zip code	Opt outs by zip code
02801	8	0
02802	198	1
02804	810	1
02806	4,969	3
02808	952	2
02809	7,169	6
02812	384	1
02813	2,986	4
02814	2,251	3
02815	74	0
02816	10,812	10
02817	1,803	3
02818	6,488	3
02822	1,769	3
02823	59	0
02824	118	0
02825	1,417	2
02826	245	0
02827	606	0
02828	2,163	2
02829	135	2
02830	692	1
02831	1,046	0
02832	1,616	0
02833	252	0
02835	1,971	5
02836	54	0
02837	1,446	4
02838	1,137	1
02839	499	1
02840	7,740	11
02841	3	0

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Division 3-8 - Supplemental, page 3

Customer Feedback

Zip Code	Total Number of Participants by Zip code	Opt outs by zip code
02842	4,606	6
02852	8,782	10
02857	2,303	2
02858	158	0
02859	28	1
02860	12,685	20
02861	8,553	10
02863	4,617	4
02864	11,414	17
02865	5,712	3
02871	5,572	10
02872	151	0
02873	98	0
02874	1,936	2
02875	130	0
02876	517	0
02877	56	0
02878	5,381	2
02879	8,508	19
02881	646	2
02882	5,898	8
02883	180	0
02885	3,915	4
02886	9,643	4
02888	6,526	2
02889	9,342	4
02891	8,678	8
02892	1,217	0
02893	9,768	9
02894	227	0
02895	11,604	11
02896	3,184	4
02898	453	0
02902	4	0

Prepared by or under the supervision of: Angela Li

Division 3-8 - Supplemental, page 4

Customer Feedback

Zip Code	Total Number of Participants by Zip code	Opt outs by zip code
02903	2,379	1
02904	8,766	8
02905	6,272	10
02906	7,334	12
02907	6,437	27
02908	8,901	6
02909	9,781	10
02910	6,629	4
02911	5,023	5
02912	2	0
02914	6,481	4
02915	5,499	9
02916	2,741	2
02917	4,702	4
02919	9,005	9
02920	10,786	7
02921	3,754	5
Total	**318,858**	**354**

Prepared by or under the supervision of: Angela Li

Division 3-9
Customer Feedback

Request:

At Bates 226, the Company reported that customer feedback is gained through sales team interactions with customers and design teams who regularly provide insights on what types of technical assistance and design support moves the builders and architects and end customers to adopt the high energy efficiency measures and design.

a. Please describe what specific technical assistance measures have moved builders, architects, and end use customers to adopt high energy efficiency measures and designs.
b. Please describe what specific high energy efficiency measures and designs have been adopted as a result of specific technical assistance measures.
c. Please describe what specific design support measures have moved builders, architects, and end use customers to adopt high energy efficiency measures and designs.
d. Please describe what specific high energy efficiency measures and designs have been adopted as a result of specific design support measures.

Response:

a. The Company offers four pathways for ground-up new construction and major renovation projects: the Zero Net Energy Ready pathway, the Whole Building Energy Use Intensity (EUI) Reduction pathway, the Whole Building Streamline pathway, and the Systems Approach pathway. For each of the pathways, the terms technical assistance and design support are used interchangeably. However, the purpose and objective of design support and technical assistance differs according to which pathway is selected.

   For the Zero Net Energy Ready pathway, building owners and design teams are provided with a Zero Net Energy expert that assesses the project to identify services or energy efficiency measures that may be needed to achieve the Zero Net Energy goal. The Zero Net Energy experts offers a series of technical assistance and design support measures that result in the customers adoption of high energy efficiency measures. These support measures include EUI benchmarking, conducting energy charrettes, load reduction analysis, and HVAC section analysis and model feedback, all of which are key to being able to achieve the Zero Net Energy target, and each of which can impact the customer's ultimate decision to install high energy efficiency measures.

