Decarbonization through Energy Audits

Understanding Energy Audit Information Form & Functions to Study Their Impacts on Consumer Decisions

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A Practicum submitted
In partial fulfillment of the requirements for the degree of
Master of Science (School of Environment and Sustainability)
In the University of Michigan
April 2026

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Acknowledgement

I would like to express my sincere gratitude to my advisor, Parth Vaishnav, for helping me along with this report and helping me complete it. I had a range of struggles with this paper and it was only with the help of Professor Vaishnav that I was able to complete the necessary work.

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Abstract

Residential energy audits are widely used to reduce household energy consumption and greenhouse gas emissions, yet recommendations are implemented at persistently low rates across diverse program contexts. This review synthesizes contemporary research on the full trajectory of audit engagement and interaction; from participant recruitment and building characteristics, through information comprehension, to retrofit adoption and the behavioral dynamics that govern actual retrofit uptake. We find that audit participants skew toward older, higher-income, long-term homeowners, diverging from households most in need of efficiency improvements. Comprehension is uneven, shaped by presentation format, contextualization of technical information, and individual cognitive tendencies. Even where comprehension is adequate, adoption remains incomplete: households favor low-disruption actions over the deep retrofits that generate the largest savings. Subsidies reduce but do not eliminate this gap, while social influences, auditor behavior, and contractor relationships emerge as underexplored contributors to follow-through. Key gaps remain such as integrated accounts linking comprehension to adoption are absent, social and institutional factors are undertheorized, and no contemporary comprehensive review of audit mechanisms exists. This review addresses that absence, distinguishes generalizable findings from context-specific ones, and identifies the mechanisms most decisive in determining whether energy audits succeed as instruments of residential decarbonization.

1.0 Introduction

Residential energy audits occupy a peculiar position in the landscape of climate policy. They are, in principle, one of the most rational interventions available: a trained professional visits a home, identifies inefficiencies, and recommends targeted improvements that would reduce both energy bills and greenhouse gas emissions. In many programs such as the federal Weatherization Assistance Program (WAP) and utility provided programs, the audit itself is offered free of charge, removing the most obvious financial barrier to engagement. And yet, the recommendations that emerge from these audits are implemented at surprisingly low rates, leaving energy savings unrealized. That this gap persists across countries, income levels, and program designs points to something more than simple inattention or financial constraint. It points to a somewhat misunderstood system of decisions.

The failure to act on audit recommendations is not merely an inconvenience. As nations including municipalities accelerate their decarbonization commitments, the residential building sector remains one of the most stubborn sources of greenhouse gas emissions. Improving the thermal efficiency of homes through insulation, air sealing, and heating system upgrades represents one of the most cost-effective pathways available to policymakers (McKenna et al., 2025; K. Palmer et al., 2013). But those pathways depend on households actually making changes, and they depend on audit programs that successfully bridge the distance between diagnosis and action. Understanding why that bridge so frequently breaks down is therefore not an academic exercise but a practical necessity.

Despite the importance of the question, the literature has not yet provided a coherent answer. Studies have identified financial barriers, information gaps, cognitive processing differences, social influences, and institutional constraints as contributors to non-adoption, but these explanations have accumulated without synthesis (Baldini et al., 2017; Matosović & Tomšić, 2018; Murphy, 2014; K. Palmer et al., 2013; Risholt & Berker, 2013; Sprehn et al., 2015). Findings contradict one another, populations studied are rarely comparable, and the mechanisms linking audit design to household behavior have never been systematically traced. Compounding this, the only major comprehensive review of residential energy audit processes was published in 1980 by Hirst et al. at Oak Ridge National Laboratory, decades before digital auditing, behavioral economics, and smart-energy systems reshaped what audits are and how households respond to them (Hirst et al., 1981). More recent reviews have addressed audits only in passing, as one policy instrument among many, rather than examining the audit process itself in depth (McAndrew et al., 2021; Ramos et al., 2015; Solà et al., 2020; Wilson et al., 2013).

This review addresses that gap directly. Drawing on contemporary research across building science, behavioral economics, cognitive psychology, human-computer interaction, and energy policy, we synthesize what is known about residential energy audits such as who participates, how information is presented and understood, what drives or suppresses retrofit

uptake, and how emerging technologies and program designs may alter these dynamics. Our goal is not simply to catalog findings but to identify which are generalizable across contexts, which are context-specific, and where apparent contradictions reflect methodological differences rather than genuine disagreement. In doing so, we aim to provide the integrated account that the field has been missing: one that traces the full trajectory from audit participation to retrofit action, and that can inform the design of programs that close the gap between what audits recommend and what households actually do.

2.0 Motivation

Audit recommendations are not always implemented, and the fact that audits are often offered free of cost to initiate retrofits makes this particularly problematic. First, the opportunity to reduce energy use, costs, and greenhouse gas emissions is lost. Second, free audits that do not result in a retrofit raise the costs of retrofits for everyone. There is a question of why this happens and despite the existence of literature covering aspects of this question there is no synthesis of the literature.

