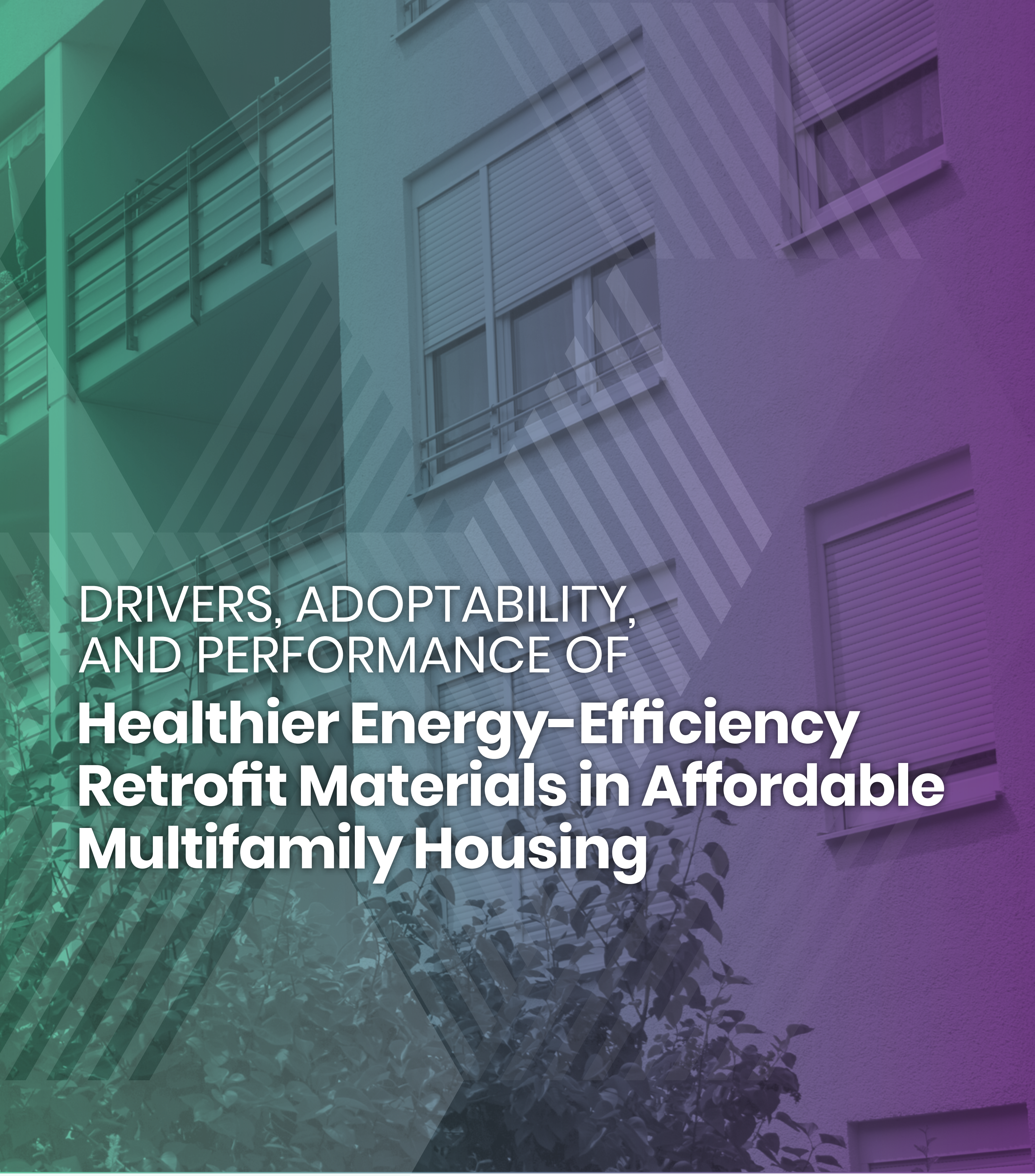


DRIVERS, ADOPTABILITY, AND PERFORMANCE OF

Healthier Energy-Efficiency Retrofit Materials in Affordable Multifamily Housing

ENERGY EFFICIENCY FOR ALL

AUGUST 2019

ACKNOWLEDGMENTS

This report was completed as part of Energy Efficiency for All (EEFA), a multi-state initiative that works to make multifamily housing healthy and affordable through energy and water efficiency. EEFA provides technical expertise and coordination support to a national network and 12 state-based coalitions to increase investments in energy and water efficiency, and to support EEFA partners in their efforts to make the strongest possible case for efficiency investments in affordable housing. EEFA is cofounded by Elevate Energy, Energy Foundation, National Housing Trust, and the Natural Resources Defense Council (NRDC), with funding support from The JPB Foundation.

The primary authors of this study are Beth Hawkins, Michaela Marincic, and Erin Rose (Three[3]). We appreciate the extensive review provided by Angelina Benson-Glanz, Abigail Corso (Elevate Energy), Rebecca Stamm, William Weber (Healthy Building Network), Elizabeth Chant (Optimal Energy), Alana D'Aleo (Consultant), Michele Knab Hasson (NRDC), and James Connelly (International Living Future Institute).

REPORT PARTNERS

Three³, Inc. (ThreeCubed) is a research and educational non-profit organization that conducts innovative and inter-disciplinary social science research, and offers educational programming, to promote the integrated achievement of the three pillars of sustainability—equity, environment, and economics—in combination.

Natural Resources Defense Council (NRDC) is an international nonprofit environmental organization with more than 2.4 million members and online activists. Since 1970, its lawyers, scientists, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment.

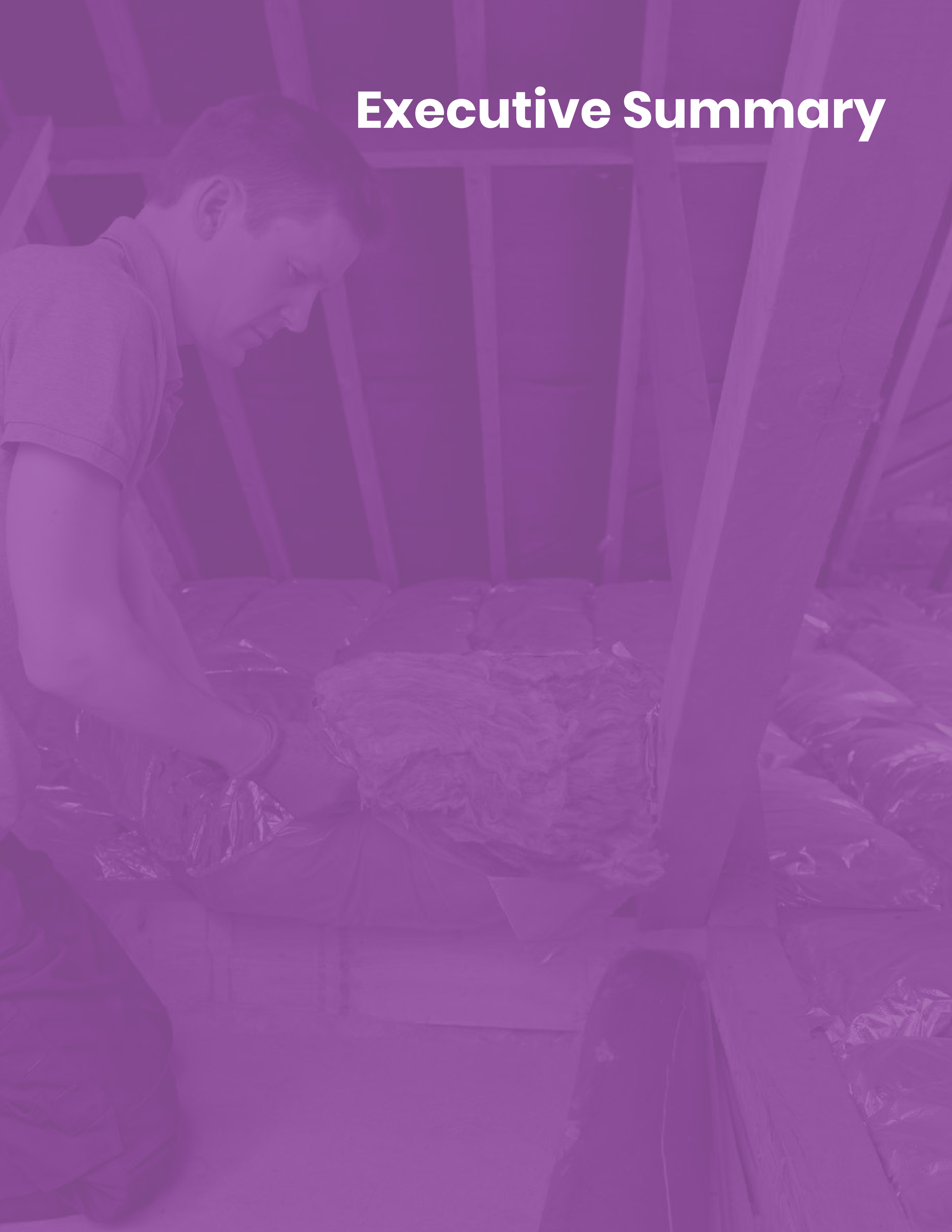
TABLE OF CONTENTS

TABLE OF CONTENTS

List of Tables

List of Figures

Executive Summary



EXECUTIVE SUMMARY

In 2017, the Natural Resources Defense Council (NRDC) contracted with Three[3] to capture insights from contractors and industry experts within the affordable multifamily energy retrofit industry through in-depth interviews. The study team aimed to understand the contractors' and other experts' motivations and values related to retrofit material choices and use; their perspectives related to usability, adoptability, and limitations of healthier materials; and their recommendations for improvements in promoting the use of healthier materials. The interviews attempted to capture rich anecdotes from those who are most familiar with the use, impact, and performance of these healthier alternatives.

Interviews revealed that health, safety, and environmental impacts are in fact being considered when insulation materials are selected. This understanding is an important starting point for designing educational information to further increase the adoption of healthier building materials. Rogers' (2003) seminal work on diffusion of innovation states that whether an innovation or an alternative is adopted is highly dependent on its relative advantage over existing materials (e.g., minimal health hazards or cost-effectiveness); its ease of use and its observable effectiveness and performance through demonstration; its acceptance by the clients served; and its adherence to existing regulations. Interviewees said that institutional support by programs and government agencies as well as evidence of performance and relative advantage–compared to standard materials–from the research and development sector are effective drivers of choice. It was said that the most persuasive source of information and technical guidance on the use of alternative materials was other people working in the industry, conveying the information through word of mouth.

Findings from this mixed-methods research contribute to a larger effort—the Healthier Affordable Building Materials (HABM) Project—sponsored by Energy Efficiency for All (EEFA) in collaboration with Natural Resources Defense Council, Healthy Building Network, Vermont Energy Investment Corporation, International Living Future Institute, and Elevate Energy. This larger effort contributes to a body of knowledge surrounding healthier building materials in energy-efficiency upgrades with the goal of mainstreaming use of these materials to reduce toxic exposures of both workers and occupants; improving indoor environmental quality; and making buildings more energy efficient. The HABM study was initiated as part of the EEFA Project, an initiative launched in 2013.[1] The EEFA project's primary objective was to expand energy-efficiency programs for the affordable multifamily sector, build a national network to help expand investments in these programs, and provide support for multifamily building owners seeking energy retrofit services.