   Under the Whole Building EUI Reduction pathway, the National Grid team offers technical assistance and design support services that engage with the customer's project design team in order to facilitate an energy design charette to better understand the project and current design and to offer building system recommendations to improve the

Division 3-9, page 2
Customer Feedback

energy efficiency of the building. The customer's goals are then used to establish an EUI target that is memorialized in the form of a Memorandum of Understanding. The EUI and associated energy savings are then assessed at the design development stage for an interim report. The customer or building owner then signs an application that includes the agreed upon energy conservation measures. Upon the completion of the project, the building undergoes a post-inspection that includes a visual inspection and review of construction design submittals. Additionally, the EUI measurements are then monitored over a prescribed period, under the prescribed conditions, before the final incentive payment is made available.

For the Whole Building Streamlined pathway, the Company's implementation team reaches out to the customers that are engaged in new construction projects. If the project meets the Whole Building Streamlined pathway criteria (small to mid-size building; from 20,000 to 100,000 square feet), a technical vendor is brought in at no-cost to the participating customer in order to conduct an energy charrette and provide feedback on the planned building design with a goal of increasing the project's energy efficiency. Additionally, the technical vendor will monitor the design progress and provide estimates of energy savings and incentive at the mid-design review. After the design is completed, a final report is submitted by the technical vendor that details the project savings and incentive this document is then used to develop the project application and Minimum Required Documents guidelines.

The Systems Approach pathway offers prescriptive incentives for the installation of energy efficiency equipment and measures on new construction and major renovation projects and for projects that are under 20,000 square feet. Technical assistance is not typically provided in this pathway.

b. The specific technical assistance and design support measures offered in the Large Commercial New Construction pathways have led to the installation of the following high-energy efficiency measures:

Division 3-9, page 3
Customer Feedback

1. Building Envelope
    a. Additional Insulation beyond code for exterior walls and roofs
    b. Better thermal performance for glazing such as lower U-value and SHGC (or SC) than required by code/ASHRAE

2. Lighting
    a. 0.5 Watts/sf or lower for interior lighting based on building area method
    b. Lighting controls in spaces beyond code/ASHRAE
    c. Network lighting controls

3. HVAC
    a. Higher heat recovery effectiveness than required by code (50%) for systems with energy recovery wheel
    b. Demand Control Ventilation coupled with heat/energy recovery wheel
    c. Occupancy based HVAC controls for spaces
    d. Kitchen hood controls for hoods < 5,000 cfm of exhaust
    e. Transfer air from cafeteria to kitchen during non-cooking hours
    f. Heat pump domestic water heaters instead of electric or gas water heaters
    g. Heat recovery for shower drains

c. Please see response to DIV 3-9a.

d. Please see response to DIV 3-9b.

Division 3-10
Customer Feedback

Request:

At Bates 226, under "Changes for 2022", the Company reported working with EERMC's consultants to alter incentives and requirements to encourage the adoption of luminaries and systems that offer more savings and flexibility of control. The Company noted that the incentives and requirements are modeled on a successful offering in Connecticut.

a. Please identify the name of the successful program in Connecticut.
b. Please provide a copy of the Connecticut program.

Response:

a. There is no separate name for a tiered lighting offering in Connecticut. It is incorporated into the "Energy Conscious Blueprint" program for new construction and the "Energy Opportunities" program for retrofit.

b. Please see Attachment DIV 3-10. The "cap sheet" (CT terminology) is labeled "Existing Buildings." The Company's Connecticut contact informed National Grid that there is no equivalent document for new construction, but the requirements and the incentive rates are the same.

Prepared by or under the supervision of: Benjamin Rivers

EXISTING BUILDINGS

TIERED PROJECT INITIATIVE

	GREATER OF		PLUS	Not to exceed	
	per kWh	per kW	per CCF	PROJECT CAP	PROJECT QUALIFICATION
TOTAL COMPREHENSIVE INCENTIVE					
Three or more End Uses*	$0.65	$1000/ summer peak	$6.00	65% of Installed Cost	• If lighting end use is needed to qualify for this tier, lighting must be at least Enhanced Performance • At least 25% of the savings must be from retrofit measures • To include standard lighting, project must qualify for this tier independent of the lighting
MULTI END USE OR EMS					
Minimum two End Uses*	$0.50	$1000/ summer peak	$5.00	50% of Installed Cost	• At least 25% of the savings must be from retrofit measures • A control device/system that just sets the space temperature or only controls lighting is not an EMS
SINGLE NON LIGHTING END USE					
Minimum one non-lighting End Use	$0.40	$1000/ summer peak	$4.00	40% of Installed Cost	• Project must impact at least one non-lighting End Use • If lighting is the only measure, - DO NOT USE - refer to below "Lighting Measures" table