This synthesis is necessary given research has produced contradictory results and left significant gaps. For example, the reasoning behind residents' inability to follow audit-recommended retrofits varies considerably across studies. Some research focuses primarily on financial barriers, including residents' budgets, permitting costs, homeownership status, and the availability of government subsidies (Baldini et al., 2017; Matosović & Tomšić, 2018; McKenna et al., 2025; Murphy, 2014). In addition to economic factors, other studies have identified non-economic factors that influence short-term decision-making. For example, Achtnicht (2011) found that discussing environmental benefits added to the motivations for retrofit decisions, while Palmer et al (2013) demonstrated that addressing information gaps played a beneficial role. Additionally, some research has examined longer-term considerations besides financial decisions, such as comfort needs (Zundel & Stieß, 2011). These oftentimes conflicting and nuanced perspectives color the relationship between energy audits, their effectiveness and suggest a natural question of why? It is the goal of this synthesis to examine the aspects of the literature further in order to contextualize findings across the discipline, identify those that are generalizable across contexts, and those that are context-specific.

At the same time, there is a notable gap in comprehensive reviews addressing aspects of energy audits and their impact, as the only major study is over 44 years old from Oak Ridge National Lab (Hirst et al., 1981). A recent review conducted by Solà et al (2020) compared energy audits with retrofit recommendations along with other information based policies to more command and control policies and direct price based policies. Similar reviews on energy efficiency interventions were conducted by McAndrew et al (2021) who compared audits to other energy interventions at the household level and Ramos et al (2015) who compared them to

other information policies. Finally, Wilson et al (2013) provides the closest analysis of all around energy audits in their larger review of audits and people's opinion of those audits in the United Kingdom. These reviews offer broad analyses on their subjects but do not analyze the various aspects of energy audits and how they can be altered for better impact which this very review seeks to solve.

3.0 Methodology

This review synthesizes contemporary research on residential energy audits, with a particular focus on audit design, information comprehension, and subsequent investment behavior. To ensure both breadth and relevance, we employed a structured multi-stage search process drawing on two primary academic indexing systems—Google Scholar and Scopus—along with targeted searches in Web of Science for interdisciplinary environmental and behavioral science sources. Google Scholar was selected for its broad coverage of diverse publication types and citation networks, while Scopus was chosen for its more curated indexing, advanced filtering tools, and detailed citation analytics. Together, these systems enabled comprehensive identification of research across energy engineering, building science, behavioral economics, and human–computer interaction.

3.1 Search Strategy and Keywords

Searches were conducted iteratively using a combination of core and peripheral terms reflecting the range of factors influencing energy audit outcomes. Core terms were directly tied to energy audits and household investment decisions, while adjacent keywords captured literature that informs how residents interpret audit information or evaluate upgrade options. The keywords included:

Term	Reason
energy visualization	A key part of energy audits is the way that energy use is visualized. To understand energy audits it is important to understand energy visualization processes.
eco-feedback	Similar to energy visualization, eco-feedback is important to understand energy audits as it is often a key way of information presentation. By examining this feedback we can understand a certain aspect of energy audit outcomes that aren't as heavily studied.
consumer energy decisions	This broader perspective allows us to show consumers and how their own history impacts their decisions to pay for certain actions in the energy market as well as what typically happens when they focus on energy.
energy investment behavior	This can allow us to analyze how investment decisions are made and often how effective investment decisions are given energy audits from residential versus commercial entities.

Search queries combined these terms using Boolean operators (e.g., “energy audit” AND “investment behavior”; eco-feedback + residential energy), with publication year filters applied to limit results to 2000–present, reflecting shifts toward digital auditing, behavioral framing, and smart-system measurement over the past two decades.

3.2 Screening and Inclusion Criteria

The initial search generated 12863 records. We screened titles and abstracts to exclude studies that:

- did not pertain to residential or household energy behavior
- focused solely on commercial or industrial auditing
- examined energy information tools not tied to retrofit or performance feedback
- lacked empirical or methodological grounding

Following this phase, 50 articles remained for full-text review. We then conducted backward citation tracking (reviewing bibliographies of included studies) and forward citation searches (identifying later papers referencing influential works) using Scopus and Google Scholar’s citation tracing features. This process added 15 additional publications that we utilized.

3.3 Treatment of Grey Literature and Temporal Scope

Peer-reviewed scholarship served as the foundation of this synthesis. However, because policy-oriented organizations have produced evaluations of residential energy audit programs, relevant grey literature from government agencies and established research institutes was also included when: the publication was widely cited in scholarly work, and methods and results were deemed clearly documented. Our coverage intentionally spans approximately 25 years from 2000 to 2025, capturing the evolution from paper-based energy audits to digitally mediated and data-driven models. A full record of screened and included studies will be cataloged in an appendix, allowing transparent replication and assessment.