In addition to this report, the HABM collaboration has produced a comprehensive guide to readily available, healthier insulation and air-sealing materials; a policy briefing sheet; a specification guide; and an energy performance assessment.[2]

HEALTHIER MATERIALS

These are materials that have less toxic or no toxic off-gassing during or after installation. Those that pose minimal to no health risks if the gasses are inhaled or if the materials are touched or ingested, and those that are made with materials that are less toxic to the environment to produce. This study solely focuses on insulation and air sealing retrofit materials.

Introduction

INTRODUCTION

Today, the green building movement in the United States focuses on sustainability and energy-efficiency design but might also include the use of low-emitting construction or retrofit materials in an effort to minimize impacts on occupant health. The purpose of this study was to better understand what motivates agencies to incorporate these types of materials into their retrofit scopes of work. Only a handful of studies have been conducted on general health, asthma, and non-asthma respiratory symptoms associated with green retrofits.[3] Furthermore, because of the research designs, results from some of the studies that have been done could not definitively discern whether health improvements were attributable to a green retrofit or other factors. As the research in the area of healthier materials develops, results from this study could be useful in understanding adoption of and barriers to using materials shown to improve health outcomes for residents in the affordable multifamily (MF) housing sector. As air sealing and insulation are most likely to be central components of any MF building energy intervention, materials used for these energy-conservation measures are the main subjects of this report.

This study aimed to better understand decision-making related to the use of healthier retrofit materials in the affordable MF housing sector. The first objective was to identify a diverse group of agencies that regularly make decisions about the use of healthier energy-efficiency retrofit materials in the affordable MF housing sector. The on-the-ground component involved gathering insights on drivers guiding this decision-making process by recruiting and interviewing a sample of the decision makers within 21 agencies.[4] The final objective was to identify patterns in the interview responses and gain insights drawn from them. This was accomplished through mixed methods and relied both on qualitative narrative approaches for assessment and quantitative methods through coding interview responses and developing descriptive statistics.

For the purposes of this study and based on guidance from the Healthy Building Network (HBN), insulation made of expanded cork, fiber-glass insulation, or cellulose insulation that does not contain formaldehyde-based binders as well as mineral wool insulation that meets the California emission Specification 01350 for residential scenarios were described as healthier building materials. Materials that include neither foam insulation, whether rigid board or spray-applied, (as they usually contain highly toxic flame retardants), nor extruded polystyrene and closed-cell spray polyurethane foam insulations (since they have been found to use blowing agents that are potent greenhouse gases) were described as healthier.

This study was a component of a partnership called the Healthier Affordable Building Materials Project, sponsored by Energy Efficiency for All (EEFA) in collaboration with Natural Resources Defense Council (NRDC), HBN, Vermont Energy Investment Corporation (VEIC), International Living Future Institute (ILFI), and Elevate Energy. The partners have also collaborated to produce several additional documents, including a comprehensive guide to readily available, healthier insulation and sealing materials, *Making Affordable Multifamily Housing More Energy Efficient: A Guide to Healthier Upgrade Materials*; a policy briefing sheet, *Policy Matters: Making Energy Upgrades Healthier for Residents, Workers, and Neighbors*; a specification guide, *Guidance for Specifying Healthier Insulation and Air-Sealing Materials*; and Case Study: *Energy Performance of Chicago Properties Retrofit With Fiber Glass Insulation.*[5,6,7]

Background

BACKGROUND

Energy-conservation measures installed during residential energy-efficiency upgrades have the potential to produce beneficial health outcomes in addition to the intended energy and cost savings. Observations augmented by empirical research suggest a variety of relationships exist between energy-efficiency upgrades and changes in health status, such as decreased incidences of thermal stress from exposure to extreme temperatures and improvements in asthma control and flare-ups.[8] The health impacts of materials advertised as "healthy" have been largely untested in the affordable MF housing sector. Affordable MF buildings, which tend to have large energy savings potential and are more likely to be of substandard dwelling quality than market-rate housing, tend to be occupied by households of low socioeconomic status. Social determinants of health disparities further alert us to the disproportionate burden of substandard dwelling quality, poor health, and affordability issues related to energy and rent.[9]

Air sealing (i.e., tightening a building's envelope) and insulation are frequently included in MF energy-efficiency upgrades. MF upgrades differ from those in the single-family sector in that they might not include unit-level air sealing and insulation, but instead might treat only the common areas and attic. Different programs, such as those of the U.S. Department of Energy's (DOE's) Weatherization Assistance Program (WAP), utility companies, nonprofit organizations, or private contractors, might provide different combinations of energy-conservation measures in addition to air sealing and insulation that could also result in health impacts. These measures may include heating and cooling system repair or replacement, window and door repair or replacement, and mechanical ventilation repair or installation. However, air sealing and insulation are most likely to be central components of any MF building energy intervention.

Conversely, several studies recognize that tightening a building's envelope, and thereby decreasing ventilation, alongside installing standard retrofit materials has the potential to adversely affect indoor environmental quality through an increased concentration of indoor toxic chemicals. These chemicals are associated with acute and chronic health conditions (e.g., asthma, respiratory illnesses, neurotoxicity, developmental disorders, male infertility, hypertension, cerebrovascular events, and cancer)[10] Furthermore, many MF housing units do not operate effective mechanical ventilation systems for either exhaust or fresh air supply. These households are limited to using natural ventilation, which may still be inadequate and potentially affect thermal comfort during the summer and winter. A final issue of concern here is that in some affordable MF buildings, windows are inoperable and therefore ventilation may be virtually nonexistent.

The practice of tightening building envelopes began in the late 1970s and was associated with a dramatic rise in reports of health issues, collectively referred to as "sick building syndrome."[11] In recent years, global concern has heightened in relation to these health impacts—studies have been done in several countries, including the United States, and measures have been taken to set minimum ventilation standards (such as DOE's ASHRAE 62.2 Standard for WAP) and to control or even ban certain building materials, such as urea-formaldehyde foam insulation.[12, 13] A number of immediate symptoms associated with exposure to these chemical agents have been reported. These include skin irritation, headache, dizziness, nausea, and difficulty breathing.[14] Chemical exposures and health impacts are of concern not only to occupants, but also to workers and communities throughout the life cycle of the material, from manufacturing to disposal. Furthermore, there is evidence that populations most affected by life-cycle exposures are "fence-line communities," communities that are often low-income or communities of color, or both, located close to industrial facilities or waste disposal facilities. Additional research on healthier materials could provide better evidence and understanding of impacts from exposure—both positive and negative—throughout the products' life cycles.

The U.S. Insulation and Air-Sealing Market

THE U.S. INSULATION AND AIR-SEALING MARKET

For an in-depth analysis of today's insulation and air-sealing market, the guide to readily available, healthier insulation and sealing materials mentioned above serves as an excellent resource.[15] The following section provides a brief discussion of these products.

Insulation

In 2014, fiber glass accounted for 47 percent of the insulation market in the United States, followed closely by foamed plastic products, such as spray foam and rigid foam board.[16] These ratios are forecasted to hold fairly steady, even amid growing demand for insulation overall, while mineral wool and cellulose shares are each projected to remain around 2 percent of the market.[17] It should be noted that many respondents in the study reported that foam-type insulation is less commonly used in low-income housing upgrades because of its higher cost.

However, reports and industry articles indicate that fiber glass and foamed plastics fulfill distinct needs in the insulation market. The Freedonia Group, a major industry market research firm, notes that fiber glass has the advantages of having "low cost, good insulative properties, and ease of installation."[18] Foamed plastic, meanwhile, is favored for its "ability to seal between walls and in hard-to-reach areas such as crawl spaces," as well as for its air-sealing qualities and R-values, according to Freedonia.[19]

The market shares above mean that nearly half of the insulation sold in the United States is not made from alternative healthier materials. Health impacts (e.g., asthma, developmental disorders, and cancer) stem in part from the presence of isocyanates and halogenated flame retardants. To mitigate some harmful impacts, contractors can take measures such as wearing proper protective gear during installation and evacuating residents for 8–24 hours, depending on the cure time for the particular foam, according to the U.S. Environment Protection Agency's report, *Safer Choice*.[20] However, the EPA also notes in the report that improper application can lead to chemical contamination of other parts of a home and that many factors, such as application techniques and humidity, can affect curing times.[21] Because the use of personal protective equipment and installation practices are subject to error, EEFA's 2018 *Guide to Healthier Upgrade Materials* ranks elimination and substitution of harmful substances as preferred strategies for reducing hazards in its hierarchy of controls.[22]

Blowing agents used to install foamed plastics are also a cause of concern. Although manufacturers have moved away from using chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), which damage the ozone layer, many now use hydrofluorocarbons (HFCs) which are also potent greenhouse gasses (GHGs) which contribute to climate change.[23] HFC-245fa, one of the most commonly used blowing agents for spray foam, has a global warming potential 858 times greater than that of carbon dioxide.[24, 25] Because of these harmful effects and the increasing number of alternative blowing agents entering the market, the EPA has outlined regulations to ban HFCs from use with spray foams beginning in 2020.[26] Hydrofluoroolefins (HFOs), a kind of alternative blowing agent, raise different concerns because they use a potent ozone-depleting substance, carbon tetrachloride, as a feedstock. With increased production and use of carbon tetrachloride for this application, increased emissions of the ozone-depleting substance are expected.[27]

Until recently, fiber glass carried measurable health hazards because of the presence of formaldehyde in binding agents. However, a report released by HBN substantiated statements by U.S. and Canadian fiber-glass manufacturers that they were no longer using formaldehyde in the manufacture of lightweight residential fiber glass. Formaldehyde has been absent from such fiber glass made in the United States and Canada since October 2015, though it remains in "some higher density batts, which are mainly sold on the commercial/industrial market," according to BlueGreen Alliance Foundation, as well as in some fiber-glass duct wrap and pipe insulation.[28, 29] Alternatives to fiber glass and foam do exist. Mineral wool and cellulose have the next largest market shares, although both remain at 2 percent or slightly less.[30, 31]

Manufacturers of both types are working to cut into the market shares of fiber glass and spray foam. Most notably, Rockwool (formerly Roxul) has begun packaging its batting to mimic fiber-glass batts and appeal to do-it-yourself homeowners. Rockwool has also developed rigid products that, as of 2015, have been approved as alternatives to rigid foam board for below-slab insulation.[32] Meanwhile, cellulose application techniques have improved so as to mirror those of other blown insulations, making the transition to cellulose smoother for many contractors. Improvements in dense packing techniques also make cellulose viable as a minor air barrier.[33]

Given the popularity of spray foam's performance but aversion to its petroleum content and off-gassing, manufacturers have begun developing plant-based alternatives, called polyols, to the spray-foam ingredient that is traditionally made from petroleum. Soy and castor oils are leaders in bio-based spray foams, though even these are only 15–30 percent plant based and still contain petroleum products.[34] Today, bio-based spray foams are available with R-values on a par with standard spray foam.