End use is defined as Gas or Electric, impacting Heating; Cooling; Lighting; Process; Domestic Water Heating; Refrigeration; Motors and Drives
*No one end use can exceed 90% of the project's value based on annual savings and each qualifying end use must contribute at least 3%

LIGHTING MEASURES

	GREATER OF		PLUS	Not to exceed	
	per kWh	per kW	per CCF	PROJECT CAP	PROJECT QUALIFICATION
HIGH PERFORMANCE LIGHTING					
LED Fixtures with Networked Lighting Controls System	$0.65	$1000/ summer peak	NA	65% of Installed Cost	80% of project load must utilize a networked lighting control system, as defined by DLC[1]. System must be capable of energy monitoring and demand response, as defined by DLC. Customer must also provide control narrative for the system, and it must be fully commissioned with reporting and demonstrated demand response capability.
ENHANCED PERFORMANCE LIGHTING					
LED Lighting with Luminaire Level Lighting Controls or Wirelessly Accessible Controls	$0.45	$1000/ summer peak	NA	45% of Installed Cost	80% of project load must consist of LED fixtures[1], with digital control and wireless accessibility to initialize, configure, and commission the system. Must include and demonstrate a minimum of one control strategy per fixture and two different control strategies at the project level; e.g., occupancy, daylighting, task tuning/ high end trim. (Small group control is advised, recommend up to 300W of controlled LED fixtures per group within same physical space and/or group space up to 1,000 sq. ft. floor area.)
STANDARD LIGHTING					
Must use Expeditied Lighting Application	$0.25	$1000/ summer peak	NA	25% of Installed Cost	The Energy Efficiency Expert reserves the right to review each claim and direct you to the required pathway. **For Express Lighting Rebate refer to Lighting Rebate Form.** EnergizeCT.com/your-business/solutions-list/Express-Service-Lighting-Rebate. **NOTE:** Type C retrofit LED full kits or type C lamps with external drivers are the only (tube) product options that qualify for this incentive.

RETROFIT MEASURES	EXISTING BUILDING RETROFIT
Cumulative Cap per Federal Tax ID	$500,000
Municipal Finance Cap (total per municipality) - Eversource	$1,000,000
Municipal Finance Cap (total per municipality) - UI	$500,000

Project Caps and Incentive Levels For Eversource CT and United Illuminating (UI) - Effective 6/1/20 through 6/30/21 while funds last.

EnergizeCT.com/your-business/solutions-list/Energy-Opportunities

Incentive caps and qualification criteria are subject to change at any time. Availability of funding is not guaranteed and the Utilities are not responsible for any costs or damages incurred by the Participant if funding for this program is reduced or eliminated. Retainage may be applied to any project if final payment is contingent on delivery of performance results or information. Utilities shall have final determination of eligible incentives and energy savings. A Letter of Agreement/Authorization detailing available incentives and energy savings for each proposed measure must be signed by Utilities Management before any equipment is ordered to be eligible for incentives.

IECC 2015 is the baseline energy code. All references to kWh and CCF savings shall refer to annual gross savings.

[1]All LED fixtures must be DesignLights Consortium® (DLC) or ENERGY STAR® certified. The lists of qualifying products can be found at www.designlights.org and www.energystar.gov, respectively.

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Program Overview

Business Sustainability Commitment
Tackle common business issues like utility costs, waste, and employee engagement in the context of sustainability and energy efficiency. Become competitive and resilient by following recommended action steps that are accessible, achievable, and profitable.