4.0 Author Examinations

The literature on residential energy audits and retrofit behavior is genuinely interdisciplinary, drawing from a set of distinct academic traditions that each illuminate different aspects of why households do or do not act on audit recommendations. Rather than completely converging on a single explanatory framework, these disciplines have developed somewhat in parallel, producing findings that are complementary and sometimes integrated. Understanding where the research comes from and what each tradition tends to assume, measure, and overlook is essential context for interpreting the synthesis.

4.1 Behavioral Economics and Energy Policy

One of the first major traditions draws from behavioral economics and its application to energy and environmental policy. Researchers in this strand are less concerned with how much energy a home could save than with why households do or do not choose to pursue those savings. They employ tools such as choice experiments, randomized controlled trials, and survey-based revealed preference methods to identify the conditions under which households respond to information, incentives, and framing. Palmer, Walls, and colleagues at Resources for the Future have been particularly productive contributors, using these methods to document both the information gaps between auditors and households and the behavioral dynamics that govern post-audit follow-through (2013). This is compared to other behavioral economics that examine choice experiments and framing mechanisms (Achtnicht, 2011; Achtnicht & Madlener, 2014; Gillingham & Tsvetanov, 2018; Newell & Siikamäki, 2014)

4.2 Cognitive Psychology and Human-Computer Interaction

A second strand, less prominent in energy policy circles but increasingly important to audit design, draws from cognitive psychology and human-report interaction. Researchers in this tradition ask not whether households receive audit information but whether and how they actually understand it, which is a question the behavioral economics literature has largely sidestepped. Some researchers explore how audits are perceived and understood by individuals in general such as Sprehn (2013), Buchanan (2014), and Canfield et al. (2017). This is compared to other psychologists that examine how people interact and alter audit comprehension (Owen & Mitchell, 2015; Scott et al., 2016).Other researchers focus rather on particular aspects of energy audits such as energy efficiency measures (Al-Kababji et al., 2022; Flora & Banerjee, 2014; Herrmann et al., 2018). Together, this strand provides the methodological conscience of the audit design literature, consistently insisting that information delivery and information comprehension are not the same thing.

4.3 Public Policy and Program Evaluation

A final disciplinary strand encompasses public policy analysis and program evaluation, which examines audit outcomes at the scale of government initiatives rather than individual households. Researchers in this tradition assess whether specific program designs such as subsidy structures, mandatory requirements, outreach strategies translate into measurable changes in retrofit rates across large populations. Researchers such as Fowlie et al. (2018) and Matosović and Tomšić (2018) examine government subsidy programs to examine the fraction of audit participation. Together, this tradition grounds the audit literature in the realities of policy implementation and reminds researchers that individual-level behavioral findings do not automatically scale to population-level program outcomes.

5.0 Who Does an Energy Audit and Invest Without One

Typically an energy audit has two purposes; allow the homeowner to understand the best efficiency retrofits to make or it also is used to meet regulatory requirements for subsidies (MI EGLE, 2025). However, regulators have required energy audits in other circumstances. The city of New York originally employed Local Law 84 which required energy assessments due to the city's concern about climate change, tenant power and climate change goals (Holbert, 2023). Inspired by the law's success, the city continued and passed Local Law 87 which required energy audits for buildings over 50,000 sq. ft (Kontokosta et al., 2020). Even nations such as Latvia and Sweden have also begun imposing energy audits across the range of their businesses in order to meet their climate goals (Backlund & Thollander, 2015; Kubule et al., 2020; Makijenko et al., 2016). These required laws are not common in the residential space and as such, many of the decisions to either do an energy audit or invest in retrofits fall to the residents themselves. Several studies have shown however that many of these participants in residential audits are statistically different from the rest of the population (Achtnicht, 2011; Belaïd, 2024; Lakić et al., 2020; Nair et al., 2010). Along with this unique difference, several pieces of literature have also found differences between people who take on retrofits in the first place, specifically without a formal energy audit.

	Belaïd	Nair et al.	Achtnicht	Lakić et al.	Ingle et al.	Murphy	Hewitt & Wang	Palmer
Income		+	+	+	+			
Education		+	+		+			
Age		+	+			+	+	+
Home Ownership	+				+			
Age of Homes	+					+		+
Race/Ethnicity					+		+	
Prior Conservation Interest					+			
Length of Residency					+			+

Figure 1: Amongst the major papers that examine who conducts an energy audit, there are a few key relationships that they point out including education, age, home ownership age, and finally income. These relationships are all positively correlated with the likelihood of conducting an audit in the first place.

5.1 Resident Characteristics of Retrofit Makers

Resident characteristics strongly shape both the likelihood of undertaking retrofits and the likelihood of participating in energy audits, yet these two bodies of literature rarely intersect and often treat these decisions as if they arise from the same underlying population. Studies examining retrofit activity more broadly, without distinguishing whether an audit preceded the investment, identify homeownership as one of the strongest predictors of action, with renters consistently less likely to invest due to short-term occupancy and limited control over the dwelling (Belaïd, 2024). Among homeowners, younger married adults (26–55) tend to prioritize envelope improvements such as insulation, whereas older homeowners (55+) more commonly invest in heating system upgrades, and education and income remain consistently correlated with retrofit adoption across contexts (Achtnicht, 2011; Lakić et al., 2020; Nair et al., 2010).