Yet another concern is that manufactured chemicals and heavy metals found inside homes may be introduced through sources such as the building materials discussed in this report. Epidemiologists have concluded that the majority of human exposure to manufactured chemicals occurs inside homes.[35] One pathway for exposure to these chemicals and heavy metals is through dust. In addition to substantial amounts of squamous (i.e., human skin cells), household dust may contain a wide range of contaminants harmful to human health including, but not limited to, flame retardants, persistent organic compounds, and semivolatile organic compounds released from vinyl flooring and other manufactured chemicals. One such substance is a plasticizer (phthalate) found in acrylic and acrylic-latex caulks. Exposure to phthalates and other endocrine disrupting chemicals is statistically correlated to respiratory diseases and infections, and can affect reproductive health.[36] Epidemiologists, exposure scientists, and others are conducting research that suggests indoor exposure to chemicals may be a more important source of asthma triggers than the usual suspects commonly referred to as environmental asthma triggers.[37]

Most Common Air Sealants

Less information is publicly available about the air-sealing than the insulation market. Compared with those for insulation, there are fewer and less distinct choices for air-sealing, and often air-sealing material is dictated by the job at hand. The Standard Work Specifications, the source for best practices in low-income upgrades through the WAP, recommends caulk, spray foam, or any other appropriate air sealing material for cracks and gaps.[38] Gaps around doors and other moveable surfaces require weather stripping. For even larger areas, more choices are available, including drywall, gypsum board, or rigid foam board with caulk or foam around the edges. Material choice is often dictated by location: Will it be exposed to moisture or heat? Does it need to be permeable to moisture? Such considerations, rather than health and environmental impacts, often determine which materials are used.

Diffusion Theory

DIFFUSION THEORY

Looking at the demand side of the healthier materials market, diffusion of innovation theory can help predict whether new types of insulation are likely to take hold among contractors and designers. Diffusion, in this context, is defined as the process in which new ideas or innovations are disseminated among members of a group.[39]

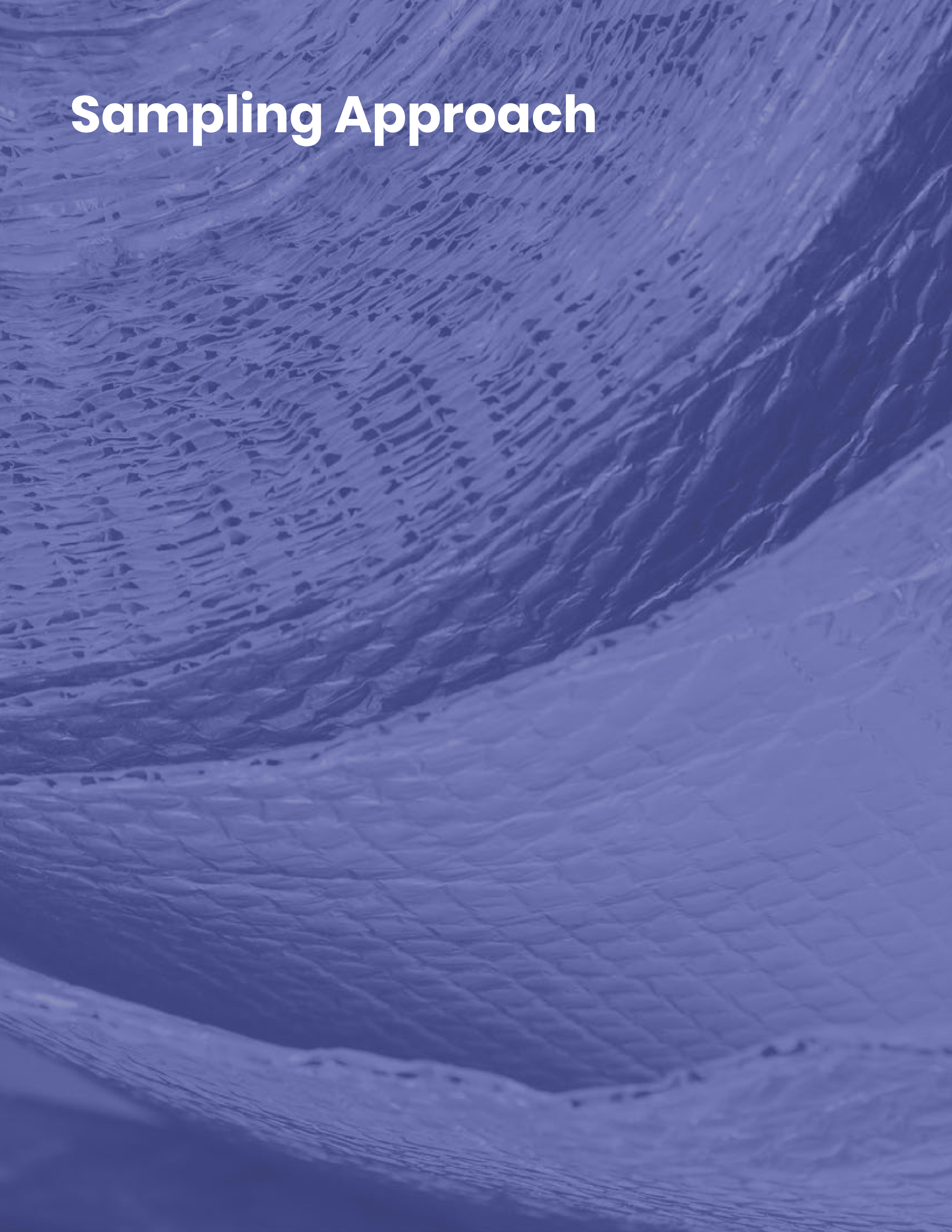
Two primary factors that help predict adoption rates of an innovation involve the *relative advantage* (e.g., economic, social prestige, and convenience) of the innovation over existing alternatives and its *compatibility* with existing systems (e.g., equipment used for installation of material). Other factors to consider with respect to successful innovations—in this case, of nonstandard retrofit materials—are sociocultural *adoptability* and institutional *integration* (i.e., acceptance and incorporation of a technology into general use and application within the user environment).[40] Adoptability of technologies in particular tends to be influenced by perceptions of user groups related to: worker skill sets, barriers to penetration (e.g. accessibility of product), demonstration of successful applications, aesthetic preferences, and institutional support.[41] Analyzing the environment in which the user group is expected to interact with the technology through an adoption analysis approach can help understand more fully how to address factors related to adoptability.[42] This approach, used in social science research, can provide valuable information ensuring successful technology adoption that is rooted in context and addresses perceptions of user groups.

In a study focused on the construction industry, researchers used diffusion of innovation theory to explain why and when construction companies did or did not implement building information modeling (BIM).[43] BIM is a method of representing the functionalities and characteristics of a structure or place and requires specific technological infrastructure and knowledge. Scholars in this field found two primary determinants of whether a company used BIM:

1. Companies' desires to establish or maintain reputations as cutting edge and competent (relative advantage of social prestige);
2. Companies' levels of infrastructure or training:
    - companies with insufficient infrastructure (e.g., compatibility with existing systems) were less likely to use the innovation;
    - companies with high capacity (e.g., adoptability due to trained staff), used the innovation to realize gains in the present (e.g., relative advantage of short-term economic benefits);
    - companies with lower capacity were motivated by the possibility of future profits (e.g., relative advantage of long-term economic benefits).[44]

Considering attributes and factors that predict diffusion can provide a theoretical background for analyzing the results of this study. One final consideration related to successful diffusion of information and innovation is the role of early adopters and their position in their professional social networks. For example, a leading voice in the energy-efficiency industry can have great influence on the adoption rate of new information or an innovation based on the leader's early experience with the innovation. Early adopters are also the first to address barriers to adoption. Therefore, experiences gleaned from these pioneers could assist moderate to later adopters in overcoming similar barriers and challenges.

Sampling Approach



SAMPLING APPROACH

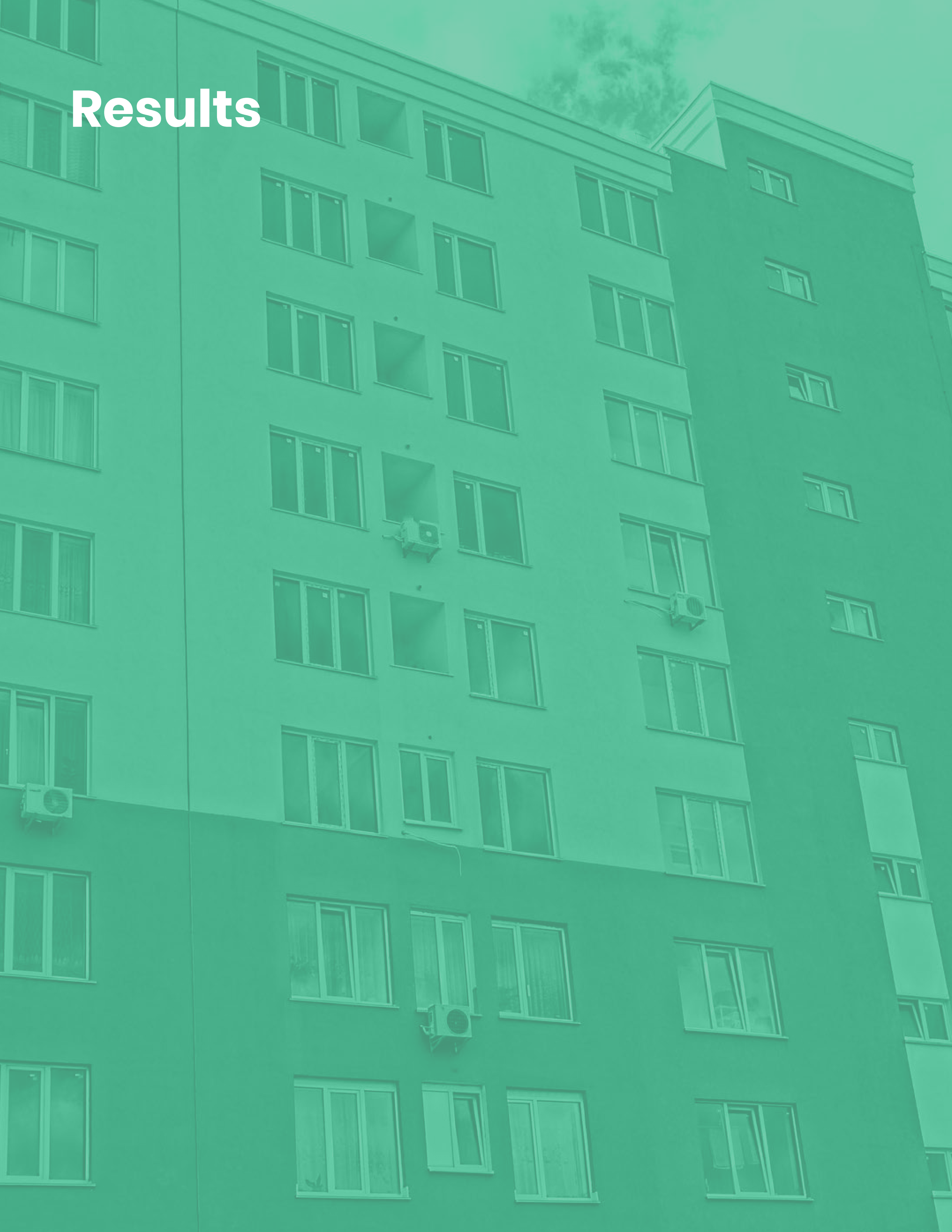
This section presents a brief description of the approach used to develop the study sample. Appendix A provides a thorough discussion on methodology, including the stratified random sampling plan; the resources and databases mined to select the target population; and a description of the purposively selected sample.[45] The recruitment strategy, interview protocol, and an overview of the data analysis approach are presented in Appendix A.