Commercial Clothes Washer Rebate
Make your laundry facility work for your bottom line. Purchase an energy-saving ENERGY STAR model for your next commercial clothes washer and earn a $200 rebate for each qualifying machine. And, get high performance with every load!

Electric HVAC and Water Heating Rebate
Save electricity and cut energy costs in your business by installing qualifying high-efficiency air conditioning, heat pump systems, and water heaters. Rebates help to offset the costs.

Energy Opportunities
With today's energy costs, delaying to upgrade old inefficient equipment can actually cost you money. Invest in energy-efficient equipment now to reduce operating costs and improve productivity, ease-of-use, comfort and even aesthetics.

Low-Interest Loans for Commercial & Industrial Customers
Make energy savings pay off with low-interest financing for qualified energy-efficient improvements. Coupled with incentives, it can make your project a reality so you can start saving sooner.

Natural Gas Water Heating Rebate
With efficiencies of up to 85 percent or more, installing high-efficiency natural gas water heating equipment is a smart way for businesses to save gas and cut energy costs. Rebates let you enjoy the energy-saving benefits without paying a premium price.

Process Reengineering for Increased Manufacturing Efficiency
Make your manufacturing operations more productive with "lean manufacturing" training. You'll learn techniques to streamline product flow, eliminate or reduce waste, improve production efficiency, minimize environmental impact and reduce energy consumption.

Small Business Energy Advantage
A utility-authorized contractor performs a no-cost, no-obligation energy assessment (audit) of your facility and then manages the installation of the energy-saving improvements. This one-stop service, combined with our incentives and zero-interest, on-bill payment plans, allows you to get started right away.

C&LM Financing-Small Businesses & Municipalities
Loans make it easier for small businesses and municipalities to invest in energy-efficient improvements. Repayment terms up to four years and an on-bill payment option make it even easier!

Commercial Kitchen Equipment Rebate
Put energy savings on the front burner with rebates on energy-saving ENERGY STAR® commercial kitchen equipment. You'll reduce energy costs, improve performance, and because many energy-saving options produce less heat, you might also reduce your cooling costs.

DEEP-Sponsored Granted Financial Incentives & Low-Interest Loans
Reduce operating costs with a combined heat and power system. Financial incentives and low-interest loans, sponsored by the Connecticut Department of Energy and Environmental Protection (DEEP), can make it a cost-effective investment. Capital grants of $200 per kilowatt are available for qualifying projects of one megawatt or less in Eversource or United Illuminating's service territory. To qualify, a project must reduce energy costs by an amount equal to or greater than the project's installation cost within 10 years of its installation.

Express Service and Instant Lighting Rebates
It is easy for businesses to save electricity and cut energy costs by installing high-efficiency lighting. Now with paper and instant rebates, you can enjoy all the energy-saving benefits without paying a premium price. What a bright idea!

Natural Gas Heating Equipment Rebate
A smart way for businesses to save gas and cut energy costs is by installing high-efficiency natural gas heating equipment. With efficiencies of up to 98 percent, they are the most efficient heating equipment available.

Programs for Municipal Utility Customers
Business customers of Connecticut's municipal utilities can also benefit from smart energy options. To learn more about available programs, please contact your utility using the information below.

Commercial Multifamily Properties
Reduce energy and operating costs and make the multifamily property you own or manage more comfortable and environmentally friendly with the Multifamily Initiative.

Energy Conscious Blueprint
Maximize your new facility's energy performance by planning for efficiency from the beginning. Utility energy experts help to identify and integrate energy-saving opportunities into your plans early.

Green Buildings Tax Credit Program
Connecticut is offering a new incentive to build or renovate commercial buildings to meet or exceed U.S. Green Building Council's Leadership in Environmental and Energy Design (LEED) Gold Standard. The Green Buildings Tax Credit makes it more cost-effective for builders and developers to invest in energy-efficient construction that supports our clean energy future.

Natural Gas Infrared Heater Rebate
Large structures, such as warehouses and loading docks, can reduce the heat needed to maintain comfortable temperatures by 15 percent with low-intensity natural gas infrared heaters. Feel the heat and see the savings with rebates!