In contrast, the literature on audit participation suggests that voluntary audit programs attract an even more selective subset of the population. Households with advanced degrees are substantially more likely to request audits, and high-income households appear overrepresented, in part due to anticipated costs of recommended retrofits (Achtnicht, 2011; Ingle et al., 2012; Nair et al., 2010). Several studies find that audit participants tend to be older, long-term residents, and in some cases more likely to be nonwhite (Hewitt & Wang, 2020; Ingle et al., 2012; Murphy, 2014; K. L. Palmer et al., 2015). Ingle (2012) and Gamtessa and Giuliani (2019) also report that 60% of audit participants had lived in their homes for more than a decade and that many had pre-existing conservation interests. These findings underscore what many have assumed, the characteristics of those who retrofit are not necessarily the characteristics of those who seek audits, yet the retrofit literature often assumes these populations overlap. Without distinguishing retrofit decisions made with versus without an audit, it remains unclear whether observed demographic patterns reflect responses to audit interventions or broader household tendencies independent of audit participation.

5.2 Building Characteristics for Non-Audit Retrofits

Dwelling age and inefficiency have been key motivators for retrofits; owners of older homes retrofit to improve thermal comfort and reduce bills (Murphy, 2014; Ramseier, 2013). However, old homes are subjectively defined by each researcher, as Belaïd (2024) identified homes after 1975 as old and which were more likely to conduct energy efficiency retrofits while Nair et al. (2010) defined older houses to be greater than 35 years old.

5.3 Building Characteristics of Energy Audit Participants

Similar to homes of residents who decided to do retrofits without energy audits, audited homes are often older. As compared to Belaïd's (2024) findings for retrofits, studies such as Palmer et al. (2013) and Murphy (2014) found that energy audit participants had homes around

40 years old (constructed in 1970) . This is on par with the American Community Survey which found that 35% of houses were built before 1969 and 25% were built between 1970 and 1989 (Bureau, 2025).The housing stock for audit participants is old but are not at the extreme ends of age suggesting that the houses are still in good enough condition to alter but need to be altered in some way.

5.4 Participation and Performance in Subsidized Programs

Even when paired with financial assistance, audit programs frequently show low completion rates. A large-scale evaluation of the U.S. The Weatherization Assistance Program (WAP) found that approximately 6% of eligible households proceeded with subsidized upgrades following outreach and recommended work scopes, compared with roughly 1% in the untreated control group (Fowlie et al., 2018). The study also reported that realized savings reached only 10–20% of projected engineering estimates due to partial measure installation. These findings resonate with modeling results from Dermentzis et al., (2019), which suggest that modeled potential frequently exceeds achieved savings when household adoption is incomplete.

6.0 Comprehension of Energy Audits

The effectiveness of an energy audit depends on the resident's ability to comprehend the information provided about household energy use, system performance, and recommended improvements (Sprehn et al., 2015). Research has examined the understandability of energy consumption feedback, appliance-specific performance indicators, and financial metrics. These elements influence whether audit findings are interpreted accurately and considered actionable (Buchanan et al., 2014; Kontokosta et al., 2020). Several characteristics shape comprehension: visualization format, degree of contextualization, framing of savings, and the cognitive processing tendencies of the auditee (Canfield et al., 2017; Herrmann et al., 2018; Sprehn et al., 2013). Together, these findings provide insight into how households interpret audit materials.

6.1 Impact of Information Presentation Format on Comprehension

When auditors draft their final reports, they often plot sources of energy loss, consumption, and the recommended retrofits. These plots are often charts and or graphs that are designed to convey the best information possible. Al-Kababji et al (2020) found that conventional chart formats such as bar graphs, line graphs, and stacked area charts were rated more understandable than complicated graphs and maps such as a heat map or spiral based displays. Flora and Banerjee (2014) also found that bar graphs and linear graphs were rated higher on understanding compared to radial graphs. These graphs were used to particularly describe energy use. Similar preferences appear in Herrmann et. al. (2018), which reported that people who looked at appliance energy consumption through a graphical display that normalizes around the activity of the appliance were more confident in their own energy assessment and accuracy.

However, several studies show that novel visualization formats may also support adequate comprehension and are not completely inadequate. In the same study, Flora and Banerjee (2014) found that radial graphs using color cues still resulted in 73% accuracy in participant responses of consumption questions. Sprangher et. al. (2019) further found that alternative "ambient-style" visualizations, based on an actual tree, could communicate performance effectively and a further qualitative analysis revealed that the visualization was more understandable by the survey participants. This highlights that despite some concerns about complicated visual displays, they are not completely all for naught.