The target population for study was industry professionals within the affordable MF energy retrofit sector (e.g., contractors, energy auditors or consultants, and weatherization personnel) in 12 states—California, Georgia, Illinois, Louisiana, Maryland, Michigan, Minnesota, Missouri, New York, Pennsylvania, Rhode Island, and Virginia. These states were purposely chosen because of their involvement with EEFA's multi-state initiative.[46]

The study team scanned the Internet and searched publicly available state and organization databases to identify 902 potentially eligible contractors (i.e., those that provided energy-efficiency upgrades to affordable MF housing). We refer to this entire pool of candidates as the sample frame. Because not all states had applicable databases, there was an unequal distribution of contractors by EEFA state in the sample frame. Based on the size of the sample frame and resources available for recruiting participants and conducting interviews, it was decided that 20 interviews would be conducted. Table A.1 in Appendix A shows the final sizes of each sample and the sample frame broken out by strata—the 12 EEFA states.

Researchers developed a semi-structured interview guide and protocol for interviews to be conducted by telephone. Although the interviews were intended to be relatively unconstrained and respondents were allowed some freedom to describe their beliefs and experiences, all interviewees were asked each relevant question in the script to ensure thorough results and that rigorous comparisons could be made between interviews.

Results



RESULTS

As hoped, this study, through in-depth interviews with contractors and industry experts, captured rich anecdotes from those who are most familiar with the use of healthier materials for insulation and air sealing. The study provided insights into:

Drivers: *Which factors drive contractors' material choices and use?*

Adoptability: *What are contractors' perceptions related to the usability, availability, complexity of installation, and cost of healthier materials compared with standard materials? What are the challenges and barriers associated with adopting healthier materials as a primary choice?*

Education: *What are contractors' recommendations for improving communications about healthier materials and on which information channels are best for getting the word out? What do they believe would drive a widespread switch?*

The following sections characterize the sample and present findings from the interviews.

Sample Characterization

Because of unanticipated challenges that arose in sampling and respondent recruitment and resulting budget and timeline constraints, it was decided that the minimum intended number of interviews would be satisfactory. The final sample (n=21) consisted of 18 males and 3 females. Eleven respondents worked for contracting companies, six for energy auditing companies, three for weatherization agencies, and one for an energy consulting and engineering design firm. Some of the contracting companies also performed audits but were not counted separately as auditors.

Most companies served a variety of types of MF buildings, but 71 percent stated that low-rise buildings (one to four stories) constituted the majority of their projects. Twenty-nine percent performed upgrades on row houses, 24 percent on mid-rise (five to nine stories), and 19 percent on high-rise (10 stories or more). Fourteen percent reported their building stock was too mixed to say which types were most common.

Eighty-one percent represented for-profit companies and 19 percent represented nonprofit organizations. Altogether, the companies represented roughly 380 years of experience in the energy retrofit industry and 313 years working with affordable MF housing.

Energy Retrofit Industry

Most of the respondents (57 percent) had been in the energy retrofit industry between 7 and 10 years, with close to one-third providing upgrades for more than 30 years.

Affordable Multifamily Sector

Close to three-quarters had worked in the affordable MF sector for less than 10 years; the remainder had done so for more than 30 years. (The remainder were the same respondents who reported having worked in the energy retrofit industry.)

FIGURE 1. Shares of Companies' Businesses Devoted to Energy-Efficiency Upgrades in Affordable MF Housing

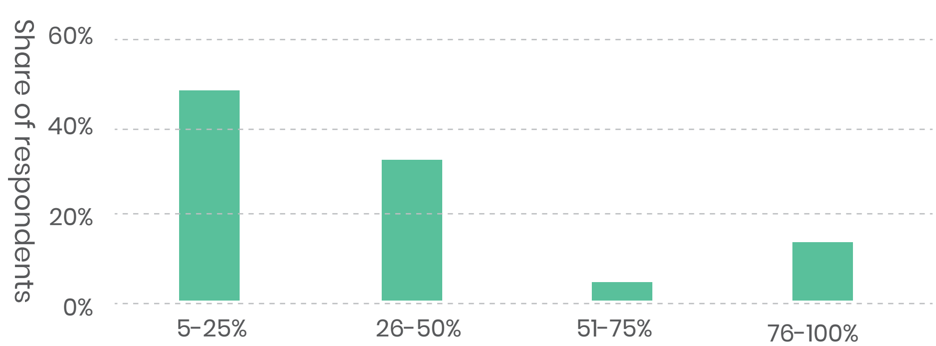
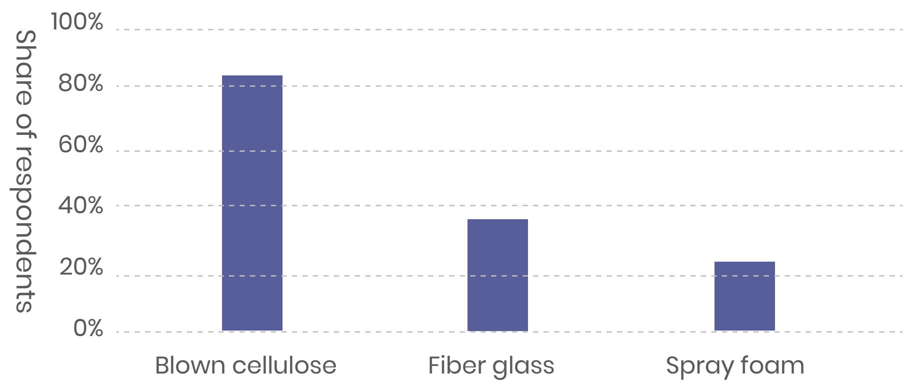


FIGURE 2. Insulation Most Commonly Reported to Be Used



Most contractors reported that 50 percent or less of their business comprised these types of projects. (See Figure 1.)

None of the respondents reported serving a primarily rural area; 67 percent operated solely in urban areas; 33 percent served both rural and suburban communities. The interviewees' companies had an average of 17 employees, but the number of employees ranged from one to 75. Seventy-one percent of the companies employed 10 people or less.

Materials in Use

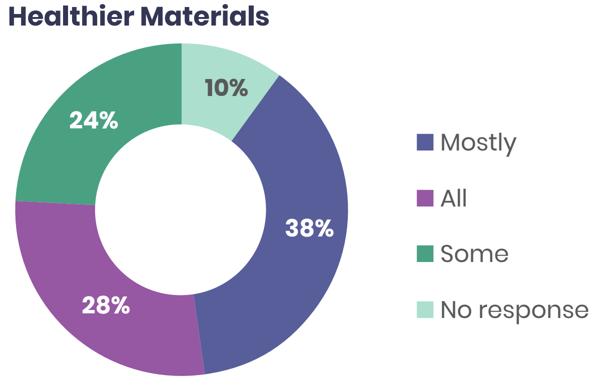
It was necessary to identify which materials the sample group was using or recommending before delving into drivers, and perceptions of challenges and barriers, to the adoption of healthier materials. Although interviewees were asked which green and healthy materials they used or were encouraged to use, respondents generally gave an account of all the materials they used or were recommended by their companies. Blown cellulose was the most frequently mentioned insulation, followed by fiber glass and spray foam; other materials reported to be used included mineral wool, rigid foam, and natural cotton fiber (also referred to by interviewees as recycled denim, or blue jeans insulation).[47] Figure 2 shows the three insulation materials most frequently reported to be used. (Many respondents reported using more than one insulative material.)

Of the types of materials mentioned, 79 percent met the researchers' definition of a healthier material. However, while formaldehyde has been removed from fiber glass made in Canada and the United States, it is possible some respondents used fiber glass imported from countries other than Canada. When asked, respondents generally were unsure whether or not their fiber glass contained formaldehyde.

When asked about energy retrofit materials, interviewees appeared to focus primarily on insulation; only four respondents commented on types of air-sealing materials they use or recommend. All four of these respondents reported using spray foam—both one-part and two-part—for air sealing. Of the caulks they reported using, the following types were mentioned: red or fire caulk (temperature resistant); silicone-acrylic; silicone; latex; and weatherproof caulk, such as Phenoseal. Two respondents from California noted the state's strict requirements that low-volatile organic compound (VOC) materials, including caulks, be used. Otherwise, the remaining respondents specified using low-VOC foams or caulks. In general, respondents seemed less likely to take into consideration the health and environmental impacts of their air sealants than of their insulation materials.

When asked to what extent their companies used healthier materials, the majority of interviewees (66

FIGURE 3. Reported Frequency of Use of Healthier Materials



percent) revealed they "always" or "mostly" used healthier materials instead of standard materials in their MF upgrades, as shown in Figure 3.

Drivers

When respondents were asked how they chose insulation and air-sealing materials, answers ranged from cost to program requirements to versatility. Figure 4 presents eight drivers ranked according to the interview responses. The top most reported reason for use of a particular insulating and air sealing material had to do with cost. The next most frequently mentioned decision-making factors that were chosen (equally) by interviewees were performance; healthier attributes; state-level and industry codes; protocols; and guidance, such as that provided in WAP, Building Performance Institute (BPI), and National Renewable Energy Laboratory (NREL). Interviews revealed both a general health, safety, and environmental motivation for material choice as well as specific reasons, such as fire safety and reduced exposure to VOCs. Some building-specific characteristics, such as inaccessible attics or unusual masonry, limited what types of insulation were feasible in some cases. Other factors driving material choice included ease of use; cleanliness; preference of architects, designers, or building owners; and whether a product serves as both an insulator and air sealer. The interview results align with the general diffusion theory discussed in the section on Diffusion Theory.

When asked which reasons motivated them to choose healthier materials (if they did) over standard building materials, respondents mentioned health and safety concerns for residents more often than when asked about material choices in general. (See Figure 5.) Performance of material and concerns for the environment were top motivating factors as well. The reports of material performance, program requirements, and price indicate that decisions are not made solely out of concern for the environment and resident and contractor health; however, it appears that benefits to health and the environment do play a role in the decision-making process.