Operations and Maintenance
Improve your facility's electrical and thermal efficiency through operational changes and repairs rather than capital investments.

Retro-Commissioning
A pre-qualified retro-commissioning engineering firm evaluates how your mechanical equipment, lighting and related controls operate and function together. Suggested improvements are supported with sustainable energy management strategies.

Energy Management System (EMS)
We are often able to incentivize the costs associated with putting in EMS strategies not previously existing or required by code.

Strategies to Consider
- Optimal Start Stop
- CO_2 or Demand Controls Ventilation
- Hot Water Reset
- Chilled Water Reset
- Condenser Water Reset
- Static Pressure Reset
- Discharge Temperature Reset

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Division 3-11
Customer Feedback

Request:

At Bates 234, under Industrial Initiatives, the Company reported that OER and its consultant team provided feedback on potential changes to the scope of work with the industrial vendor.

a. What specific potential changes were discussed?
b. What recommendations did OER and/or its Consultant team make?
c. What recommendations, if any, did the Company adopt, and why?
d. What recommendations, if any, did the Company reject, and why?

Response:

The table below lists all substantive changes to the scope of work that were recommended by OER and the Energy Efficiency Resource Management Council (EERMC)'s consultant team next to the Company's rationale for accepting or rejecting the recommended changes.

Recommendation (part b.)	**Rationale for adopting/rejecting (parts c. and d.)**
Adding a demand response (DR) component to the scope of work (SOW).	Adopted - The Company believes many customers served by the Industrial Initiative are good candidates for DR, and the vendor is well positioned to attract additional participants in the ConnectedSolutions program.
Making the vendor responsible for connecting the customer to other National Grid resources, including electric vehicle (EV) charging station discounts and the Renewable Energy Growth (REG) Program, as well as providing training on these offerings.	Rejected – EV charging stations and the REG program do not meet the definitions of Energy Efficiency Procurement and Conservation Procurement established under the Least Cost Procurement Standards[1] and are therefore beyond the scope of this Plan.

[1] State of Rhode Island Public Utility Commission, Least Cost Procurement Standards. August 2020. http://www.ripuc.ri.gov/eventsactions/docket/5015_LCP_Standards_05_28_2020_8.21.2020%20Clean%20Copy%20FINAL.pdf

Prepared by or under the supervision of: Joshua Kessler

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Customer Feedback

Ensure the vendor makes a concerted effort to gain executive-level buy-in from customers to build a culture of energy conservation within the organization, in alignment with the Continuous Energy Improvement (CEI) delivery model.	Rejected – In implementing the Industrial Initiative, the Company and its vendor adopt an individualized approach for each customer according to the customer's unique needs and organizational decision-making processes. This includes engaging executive decision makers as appropriate but allows for a flexible engagement approach.
Encourage the vendor to serve a greater number of small and medium customers.	Adopted – In the approved 2021 Plan, to improve parity among customers, the Company committed to "increase focus on customers in the 200-400 kW range" (Bates 366) and restated in the 2022 Plan (Bates 234). To more effectively pursue this objective in 2022, the Company opted to incorporate a time and materials element into the SOW (see discussion in PUC Requests 1-88 and 1-89).
Requiring the vendor to collect customer feedback to help identify areas for program enhancement.	Rejected – The vendor already actively solicits customer feedback, shares it with the Company, and collaboratively discusses strategies for program enhancements. Adding this to the SOW is unnecessary.
Shifting the vendor's annual savings goals and associated pay-for-performance structure so it is based on lifetime savings instead of annual.	Rejected – Although lifetime savings align more closely with the Company's goals in the 2022 Plan, these savings are impacted by evaluation, verification, and monitoring (EM&V) factors beyond the vendor's control and that are sometimes adjusted at year-end to ensure consistency with EM&V guidance. Thus, out of fairness to the vendor and for simplicity's sake, the goals are based on gross savings. Furthermore, this vendor is already achieving a savings mix that helps diversify the energy efficiency portfolio (see Bates 234).
Make it the responsibility of the vendor to recommend new energy saving measures or demand response measures each year.	Rejected – Although not explicitly stated in the SOW, the vendor already regularly shares proposed program enhancement ideas.