Yet still, some other researchers have countered the needs of visualization in the first place, showing that tabular data can be better understood. Though not through energy audits, Canfield (2017) found that tabular displays led to higher comprehension when participants reviewed historical consumption data or appliance contribution rankings of energy bills which are key aspects of energy audits. These findings correspond with work by Ellegård and Palm (2011), who reported that numerically explicit and detailed information supports more accurate conceptual mapping between household activities and energy use which in turn allows for greater understanding. A combination of both tabular and graphical visualizations may be extremely beneficial for the comprehension of energy audits.

Along with the differences between tabular and graphical displays, research also highlights the benefits of layered or mixed-format communication. Sprehn (2015) found that pairing graphical representations with textual explanations improved confidence and recall relative to single-format presentations. Rist and Masoodian (2019) support the idea that multimodal formats enable flexibility in information navigation, which may reduce cognitive burden for users unfamiliar with performance metrics. Buchanan (2014) also shows that graphical displays attract initial attention, while supporting explanation strengthens interpretability. Though these may not be within energy audits themselves, they can provide extremely useful aspects to examine energy audit frameworks.

6.2 User Characteristics Impact on Comprehensivability

Audit comprehension is influenced not only by how information is presented but by how residents cognitively process it. Sprehn et. al. (2015) classified users into visualizers and verbalizers and demonstrated that style-aligned displays improve processing efficiency and self-reported understanding of the said goals of the energy visualization. Style aligned formats did not significantly alter accuracy of data, but it did rapidly improve the processing time of the data (Sprehn et al., 2013). Although matched formats did not significantly alter accuracy, processing time differences suggest that cognitive mismatches contribute to comprehension challenges. Canfield (2017) also found that younger participants demonstrated better comprehension of graphical interfaces, while older participants performed better on text and

tables, indicating demographic variation in preferred processing modes. These findings highlight the importance of customer specific methodology of energy audit presentation.

6.3 Subjective Interpretation and Contextualization

Studies also examine how residents interpret energy audit findings in relation to subjective perceptions of home performance. Buchanan (2014) found that although most residents can identify high-consuming appliances such as dishwashers, their interpretations of the graphical displays are themselves shaped by expectations about what should contribute most to energy use. This slight bias can play a slight role in further adoption of particular retrofit suggestions such as rewaxing a window versus replacing a boiler. Ellegård and Palm (2011) similarly observe that comprehension improves when consumption feedback is linked directly to recognizable daily activities such as washing the dishes. These findings suggest that audit outputs must connect clearly to household context to support meaningful understanding rather than a purely technical output.

6.4 Comprehension of Financial Metrics and Recommendations

Comprehension of financial impacts is central to interpretation of audit recommendations especially as adoption of retrofit recommendations is what actually impacts our green transition. Though not directly energy audit findings, Newell and Siikamäki (2014) find that consumers more accurately understand efficiency outcomes when labels emphasize cost implications rather than purely technical metrics. Though Newell and Siikamäki (2014) focus on energy labels, energy audits function similarly in terms of information and can provide a helpful point of similarity between the two types of assessments. Palmer et. al. (2013) report that when audit reports bridge information gaps regarding payback expectations and on-site scheduling options, comprehension of financial returns improves. However, Murphy (2014) finds that although a majority of audited households reported understanding the meaning of recommended improvements, prioritization of the retrofits differed from auditor valuations, indicating divergence between comprehension, perceived relevance, and actual adoption.

7.0 Adoption of Audit Recommendations

Residential energy audits identify substantial technical potential for retrofit improvements, yet post-audit adoption literature remains limited. Multiple studies document a gap between the number of recommended measures and those ultimately implemented (Delmas et al., 2013; Murphy, 2014; K. L. Palmer et al., 2015). Adoption outcomes are typically characterized by low rates of follow-through, preferences for less intrusive interventions, and notable attrition after initial audit engagement (Berretta et al., 2021; McKenna et al., 2025). These findings have been observed in programs designed with and without financial incentives,

such as the Weatherization Assistance Program, indicating that receipt of audit information does not reliably translate into retrofit activity no matter income.

7.1 Adoption Rates Across Contexts

Empirical work shows that follow-up on audit recommendations is significant but incomplete, with wide variation across contexts. In a survey study representative of the United States population, Palmer et. al. (2015) document that follow-up on the two most common recommendations—air sealing and insulation—was substantial: 79% of households who received an air-sealing recommendation completed "some or all" of the work, and 64% did so for insulation, though many cited procrastination or uncertain savings for non-completion (e.g., 46% reported they "had not gotten around to it," and 32% cited uncertain savings).

However, in the Netherlands Murphy (2014) finds that a large share of recommendations were not adopted or planned, with the study showing that for most measures—such as roof, floor, and wall insulation—well under half of recommended items were implemented. Qualitative evidence from Ingle et. al. (2012) further shows that only some households act on auditor suggestions, with 32% of those receiving prioritized customized recommendations completing at least one upgrade and 29% of those receiving non-prioritized recommendations doing the same. Both Ingle et. al. (2012) and Murphy (2014) find that all recommendations are less than 50% likely to be adopted and of the few that were, many of these upgrades were often minor, low-cost actions, reflecting homeowner preferences for manageable measures rather than deep retrofits. At the same time, Murphy (2014) study in the Netherlands identified only marginal differences between audited households (64% investing) and non-audited households (63% investing), with key variation instead in the type of measures selected. These studies once again emphasize the varied nature of audit recommendation adoption based also on additional contexts besides just recommendation type.