FIGURE 4. Most Commonly Reported Drivers of Materials Choice

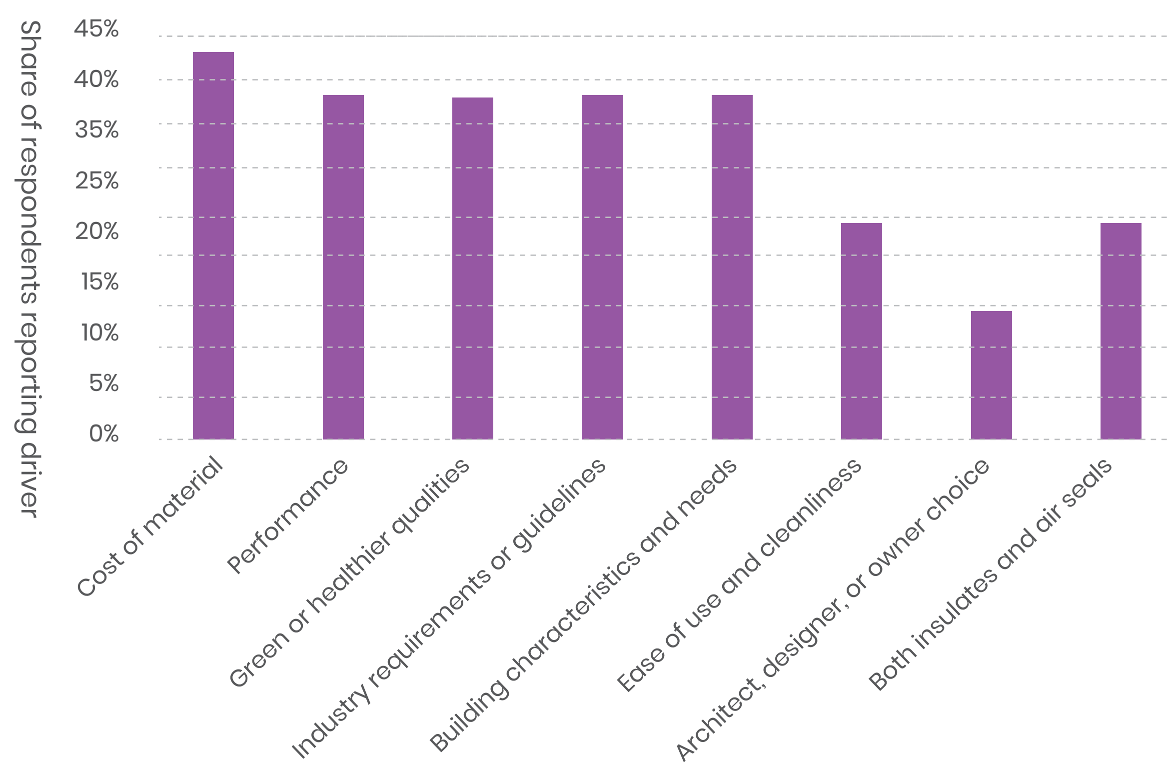
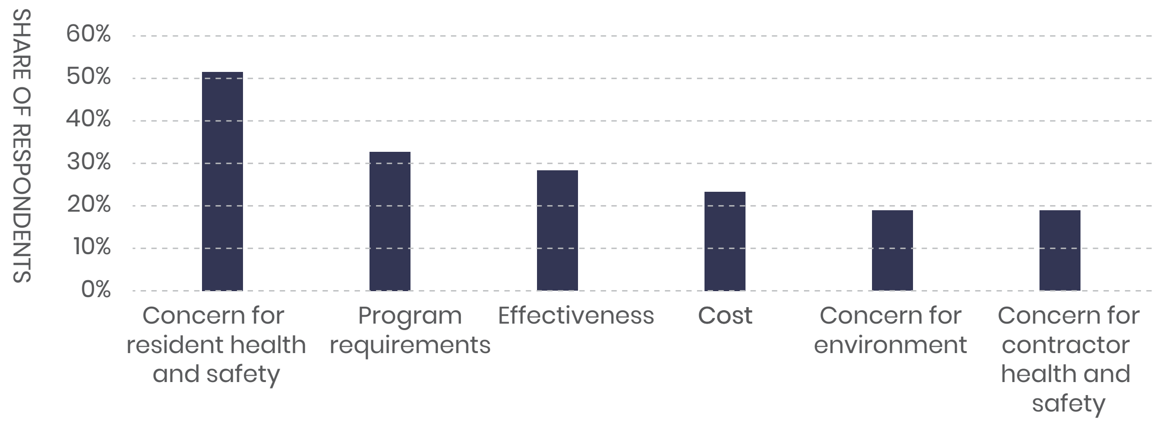


FIGURE 5. Most Commonly Reported Motivating Factors for Choosing Healthier Rather Than Standard Materials



Adoptability

Ninety-five percent of the respondents said that the healthier materials they used were either easy or very easy to adopt. One respondent mentioned having had "major challenges" associated with the availability and the usability of the healthier alternatives.[48] This respondent said that existing insulation materials partially determine which retrofit materials can be installed. For example, since placing cellulose over fiber glass can compress the fiber glass and potentially render it ineffective, cellulose is apt not to be used in such circumstances. The remaining respondents said they did not have enough experience with the materials to provide input.

Reported Barriers to Adoption

For analysis, concerns about the use of healthier materials were grouped into two categories: barriers to adoption and challenges while installing materials.

Some of those that adopted the healthier materials with ease also acknowledged confronting some barriers and challenges. However, 60 percent reported facing no barriers and 57 percent reported facing no challenges. Table 1 shows the reported barriers to adoption of healthier materials.

Challenges in Installing Materials

Nearly 20 percent of respondents mentioned the excessive amount of dust that cellulose can release while 10 percent noted that existing materials can introduce issues surrounding installation of healthier alternatives. Eight other challenges received one mention each: low-VOC materials performing poorly; excessive dust from fiber glass; cellulose being too heavy for some applications; the need to add moisture to cellulose because of dryness and dust, and conversely, cellulose absorbing too much moisture and becoming too heavy in humid climates; fiber glass being scratchy and "unpleasant"; and rodents making nests in fiber glass and cellulose.

TABLE 1. Reported Barriers to Adoption of Healthier Materials

Barriers to Adoption
Contractor or subcontractor resistance to learning how to use new materials and techniques
Contractors or subcontractor lack of familiarity with these materials
Slight learning curve with respect to best practice installation techniques
Resistance from clients with misconceptions
Healthier alternatives can be more expensive
Expensive equipment (e.g., cellulose blower was specifically mentioned)

Observations and Suggestions

When asked the question, *Have you ever heard of an occupant of a multifamily building having any health issues (e.g., headaches, burning eyes, or asthma symptoms) from the installation of retrofit materials?* two of the 21 respondents said they had personally witnessed or heard of MF residents who had physical symptoms seemingly related to standard building materials. In the first instance, a contractor reported that formaldehyde from a common indoor glue used into the 1990s was exacerbating asthma and other respiratory issues, especially as the practice of tightening building envelopes became more prevalent. However, they had not heard claims of this recently. Conversely, the second contractor reported seeing residents' asthma and respiratory symptoms decrease after insulation was installed. This contractor often used spray foam, though foam that the contractor described as, "a specifically low-VOC variety due to state regulations."[49]

When asked, *Do you have any suggestions related to how healthier retrofit materials could be further improved?* respondents made seven suggestions, the most common being lowering their cost. Increasing the availability of products and reducing the presence of dust in fiber glass and cellulose were also mentioned. Other answers, given once each, were better field testing and improved performance; a healthier alternative to spray foam air sealing; and adding a nontoxic deterrent to rodents making nests in cellulose and fiber glass.

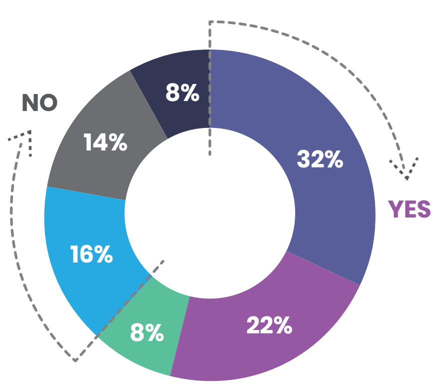
Education

Fifty-two percent of respondents said that more education is needed about the benefits of healthier materials; some said contractors needed more education while others thought it would be more effective to target the public or the architects and designers who collaborate on retrofit work. (See Figure 6.) As mentioned above, unfamiliarity with materials and resistance from clients with misconceptions associated with nonstandard materials were both identified as barriers to adoption. These two sets of findings indicate that more education is still needed to further accelerate the wide adoption of these healthier alternatives in the affordable MF retrofit industry.

As can be seen, respondents interpreted the question of whether more education is needed in various ways, and some volunteered their perceptions about the best way to increase the use of healthier materials. Fourteen percent said they didn't think education would have a positive impact on increasing the adoption rate. Suggestions for alternatives to education included the following:

- State agencies need to know more about the benefits of healthier materials and tighten regulations; clients and contractors are driven by money, so the regulators should have high standards for the work they'll pay for.

FIGURE 6. Is More Education Needed?



- **Yes.** Contractors require more education to better understand the impacts of different materials.
- **Yes.** The public should be made aware of the benefits of healthier materials.
- **Yes.** Architects and designers require more education for recommending materials.

- **No.** Contractors are already aware of the benefits.
- **No.** More education would not change anything; alternative approaches are recommended to increase adoption.
- **No.** The public has no misconceptions.

- Pressure needs to come from distributors and clients and the proper incentives need to be put in place in the utility-run weatherization programs.
- The real burden is the poorly run utility programs: there is a huge amount of paperwork, and frequent late payments force contractors to finance supplies. With the resources they (the states' utility companies) have, it shouldn't be like this. They are losing a lot of good, qualified contractors.
- The best way to increase adoption of these materials is to incorporate requirements, such as those in the Indoor Air Plus program, into the building codes and state weatherization programs.
- If contractors are required to learn about healthier materials for one program, they are more likely to use them in other projects as well.

Those who said they believed more education would be beneficial recommended a variety of information channels to target, as well as educational formats that had been most informative to them. (See Table 2.) Respondents also provided their main source of information related to healthier materials. (See Table 3.) The Internet was most frequently (45 percent) mentioned as an information channel to target. It was also cited as the most helpful format (30 percent). Demonstrations got the second most mentions as a channel to target. Asked to identify their main source of information related to new or existing retrofit materials, respondents focused on in-person interactions ranging from those at formal events, such as trade shows, to informal word-of-mouth communication with colleagues. Other reported sources of information included continuing education classes and suppliers and manufacturers.

TABLE 2. Recommended Information Channels and Formats for Education

Information Channels	Educational Formats
Internet	Websites
Product labeling	Demonstrations of materials
Conferences	Magazines or newspaper
Trainings	Emails
Utility programs	Informational videos

TABLE 3. Reported Sources of Information on New Retrofit Materials

Sources of Information
Word-of-mouth through colleagues
Trade shows, industry conferences
Continuing education classes
Communication with suppliers and manufacturers
Digital formats (e.g., blogs, government websites, and other Internet sources)
Email exchanges
State regulations
Professional organizations
Industry magazines

Discussion

DISCUSSION

For many of the interviewees who used alternative materials, the health benefits appeared to be of secondary importance rather than a primary deciding factor, except when building codes or regulations dictated the use of such materials. All respondents seemed at least aware that health and environmental hazards exist, even if they did not identify the hazards as core drivers for decision making and behavior. Those who voiced the most concern about potential health and environment impacts tended to use a holistic approach to weatherization and expressed a clear concern about indoor environmental quality. A few respondents debated the researchers' definition of healthier materials, saying in particular that spray foam is considered inert and therefore is safe after the proper curing time has passed. Overall, awareness of the health and environmental hazards appeared widespread, but there were varying levels of knowledge and use of healthier materials.

Knowledge Gaps

While the level of knowledge varied among respondents, most if not all demonstrated awareness of health and environmental impacts, especially regarding insulative materials, and the ways to mitigate them.