Division 3-12
Commercial & Industrial Pilots, Demonstrations & Assessments

Request:

At Bates 483, under Peak Period Demand Response, the Company reported that it expects to increase participation on the PPDR by adding one or two new customers.

a. Is this an aspirational goal, or has the Company secured initial commitments from customers to participate?
b. Are the direct incentive payments received by the Customer for participation taxable income for that customer?
c. What is the average payment received by currently participating customers?
d. How many participating customers were there in 2021?

Response:

a. Yes, this is an aspirational goal. The Company is currently in discussions with potential customers for the 2021-22 winter season.
b. The Company does not take a position on the tax treatment of EE rebates or incentives sent to Customers for any measure. The decision regarding tax treatment of these incentives is left to the Customer's determination.
c. The average incentive paid in 2020-21 for the PPDR program was $5,290.38. Each Customer's incentive is dependent on the amount of gas they commit to reducing and their performance during events.
d. There were 2 Customer accounts that participated in the PPDR program in 2020-21.

Prepared by or under the supervision of: Owen Tyrrell

Division 3-13
Residential Pilots, Demonstrations & Assessments

Request:

At Bates 496, the Company reports that an independent evaluation of the Solar Inverter Direct Load Program will be conducted in conjunction with the Company's Massachusetts service area. If the proposed PPL transaction proceed in calendar year 2021, how will this independent evaluation be conducted for Rhode Island customers?

Response:

The Company will continue the solar inverter demonstration evaluation in conjunction with the Company's Massachusetts and Rhode Island service. After the Rhode Island business transitions to PPL, the Company's expectations are that this study will be completed. Any costs or payments for the evaluation invoiced before the transition to PPL will be the responsibility of the Company. Any costs or payments for the evaluation invoiced after the transition to PPL will be the responsibly of PPL. Once the evaluation is complete, the decision of whether this measure should be proposed as an ongoing measure in the 2022 EE plan will be left up to PPL and the RI stakeholder community.

Prepared by or under the supervision of: Paul Wassink

Division 3-14
Regulatory Allocation

Request:

Please refer to Table E-4 of the 2022 Provisional Plan under the heading *Regulatory*. The Division is aware of recent amendments to *R.I. Gen. Laws § 39-1-27.7* that increased the permittable Regulatory allocation from the demand-side electric and gas funds to the EERMC and OER in "an amount *not to exceed* three percent (3%)." (Emphasis added). Please explain the basis for the Company's proposal and recommendation for the full 3% in the Regulatory allocation, which would result in an increase of $535,900 to the EERMC and an increase of $1,173,000 to OER from the amounts approved last year?

Response:

The Company believes the proposed allocation of the full three percent (3%) of the demand-side electric and gas funds to the Regulatory allocation to be consistent with the legislative intent of the recent amendments to R.I. Gen. Laws § 39-2-1.2(i) and (j).
(See 2021 R.I. Pub. Laws, Ch. 224, §2, effective July 8, 2021).

The passage of the recent amendments with a significant majority (passed 54-10 in the House[1] and 32-5 in the Senate[2]), is an indication, the Company believes, from the General Assembly to invest more in resources for OER and the EERMC.

The Company also notes that a full allocation of the amount authorized by the legislature is consistent with past precedent in submitted and approved Energy Efficiency Plans dating back to the 2007 Energy Efficiency Plan which was the first plan following the passage of the Least Cost Procurement ("LCP") statute and corresponding allocation provision contained in R.I. Gen. Laws § 39-2-1.2 in 2006. (See 2006 R.I. Pub. Laws, Ch.237, §§ 6-7, effective June 29, 2006).

[1] See http://webserver.rilegislature.gov/HVotes/votereport.asp?id=17895
[2] See http://webserver.rilegislature.gov/SVotes/votereport.asp?id=13377

Prepared by or under the supervision of: Christopher Porter