7.2 Participation and Performance in Subsidized Programs

Even when paired with financial assistance, audit programs frequently show low completion rates and find similar results as Murphy (2014) and Ingle (2012). A large-scale evaluation of the U.S. Weatherization Assistance Program found that approximately 6% of eligible households proceeded with subsidized upgrades following outreach and recommended work scopes, compared with roughly 1% in the untreated control group (Fowlie et al., 2018). The study also reported that realized savings reached only 10–20% of projected engineering estimates due to partial measure installation.

Similar patterns are observed internationally. Backlund and Thollander (2015) examined Sweden's energy audit program and found that while audits were widely conducted, depth of retrofit remained limited and largely dependent on supplementary incentives. Kubule (2020)

similarly reported that in Latvia, the presence of public financing did not guarantee implementation of audit recommendations. These findings once again interestingly resonate with other pieces of literature whereby the retrofits themselves were not subsidized.

7.3 Measure-Specific Uptake Patterns

Adoption is highly selective across the set of recommendations delivered to households. Ingle (2012) reported that although 57% of audited residents completed at least one recommended measure, the majority were low-disruption actions. Air sealing achieved the highest uptake (34%), followed by floor insulation (19%), ceiling insulation (16%), wall insulation (7%), and duct sealing (6%), with appliance upgrades at 0–3%. This ordering reflects broader findings in which households tend to install measures requiring less contractor involvement and reduced home disruption (Benders et al., 2006; Ellegård & Palm, 2011; Murphy, 2014).

Research linking measure characteristics to adoption identifies multiple relevant factors. Rockstuhl et. al. (2021) show presenting benefits in terms of reduced monthly energy bills, rather than up-front costs, increases adoption of bundled measures with identical costs. Achtnicht and Madlener (2014) observe that familiarity with a measure contributes to its uptake more strongly than modeled cost-effectiveness. While cost is often cited as a barrier, cost alone does not fully predict selection patterns, rather the interpretation of upfront costs. Appliance replacement and deep envelope improvements—typically associated with larger projected savings—show lower implementation frequencies across multiple studies as these costs are typically higher upfront (Murphy, 2014). Consistency across these results indicates that audit recommendations of specific measures expand awareness of options but do not equally shift the perceived desirability of all upgrades.

7.4 Auditor–Household Interaction, Quantification, and Cost Sharing

Processes of communication during and after the audit visit influence household responses. Palmer et. al. (2015) report that adoption rates for insulation and air sealing were higher when auditors physically identified problem locations during the assessment similar to De Wilde et. al. (2019) and Owen and Mitchell (2015). Ingle et. al. (2012) similarly found that spatially specific guidance increased homeowner recognition of energy deficiencies.

Economic structure and quantification of benefits can also affect adoption probabilities as well. In Jackson, Wyoming, each incremental increase in the potential increase thermal efficiency recommended by auditors was associated with an increased likelihood of taking up the installation (Considine & Sapci, 2016). That study also found that cost-sharing with other organizations and co-funded arrangements increased implementation, a finding consistent with

evaluations of Croatian households estimating a statistically significant relationship between subsidy amount and probability of actual retrofit (Matosović & Tomšić, 2018).

7.6 Social and Community Influences

Studies addressing the social context of retrofit adoption find effects from peer behavior and community engagement. In Norway, households were more than twice as likely to conduct efficiency measures if neighbors had recently completed similar upgrades (Risholt & Berker, 2013). A New Zealand experiment demonstrated greater reductions in household energy use when community events accompanied audit delivery, compared to audits alone (Scott et al., 2016). Petkov et. al. (2011) show that comparative feedback delivered via social media platforms encourages greater efficiency actions. Neighbors impacting neighbors in a competitive way.

Other research suggests that the influence of social information can vary by socioeconomic conditions and motivation orientation. Belaïd (2024) reports that energy-saving decisions in France may depend more on individual household preferences than external influence, while Gamtessa (2019) observes that pre-existing pro-environmental behaviors moderate responsiveness to social signals such as comparison to neighbors. This undergirds much of the individualistic, market based understanding of energy audits and retrofits.

8.0 Behavioral Decision Drivers of Why Not Following Audits

Studies consistently report that comprehension of audit findings is not by itself sufficient for action; the decision to implement recommendations reflects additional behavioral dynamics, including prioritization among household goals, perceptions of risk and uncertainty, and the influence of social and market intermediaries (Ingle et al., 2012; McAndrew et al., 2021; Ramos et al., 2015). Evidence points to heterogeneity across households in how these dynamics are weighed and at what point indirect energy objectives shape outcomes (Achtnicht, 2011; Nair et al., 2010; Risholt & Berker, 2013).