Cellulose
Evidence-based research indicates that cellulose carries relatively few health or environmental hazards. The interviews seemed to substantiate these findings as there were no concerns expressed about this material. Most respondents identified cellulose as a healthier alternative. However, one respondent noted some clients have the misconception that because cellulose is made of paper, it is flammable and therefore a fire hazard.

Fiber Glass
Fiber glass insulation also poses relatively few health or environmental hazards unless it contains formaldehyde binders. Again, respondents had no concerns about the health and safety of this material and considered it to be healthy. However, two contractors, asked if the fiber glass they used contained formaldehyde, said they did not know, and they seemed surprised that it might.

Spray Foam
Those who reported using spray foam were also aware of the hazards and the training required to install foam as safely as possible. All acknowledged that spray foam off-gasses toxic chemicals and reported following steps to mitigate harm, including evacuating residents in some cases. One respondent said that foam was safe when proper procedures were followed and environmentally friendly when used with newer, low-GHG blowing agents. Despite these mitigating measures, other respondents still had concerns, and one observed that EPA's official stance was that more information is needed, especially from longer-term studies. This diversity of views is indicative of the abundant and conflicting marketing surrounding spray foam in the industry, which some respondents mentioned as contributing to misconceptions and uncertainty about insulation materials in general.

Mineral Wool, Sheep's Wool, and Recycled Denim
Two respondents reported using mineral wool, and one of the two had also used sheep's wool and recycled denim in the past. Recycled denim insulation, also known as natural cotton fiber insulation, is made from scraps and clippings from the manufacture of denim clothing. According to one interviewee, this insulation is suitable for residential and commercial use in the same places as fiber glass or mineral wool batts would be used—between open roof rafters, ceiling joists, and wall studs.

Given that none of the 19 other respondents mentioned mineral or sheep's wool or recycled denim, it is difficult to gauge how much they have permeated the industry. One can only speculate that contractors are aware of these materials but prefer others, or simply that they do not know about them or know very little about them. The two respondents had no complaints or issues related to the usability of mineral wool. The respondent who had used sheep's wool reported it gave off an unpleasant odor after sitting in storage a few days, was expensive, and didn't perform well. The recycled denim was reported to perform on a par with cellulose or fiber glass, but the respondent was disappointed that the material had no preconsumer recycled content.

Air Sealants

Several respondents were not sure of the type of caulk used in their projects. They used descriptors such as "white," "clear," and "temperature resistant." None of the respondents reported using a specific air sealant that is advertised as healthier. Some, however, reported using air sealants carrying indirect indications that they were healthier in that they were labeled as compliant with state regulations on off-gassing. It is unclear how many respondents were aware of air-sealant options, which suggests the need for increased awareness related to air sealants.

Drivers

Factors influencing a respondent's choice of retrofit materials and a hierarchy of values and motivations emerged from the interviews. For upgrades in low-income buildings, cost appeared to take priority: funding for these programs is limited, and often contractors are submitting competitive bids. Being able to bid lower than others gives a contractor an edge.

The next most important motivating factor, which underlies all others, was existing regulations. Whether because of state building standards, program requirements, or industry best practices, respondents had to consider which materials would pass inspection. After meeting cost and regulatory constraints, respondents were next most concerned about material performance. Of the options remaining to them after satisfying the primary imperatives, respondents took into consideration specification sheets, building construction type, ancillary benefits such as blocking air flow, and other factors in determining which materials to use.

These drivers reflect the mission of a low-income energy retrofit professional—to reduce energy usage—who is usually constrained by resources and cost-effectiveness. Given that respondents take health, safety, and environmental impacts into consideration during decision making related to selection of building materials, it is logical to conclude that if healthier products provide advantages over existing materials, and with the aid of effective communication and support from program funders, adoption of these materials would increase.

Barriers

Most respondents did not report any problems with adopting healthier materials. Cultural barriers that were reported included lack of experience and training, but also some unwillingness on the part of contractors to try a new material or installation technique. For example, blowing cellulose or fiber glass requires the drilling of holes in interior walls. The cost of equipment for blowing cellulose or fiber glass was the most commonly reported technical barrier, followed by concerns about the materials themselves. Cost was also an issue with some materials. Another deterrent that deserves further examination is performance. Many respondents reported that spray foam insulated better than any other material on the market, and that when it came to air sealing gaps too large for caulk, the alternatives to spray foam were too expensive and time-consuming. Respondents reported that for some types of construction, spray foam was the only material that could reach and adhere to the spaces where insulation was needed, especially in buildings with stone masonry. Many respondents said they use spray foam because they see no other choice, but they would discard it for a healthier alternative, if one existed. Low-VOC spray foams exist, but one respondent noted the performance was subpar. There was a sense, especially with regard to air sealants, that there are few or no feasible healthier options.

Recommendations

The following recommendations are drawn from the in-depth interviews of industry professionals working to improve energy-efficiency in the affordable MF housing sector.

For Professionals

- Create easy-to-understand educational materials about the health and safety impacts of spray foam, even after the curing period.
- Increase awareness among professionals of the potential presence of formaldehyde in some fiber glass and mineral wool.
- Increase awareness among professionals related to healthier air-sealing alternatives.
- Promote mineral wool and recycled denim as healthier insulative alternatives.
- Disseminate information related to healthier materials at contractor conferences, trade shows, seminars, and forums.
- Market websites with recommendations on healthier materials, such as homefree.healthybuilding.net.
- Conduct in-person trainings and demonstrations through formats such as "Lunch and Learn."
- Emphasize impacts of materials on indoor environmental quality when providing information about health and environmental impacts.

For the Public

- Encourage the public to request healthier materials and to ask questions about the materials being used in their homes.
- Create awareness of hazards associated with spray foam.

Advocacy

- Advocate for local governments and weatherization programs to incorporate considerations of health and environmental impacts into their building codes and material requirements.
- Encourage BPI, NREL, and other organizations responsible for continuing education to incorporate more discussion of health and environmental impacts in their best practices and contractor trainings.
- Press the EPA and national professional organizations to include information on health and environmental hazards prominently on their websites.
- Press for product labelling with health and environmental impact warnings.
- Put pressure on manufacturers to create higher performance alternatives to standard materials, especially air sealants, and to publicly disclose contents so the products can be vetted as potentially healthier alternatives.

Conclusion

CONCLUSION

The findings elicited from 21 interviews with contractors and industry professionals indicate that insulation materials deemed healthier are used in affordable, MF energy-efficiency upgrades. The interviews underscore key opportunities to expand knowledge about and adoption of healthier air-sealing materials. While there is still work to be done to close persisting knowledge gaps pertaining to potential, adverse side effects of insulation materials, there remains the greater challenge of developing viable alternatives for air sealants. Notable observations were made by leaders in the industry, who could be classified as early adopters, of innovative materials, such as the use of sheep's wool as insulation for MF buildings. Further insights on performance, advantages, and barriers from early adopters can be elicited and shared with others in this network.

Key findings from the interviews revealed that health, safety, and environmental benefits are considered when insulation materials are being selected. This is an important starting point for designing educational information to increase the adoption of healthier building materials. Another key finding is that whether healthier material is adopted is highly dependent on other factors, such as its relative advantage (e.g., cost and cost-effectiveness) over existing materials; observable effectiveness and performance through demonstration and word-of-mouth approval; ease of use; adherence to existing regulations; and acceptance by the clients served. Finally, interviewees relayed the importance of encouragement and guidance on the use of new materials from trusted sources of information, including program sponsors (e.g., DOE and utility companies), government agencies (e.g., EPA), and researchers (e.g., NREL).

If current trends continue, a fully healthy insulation market is possible. In the past five years alone, U.S. and Canadian manufacturers eliminated formaldehyde-based binders from their light-weight, residential fiber-glass batts, and makers of spray foam blowing agents have begun to move away from using chemicals that have high global warming potential. In fact, HFOs, a greener alternative to the predominant HFC blowing agents, entered the market as early as 2008 and an increasing number of manufacturers have been adopting them since 2016. An important, remaining knowledge gap is related to the demand side of the equation—understanding the market drivers, adoptability, and performance of these nonstandard, and in some cases innovative, materials. Learning more about the needs and values of the intended user group (e.g., contractors and installers) can assist with user-centered product design and marketing. Researchers can consider these factors and, using the diffusion of innovation theory, inform their understanding of user acceptance.

Future studies that use, at a minimum, a quasi-experimental approach with a treatment and control groups would be beneficial. It is uncertain how the green building trends and the emergence of healthier energy conservation measures will change indoor exposure profiles, especially within low-income housing.[50] Ultimately, the link between exposure to poor indoor environmental quality and human health is difficult to accurately evaluate because exposure might include air contaminants from both indoor and outdoor sources. The literature suggests that both health benefits of energy-efficiency upgrades and health impacts from exposure to insulation and air-sealing materials have been observed. In light of this, we ask: How might we continue to expand the reach of known evidence the known health benefits of energy-efficiency upgrades while also reducing and eliminating harmful chemical exposures often associated with standard insulation and air-sealing materials? Future research within the affordable housing space that collects data related to occupant health, both pre- and post- healthier energy retrofits, through occupant surveys and health diaries could assist with filling the evidence gap.

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Appendix A

APPENDIX A. METHODOLOGY

This section provides a detailed description of the research design followed for this study. It includes a list of the resources and databases used to select the target population and descriptions of the stratified random sampling plan and selected sample. It also includes a description of the recruitment strategy, interview protocol, and the data analysis approach.

Sampling

The target population for study was industry professionals within the affordable MF energy retrofit sector (e.g., contractors, energy auditors and consultants, and weatherization staff) in 12 states—California, Georgia, Illinois, Louisiana, Maryland, Michigan, Minnesota, Missouri, New York, Pennsylvania, Rhode Island, and Virginia. These states were chosen because of their involvement with the EEFA project.[51]

The goal of conducting 20 interviews was set based on the final size of the sample frame and resources available for recruiting participants and conducting interviews. It was initially anticipated that recruits would be drawn from project partners' databases. However, too few contacts were received and an alternative approach was developed. The study team scanned the Internet and searched publicly available state and organization databases to identify eligible contractors (i.e., those that provided energy-efficiency upgrades to affordable MF housing).[52] However, not all databases provided the option to incorporate the eligibility criteria into queries, the scan produced a target population of 902 companies. It should be noted that not all EEFA states had applicable databases so there was an unequal distribution of interviewees drawn from among EEFA states.

The handful of known eligible contractors recommended by others in the industry were referred to as the purposive sample (n_p).[53] These potential participants were not included in the stratified random sampling process. It was anticipated that there would be a low response rate (50 percent) from the random sample frame during the recruitment process. The study team therefore included the purposive sample in hopes that it would compensate for this limited response.

TABLE A.1. Size of Sample Frame and of Random and Purposive Samples by Stratum			
Study Target Population			
EEFA State (Stratum)	**Sample Frame (N_s)**	**Random Sample (n_s)**	**Purposive Sample (n_p)**
California	163	7	10
Georgia	43	2	1
Illinois	76	3	2
Louisiana	15	1	0
Maryland	62	3	0
Michigan	32	1	0
Minnesota	41	2	2
Missouri	35	2	1
New York	299	13	0
Pennsylvania	86	4	1
Rhode Island	21	1	1
Virginia	29	1	0
Totals	**902**	**40***	**18**

*Intended goal was 20 interviews. Recruitment rate was estimated to be 50 percent; therefore, the size of the random sample was doubled to 40.