8.1 Prioritization, Perceived Need, and Temporal Context

Studies indicate that upgrades are more likely when households perceive a salient deficiency or an immediate co-benefit, while perceived sufficiency of current comfort or performance is associated with lower priority for energy measures (Ingle et al., 2012; Nair et al., 2010). Choice experiments and survey evidence suggest that households often evaluate retrofit relevance within broader lifestyle or renovation objectives rather than purely energy considerations (Achtnicht, 2011; Banfi et al., 2008). In some cases, anticipated moves or larger planned renovations redirect attention away from specific audit recommendations despite acknowledged deficiencies such as Murphy (2014), whereas long-term comfort aspirations and

planned envelope improvements are associated with more ambitious investments (Zundel & Stieß, 2011).

9.0 Emerging Methods and Technologies for Audits and Feedback

Recent scholarship has expanded beyond traditional single-event audit models to explore new program architectures that may address informational, behavioral, and process-related barriers documented in previous sections. Innovations target recurring challenges such as comprehension limitations, decision conflict, delayed follow-through, and reliance on homeowner initiative. Across the literature, four developments in audit design appear most frequently: ongoing data feedback, automated and predictive audit formats, expanded auditor and contractor roles, and integration with community or regulatory structures (McAndrew et al., 2021; Kontokosta et al., 2020; Herrmann et al., 2018).

9.1 Continuous and Iterative Feedback Models

Studies suggest that households may benefit from energy audits that extend beyond a single interaction. Instead of diagnosing issues once, iterative systems provide progress tracking, evolving recommendations, or reminder prompts tied to household behavior (Buchanan et al., 2014; Herrmann et al., 2018). Digital feedback tools have enabled more frequent and context-responsive communication. In student housing settings, mobile interfaces increased engagement with consumption information compared to static reporting formats (Chiang et al., 2014). Social-norm-based updates delivered via smartphone platforms resulted in increased interpretation of performance trends, suggesting comprehension gains when feedback is continuous rather than episodic (Petkov et al., 2011). Though these do not operate as a single one time evaluation like an audit and lack particular key recommendations and auditor visits, there are still aspects of the audit that can be utilized for this purpose.

9.2 Predictive, Remote, and Automation-Enabled Audit Formats

Technological advancements have supported new models that reduce the logistical burden of on-site auditing. Remote, data-driven diagnostic tools, including smart meter analytics and model-based virtual audits, may identify opportunities earlier in the decision cycle. Combining these models with real-time sensor data enables greater personalization of recommendations and can refine estimates of savings reliability, addressing one known source of uncertainty in household decision-making (Gillingham & Tsvetanov, 2018). At the same time, this customization can allow for data presentation formats to be altered by the user to enable better comprehension.

Automation can also facilitate financial navigation. Platforms that integrate incentive eligibility, contractor scheduling, and savings projections into a single decision interface have

shown promise in pilot deployments, addressing high-friction transitions between evaluation and execution (McAndrew et al., 2021). These innovations attempt to reduce reliance on homeowners to coordinate sequential steps across multiple service providers.

9.3 Broadened Operational Roles for Auditors and Contractors

Some programs increasingly combine audit and installation services into a single workflow, consistent with cost-sharing and co-funded delivery models shown to increase adoption likelihood (Considine & Sapci, 2016; Matosović & Tomšić, 2018). Integrating contractor presence during or immediately after the assessment can shorten delays that diminish completion probability (Fowlie et al., 2018).

10.0 Gaps

Despite the substantial body of work examining household energy audits, significant inconsistencies and blind spots remain in the literature, limiting our understanding of why audits frequently fail to translate into retrofit adoption. Across studies, the underlying mechanisms explaining the disconnect between receiving audit recommendations and acting on them are contested, fragmented, and often incompletely theorized. Much like the contradictions observed in research on retrofit behavior more broadly, the literature on audit follow-through has produced a series of disconnected micro-explanations rather than a unified account of audit effectiveness.

First, existing research disagrees on the fundamental drivers of non-adoption after audits. A large subset of studies foreground financial barriers, emphasizing household budget constraints, the perceived riskiness of long-term investments, loan aversion, and uncertainty about payback periods (Achtnicht & Madlener, 2014; Baldini et al., 2017; Matosović & Tomšić, 2018; McKenna et al., 2025; Murphy, 2014). Several studies further highlight the importance of external financing conditions such as subsidy availability in Matosović and Tomšić (2018) or permitting costs. In contrast, other research highlights personal feelings such as environmental framing, information gaps, and desires of comfort (Achtnicht, 2011; K. Palmer et al., 2013; Zundel & Stieß, 2011). These divergent explanations create ambiguity about whether audits fail because they do not adequately reduce objective financial obstacles, or because they are not designed or communicated in ways that align with households' subjective priorities and cognitive constraints. As such, new studies need to be conducted with all of these factors as understandable and possible variables.