The EEFA states were selected as the strata at the outset, and the sample size for each stratum was based on a minimum goal of n=20 total interviews, while taking into consideration the estimated 50 percent recruitment rate. For a given stratum (i.e., EEFA state), researchers calculated the ratio of potential recruits to the target population (culled from the resources listed above) and then assigned a proportional sample size per stratum. Table A.1 breaks down the target population to show sample sizes of the sample frame, random and purposive samples, by stratum.

Variables:

- *Target Population = N*
- *Sample frame per stratum (EEFA state) =* N_s
- *Random sample per stratum =* n_s
- *Purposive sample per stratum =* n_p

Equation:

$$n_s = (N_s * n) / N$$

Sampling Approach

Step 1. Contractors selected from existing databases and lists available through relevant sources, produced (N) = 902.

Step 2. Potential participants were grouped into strata (N_s). The proportion of (N_s) to (N) established the sample size per individual stratum (n_s) to include in sample frame (n=40).

Step 3. A simple random sample was selected by randomizing each N_s using Excel's =RAND() function.

Step 4. Purposively sampled contractors (n_p) were added to the top of the list in appropriate stratum. They were not randomized.

Step 5. The study team attempted to verify that contractors were eligible (i.e., that they worked on MF, low-income, energy-efficiency upgrades).[53] Eligibility was verified either by reviewing websites or by asking screening questions during recruitment phone calls. The actual recruitment rate ended up being 10 percent.

Step 6. Contractors that were not eligible were eliminated from the list.

Interview Protocol

Researchers developed a semi-structured interview guide and protocol for interviews to be administered by telephone. These were designed through an iterative process that involved piloting the interview with contractors in the field. The trained interviewer who conducted all the interviews for the study followed the open-ended questionnaire and interview protocol that was developed rather than a rigid survey structure. This relatively unconstrained approach allowed the interviewer to follow the contractors' leads and capture additional themes that the research team had not previously considered. However, the format remained at least partially guided in order to maintain consistency and facilitate comparisons between interviews.

Table A.2 shows the themes that were explored in the interviews.

Interview Administration

The protocol opened with screening questions to ensure that interviewees met the criteria for inclusion in the sample, (i.e., that they install insulation or air sealing in existing multifamily buildings in which at least 50 percent of the units are designated as low-income housing.) It was also important to ensure the installations were upgrades and not new construction. The protocol also included acquiring a verbal informed consent from the interviewee to participate in the study. Initially, the sample included only contractors or their supervisors. As the interviews progressed it was determined that including energy auditors and consultants would be beneficial–many contractors interviewed said that an architect or energy consultant dictated or influenced their choice of building materials.

The study team provided the interviewees with the following definition of healthier materials to assist with characterization:

> *Healthier materials are those that have less toxic or no toxic off-gassing during or after installation; those that pose minimal to no health hazards if the gasses are inhaled or if the materials are touched or ingested; and those that are made with materials that are less toxic to the environment to produce, dispose of, or recycle.*

Although the semi-guided interviews were intended to be relatively unconstrained and respondents were allowed some freedom in expressing their beliefs and experiences, all interviewees were asked each relevant question in the script to ensure thorough results and that rigorous comparisons would be possible between interviews. All interviews took place by phone and lasted an average of 30 minutes. Answers were recorded by hand during the interviews and transcribed into an Excel spreadsheet after; interviews were not audio recorded. All recruitment calls and interviews were completed by the same researcher. An incentive of $50 was provided to compensate the interviewees for their time. Names of contractors, industry professionals, companies, and all other identifying information were saved in a password-protected location.

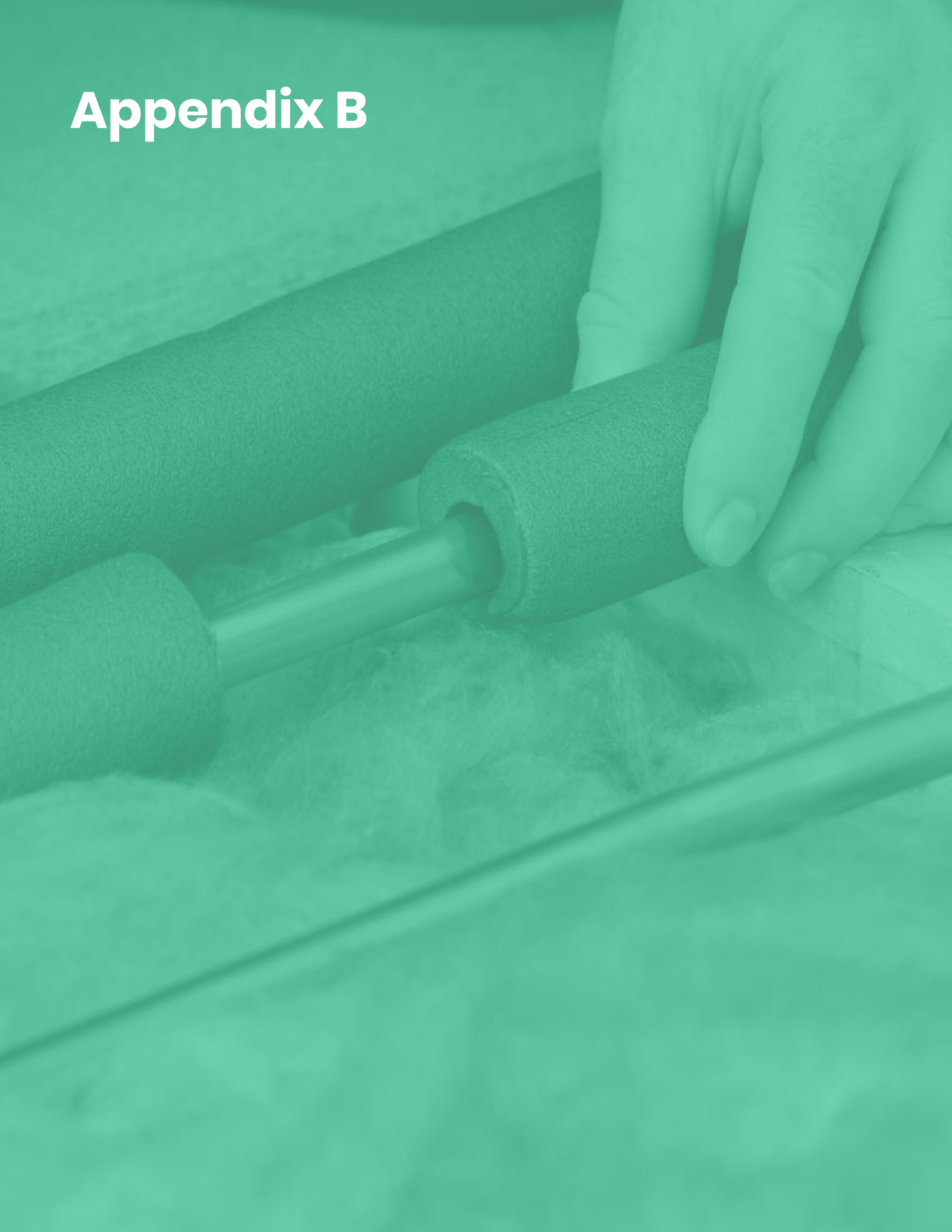
Data Analysis

Once all interviews were complete, the interviewer coded answers for each question to more easily find relationships, patterns, and frequency of responses. Additional comments that were relevant to the research question but that did not pertain directly to one of the interview questions were put into their own category. These responses comprised their own variable and were coded as such. For example, six respondents mentioned that they believed demand-side pressures (e.g., client preferences and program requirements) would be critical to increasing adoption of healthier retrofit materials. None of the questions in the protocol asked the respondent for an opinion on the best way to increase adoption specifically, and yet the insights were highly relevant to the research question. Other comments, such as those concerning state regulations on mechanical ventilation, were less directly relevant and therefore not included in the interview coding. These types of comments were retained in the transcripts.

TABLE A.2. Key Thematic Areas Explored in Interviews

Key Thematic Areas Explored	
Information Channels	How and where do they learn about new materials?
Drivers, Motivations, and Values	What are the drivers, motivations, and values related to material choices and use?
Challenges and Barriers	What are the challenges and barriers to adopting healthier materials as first choice (e.g., training, equipment)?
Perceptions: Usability and Adoptability	What are the perceptions of the usability and adoptability of healthier materials?
Perceptions: Cost, Complexity, and Availability	What are the perceptions related to the cost, complexity of installation, and availability of healthier materials?
Perceptions: Limitations	What are the perceptions related to the limitations of healthier materials (e.g., compatibility, availability, and practicality)?
Awareness and Understanding	What is the current level of awareness and understanding of the health and environmental impacts of standard materials?
Recommendations: Innovation	What ideas and recommendations do these implementers have for healthier material innovation and development?
Recommendations: Communication	What ideas and recommendations do these implementers have for improvements in communications surrounding healthier materials and alternative information channels?

Appendix B



APPENDIX B. SEMI-GUIDED INTERVIEW PROTOCOL

ELIGIBILITY VERIFICATION

Hello, I was calling to see if your company provides construction services related to energy efficiency for multifamily buildings, specifically affordable or low-income multifamily buildings?

- [If not] *Might you be able to recommend another company that does?*

  ____

  Ok, thanks so much for your time.

- [If yes] *Ok, great! Might you be able to direct me to a [person responsible for scoping jobs and materials selection OR head of the company, or Project Manager?] that handles these types of contracts* [MF energy-upgrades]*? Or one of your lead contractors that does this type of work?*

  [Get contact information for the recommended industry expert. May need to provide project information provided below before they will give you contact information or transfer you. Might only let you leave your phone number for a return call.] *Great! thanks so much for your time.*

RECRUITMENT

I am working with a non-profit organization, named ThreeCubed, out of Tennessee. We were tasked by Natural Resources Defense Council to talk briefly with experts around the country, like yourself, that do energy retrofit work in affordable multifamily buildings. We are providing a $50 Visa gift card in exchange for about 30 minutes of your time so the industry can learn more about which types of building materials companies use and why. Would you be willing to participate in this interview? If so, is now a good time to talk?

Would you be willing to participate in this interview? If so, is now a good time to talk?

- [If not: *When would be a good day and time for me to call you back?*]
- *To confirm, is this the best phone number for me to reach you?*
- [If not: *Which one?*] ______________________________

[Additional information if they are hesitating or asking:

Results from these interviews will be published in a Guide for Healthier Energy Efficiency Upgrades in an effort to improve building materials and mainstream the use of healthier building materials in an effort to further improve the health of occupants and installers. This guide will be published next Spring and will be available to people, like yourself, that are in the multi-family energy retrofit industry.

The goal of this study is to capture on-the-ground insights from the experts themselves to understand what drives their decisions related to the types of building materials they choose to use and get their perspectives and opinions on materials that are considered "greener or healthier"… Like are they effective? are there limitations with their use? do they believe they are healthier than the standard building materials? And that sort of thing.