Second, research on audit information comprehension and report format has grown substantially, but it remains siloed. Studies show that households often struggle to interpret technical information in audit reports possibly because their data visualization wants or needs (Al-Kababji et al., 2020; Chiang et al., 2014; Ingle et al., 2012; Sprehn et al., 2013). However, they do not take these into account with actual adoption of energy audits. As such, further

research needs to be conducted about the effect of the methods of comprehension and actual audit recommendation adoptions.

Finally, the emerging literature on social and institutional factors suggests that audit outcomes depend heavily on roles played by contractors, auditors, intermediaries, and local governance structures (De Wilde & Spaargaren, 2019; Owen & Mitchell, 2015). However, these findings remain peripheral to the mainstream energy-efficiency literature, which tends to treat households as autonomous decision-makers. The result is a gap in knowledge about how trust, social norms, and interpersonal persuasion shape whether audits lead to retrofits and how these mechanisms vary across socioeconomic groups, housing types, and regions.

Together, these gaps demonstrate the need for an integrated, cross-disciplinary audit study that combines insights from building science, behavioral economics, cognitive psychology, human–computer interaction, and energy policy. Such a study would need to collect a range of audits from a range of organizations and styles to then understand the report but with that understand the auditor, auditee relationship.

11.0 Conclusion

The central finding of this review is not that energy audits fail, it is that they fail in understandable and, in many cases, addressable ways. The evidence gathered here reveals a system that consistently produces useful diagnoses but inconsistently produces action. Households receive audit reports, comprehend at least some of what they say, and then, for reasons that vary considerably by income, age, housing type, social context, and the specific design of the intervention, do not follow through with the retrofits they have been advised to make (McKenna et al., 2025; Murphy, 2014; K. L. Palmer et al., 2015). That failure is not random. It is structured, and understanding its structure is the first step toward changing it.

Several conclusions emerge with reasonable confidence across the studies reviewed. Audit participants are a self-selected population: older homeowners, long-term residents, and those with pre-existing conservation interests are substantially overrepresented, meaning that even the households most likely to receive and act on recommendations are not representative of those who would benefit most from energy improvements (Achtnicht, 2011; Belaïd, 2024; Ingle et al., 2012; Murphy, 2014; Nair et al., 2010; K. L. Palmer et al., 2015). Among those who do receive audits, comprehension of findings is uneven, shaped by the visualization format used, the degree to which information is connected to familiar household activities, and the cognitive tendencies of the resident (Al-Kababji et al., 2022; Buchanan et al., 2014; Canfield et al., 2017; Ellegård & Palm, 2011; Flora & Banerjee, 2014; Herrmann et al., 2018; Sprehn et al., 2013). Auditor behavior during the site visit matters as well: physically identifying problem locations, providing spatially specific guidance, and supporting information with multiple formats all

appear to improve both comprehension and follow-through (Ingle et al., 2012; K. L. Palmer et al., 2015; Sprehn et al., 2013).

These findings suggest several practical directions. Audit reports should be designed with comprehension as a primary goal, prioritizing familiar formats, layered presentations, and explicit connections between technical findings and household experience (Buchanan et al., 2014; Herrmann et al., 2018; Sprehn et al., 2013). Programs that integrate contractor services into or immediately after the audit process rather than leaving households to coordinate multiple providers independently show promise in reducing the friction between evaluation and execution. Continuous feedback tools that extend engagement beyond a single visit may help sustain motivation after the initial audit interaction (Herrmann et al., 2018; McKenna et al., 2025; Petkov et al., 2011). And policies that account for social influence, whether through community-based delivery or peer-norm communication, appear to provide incremental benefits alongside traditional information-provision approaches (Gamtessa & Guliani, 2019; Risholt & Berker, 2013; Scott et al., 2016).

At the same time, significant uncertainties remain. The mechanisms linking audit design to adoption outcomes have rarely been tested in studies designed to isolate them (Palmer et al 2015, McKenna et al 2025), and the full trajectory from audit participation to completed retrofit has been traced in only a handful of studies. Research on comprehension and research on adoption have largely developed in parallel, without the integration necessary to determine which informational elements most influence which behavioral decisions. Social and institutional factors such as the role of trust, local contractor networks, regulatory context, and interpersonal persuasion remain undertheorized relative to their apparent importance (De Wilde & Spaargaren, 2019; Ingle et al., 2012; Owen & Mitchell, 2015; Sprehn et al., 2015). Additionally, the literature's demographic gaps are substantial: studies conducted in high-income countries with relatively homogeneous housing stocks cannot be assumed to generalize to other contexts without direct replication (Achtnicht & Madlener, 2014; Dolšak et al., 2020; Nair et al., 2010).

Addressing these gaps will require closer collaboration between building scientists, behavioral economists, and practitioners working in the field. It will also require study designs that follow households through the full decision process rather than capturing a single moment within it. The energy transition will depend in part on whether the housing sector can be decarbonized at scale, and that scale depends on closing the distance between what audits recommend and what households actually do. The evidence reviewed here suggests that distance is not fixed. It can be narrowed by better design — of the audit itself, of the programs that deliver it, and of the policy frameworks that support both.

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