I would like for you to know that this study is part of a much larger, and important, scientific research project that is being funded by the Natural Resources Defense Council and Energy Efficiency for All, in collaboration with the Healthy Building Network.]

INTRODUCTION (if interview was not conducted on the first phone call)

Hi, this is ____________, I talked with you a couple of days ago and you gave me permission to interview you for about 20 minutes and in return I will send you a $50 gift card? Is this still a good time for you?

- [If not: *When would be a good day and time for me to call you back?*]

- [If yes: *Great!*] *Again, this study is being funded by the Natural Resources Defense Council and Energy Efficiency for All, in collaboration with the Healthy Building Network. These research results will be published in a Guide for Healthier Energy Efficiency Upgrades that we will be sharing with experts, like yourself, that are in the multi-family energy retrofit industry. Do you have any questions before I start the interview?*

INTERVIEW

A. First, I would like to discuss the types of building materials used in your business.

1. How does your company decide which type of insulation and air sealing materials to use when providing energy retrofit services in MF housing?

(Probe: dictated by building codes only? Or building owner/client?)

I will be referencing green, or healthy, building materials throughout the rest of this interview, I would like to share the industry's definition of healthier materials. These are materials that have less toxic or no toxic off-gassing during or after installation. Those that pose minimal to no health risks if the gasses are inhaled or if the materials are touched or ingested, and those that are made with materials that are less toxic to the environment to produce. I should note that for the purposes of our study, we are only focusing on insulation and air sealing retrofit materials.

[Examples of healthier retrofit materials if more information is needed:

Includes insulation that is made of expanded cork, fiber glass or cellulose insulation....and does not contain formaldehyde-based binders. For rigid board insulation, mineral wool insulation that meets the California Emission Specification 01350 for residential scenarios. Materials we are considering "healthy" does NOT include any foam insulation, whether rigid board or spray-applied (as they typically contain highly toxic flame retardants; and extruded polystyrene and closed cell spray polyurethane foam insulations also use blowing agents that are potent greenhouse gases.) These gases contribute to global warming and detract from the positive effects these insulations have on climate change by saving energy.]

2. What green and healthy materials have you used or been encouraged to use by affordable multifamily energy efficiency programs or clients?

[If No: SKIP to Q7]

3. Specifically, which type of insulation materials?

(Prompts:

- expanded cork
- fiber glass without formaldehyde-based binders
- cellulose
- mineral wool)

4. Would you say that your company uses some, mostly, or all greener materials for your multi-family jobs, as opposed to standard materials? For how many years?

5. Which reasons motivate your company (or the client, if they stated this in Q3) to choose these materials over non-standard building materials?

   (Probe:

   - incentives? (which type, which level?)
   - program mandates
   - certifications)

6. Have you ever heard of an occupant of a multifamily building that had any health issues (headaches, burning eyes, asthma symptoms, that kind of thing) from the installation of retrofit materials? (If so, probe for stories and make sure to connect/document the specific material(s) (healthier or standard, or...?) to the story/health impact.

B. Now I would like to talk about any challenges or barriers that you may know about related to using greener retrofit materials.

7. Overall, how easy has it been, or **was** it [if they no longer use], to adopt and use these materials in the field? (extremely, somewhat, not at all)

8. What challenges have you encountered, or would you **anticipate** having to encounter [if they have not ever used these materials], while **using** these materials?

   (Prompts:

   - materials are too expensive
   - installation process, usability
   - accessibility/availability from vendors (compared to standard materials)
   - do not perform as well as standard materials)

9. What challenges have you had to overcome, or would you **anticipate** having to overcome [if they have not ever used these materials], to **incorporate the use of** these materials?

   (Prompts:

   - need for additional training
   - need to convince clients of the benefits
   - need to convince occupants of the benefits
   - need to convince your installers of the benefits
   - need and cost for new equipment)

C. I wonder if you might be able to share some suggestions and recommendations?

10. Such as, do you have any suggestions related to how greener retrofit materials could be further improved?

(Prompts:

- cost
- usability
- reliability)

11. If so, which type?

12. Do you think that more information needs to be available about the benefits of greener retrofit materials?

[If No: SKIP to Q15]

13. Which format has been most helpful or informative?

(Prompt:

- informative booklets or manuals
- video tutorials
- presentations by sales reps…?)

14. Which information channels would you recommend?

(Prompt:

- conferences
- training centers
- magazines, such as Home Energy?)

15. What is your company's source of information related to building materials that are considered greener or healthier?

(Prompts:

- Trade shows
- Trade magazines
- Sales reps
- Internet)

D. Ok, just a few more general questions and we can wrap this interview up.

16. What types of multi-family buildings does your company typically work on?

(Prompts:

- Low-rise (4 stories or less)
- Mid-rise (5-9 stories)
- High-rise (10 or more stories)
- Row-houses (rows of houses with at least one shared wall)
- Other?)

17. Is your company a not-for-profit, or?

18. How long has your company worked in the energy retrofit industry?

19. What percent of your business is multifamily energy efficiency retrofit based work vs. multifamily new construction vs. commercial or single family?

20. How long has your company worked in the affordable multi-family sector?

21. Do your clients, or programs, require that your crew leaders and installers have any special certifications? (Prompts:

- BPI? If so, which type?
- Home Performance with Energy Star)

22. Even if not required, do you personally hold any special certifications?

23. Is your company's service territory mostly urban or rural? Which region of the state does your company mainly serve? (Prompts: North, East, etc.)

24. Does your company serve more than one state?

25. How many employees would you estimate that your company has?

(Prompt:

- 1 to 19
- 20 to 40
- 41+)

END.

THANK YOU SO MUCH FOR YOUR TIME.

CAN WE HAVE AN ADDRESS TO MAIL YOU THE $50 VISA GIFT CARD?

Address: ___________________________________

Endnotes

Endnotes

1 In 2013, Natural Resources Defense Council, National Housing Trust, Energy Foundation, and Elevate Energy launched the Energy Efficiency for All project, which was funded by The JPB Foundation. For more information, see: http://energyefficiencyforall.org/.

2 These documents are available on the EEFA website, http://www.energyefficiencyforall.org/.

3 Colton et al., 2015; Colton et al., 2014; Breysse et al., 2011.

4 A small purposive sample (selected based on characteristics of a population and the objective of the study rather than random selection) of well-known agencies was used to both pretest the semi-structured interview guide and ensure that a diverse sample was achieved and that the results were relevant and representative of the industry.

5 https://www.energyefficiencyforall.org/resources/making-affordable-multifamily-housing-more-energy-efficient-guide-healthier-upgrade/

6 https://www.energyefficiencyforall.org/resources/policy-matters-making-energy-upgrades-healthier-for-residents-workers-and/

7 https://www.energyefficiencyforall.org/resources/guidance-for-specifying-healthier-insulation-and-air-sealing-materials/

8 Findings related to these specific health-related non-energy impacts can be found in the following reports: Hawkins et al., 2016; Rose et al., 2015; and Tonn et al., 2014.

9 Drehobl and Ross, 2016.

10 Coombs et al., 2016; Weschler, 2013; Adamkiewicz et al., 2011; Sandel et al., 2010; Franklin, 2007; Breysse et al., 2004; Fisk, 2000.

11 Samet and Spengler, 2003.

12 In 2012, DOE instituted a minimum ventilation requirement for WAP, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 62.2 Standard, for single-family and multifamily (three stories or less) dwellings.

13 Urea-formaldehyde foam insulation was banned in Canada in 1980 and in the United States in 1982. However, the ban was almost immediately overturned in the United States in 1983 and the material is still in use today. (Tsakas, Siskos, and Siskos, 2011; Franklin, 2007)

14 Tsakas, Siskos, and Siskos, 2011; Franklin, 2007; Broder et al., 1988.

15 https://www.energyefficiencyforall.org/resources/making-affordable-multifamily-housing-more-energy-efficient-guide-healthier-upgrade/

16 The Freedonia Group, 2017; Grand View Research, 2018; Sto Corp, 2015; Plasteurope.com, 2013; Hunter, 2015; Cision PR Newswire, 2014; Plasteurope.com, 2013.

17 The Freedonia Group, 2017; Grand View Research, 2018; Hunter, 2015; Cision PR Newswire, 2014.

18 The Freedonia Group, 2017.

19 R-values are the industry standard measurement of how well a material insulates, i.e., blocks thermal flow. The Freedonia Group, 2017.

20 U.S. Environmental Protection Agency, 2018.

21 Ibid.

22 EEFA, 2018.

23 Long et al., 2014; Green Building Advisor, 2017.

24 The Global Warming Potential (GWP) for a gas is a measure of the total energy absorbed over a particular period of time compared to carbon dioxide (GWP = 1). An increase in GWP equals an increase in impact.

25 Intergovernmental Panel on Climate Change, 2007.

26 EEFA, 2018.

27 Ibid.

28 BlueGreen Alliance Foundation, 2015.

29 EEFA, 2018.

30 Hunter, 2015; Plasteurope.com, 2013.

31 European Cellulose Insulation Association.

32 Holladay, 2015. uropean Cellulose Insulation As

33 Lstiburek, 2010. sociation.

34 IndoorDoctor, 2017; Spray Foam Staff, 2008.

35 Little, 2013.

36 Takaro et al., 2013

37 Bornehag 2013.

38 https://sws.nrel.gov/spec/4, https://sws.nrel.gov/spec/3

39 Rogers, 2003.

40 *Adoptability* and *compatibility* differ in that former relates to the user group and the latter relates to systems (e.g. mechanical).

41 Carr, 1999; Rogers, 2003.

42 Farquhar and Surry, 1994.

43 Cao et al., 2017.

44 Ibid.

45 Purposive sampling is also referred to as "non-probability" sampling and is selected based on characteristics of a population and the objective of the study rather than random selection.

46 The primary objective of the EEFA initiative was to expand energy-efficiency programs for the affordable multifamily sector, build a national network to help expand investments in these programs, and provide support for multifamily building owners seeking energy retrofit services.

47 For more information on the use of recycled denim as an insulative material, see section: Results > Sample Characterization.

48 This agency was located in Maryland; it is possible that materials are more readily available in certain states or regions than in others.

49 This respondent was unable to provide any more information as to which low-VOC variety of spray foam is used

50 Colton et al., 2014.

51 In 2013, Natural Resources Defense Council, National Housing Trust, Energy Foundation, and Elevate Energy partnered to launch the Energy Efficiency for All Project. The project was funded by The JPB Foundation. http://energyefficiencyforall.org/.

52 http://www.bpi.org/sites/default/files/Locator.html, https://www.elevateenergy.org/get-know-energy-efficiency-contractor-energy-reduction-inc/, https://camultifamilyenergyefficiencydotorg.files.wordpress.com/2016/02/liwp_participatingcontractors_2017-02-07.pdf, https://www.nyserda.ny.gov/Contractors/Find-a-Contractor/Multifamily-Building-Solutions-Network, https://nyserda.energysavvy.com/contractors/?page=3, http://aea.us.org/wp-content/uploads/2014/06/Con-Edison-MFEEP-Participating-Contractor-List-as-of-6-20-14-by-category.pdf

53 A purposive sample is one that is selected based on characteristics of a population and the objective of the study rather than random selection.

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