U.S. House Committee on Energy and Commerce
Subcommittee on Energy
Building the American Dream: Examining Affordability, Choice, and Security in Appliance and Buildings Policies."
September 9, 2025
Documents for the Record

1. A letter from the American Chemistry Council addressed to Chairman Latta and Ranking Member Castor, submitted by the Majority.
2. A letter from the International Code Council addressed to Chairman Latta and Ranking Member Castor, submitted by the Majority.
3. A letter from GeoExchange addressed to Chairman Latta and Ranking Member Castor, submitted by the Majority.
4. A letter from 8 organizations addressed to Chairman Latta and Ranking Member Castor, submitted by the Majority.
5. A letter from BlackFlare addressed to Chairman Latta and Ranking Member Castor, submitted by the Majority.
6. A letter from the American Cement Association addressed to Chairman Latta and Ranking Member Castor, submitted by the Majority.
7. A letter from the Spray Foam Coalition addressed to Chairman Guthrie, Ranking Member Pallone, Chairman Latta, and Ranking Member Castor, submitted by the Majority.
8. A letter from the National Multifamily Council and the National Apartment Association addressed to Chairman Latta and Ranking Member Castor, submitted by the Majority.
9. A study from the National Bureau of Economic Research entitled, "Do Energy Efficiency Investments Deliver? Evidence from the Weatherization Assistance Program," submitted by the Majority.
10. A report from UL Environment entitled "Effect of Indoor Environmental Quality on Performance and Productivity," submitted by Rep. DeGette.
11. A press release from the Department of Energy entitled, "Energy Department Announces Over $400 Million in Funding and Removes Burdensome Policy, Helping Americans Save on Energy Bills," submitted by Rep. Tonko.
12. A letter from multiple Home Performance Contractors and Energy Efficiency Companies addressed to Chairman Guthrie and Ranking Member Pallone, submitted by Rep. Tonko.

American Chemistry Council | Plastics Division

September 9, 2025

The Honorable Bob Latta Chairman House Committee on Energy and Commerce Subcommittee on Energy U.S. House of Representatives Washington, D.C.	The Honorable Kathy Castor Ranking Member House Committee on Energy and Commerce Subcommittee on Energy U.S. House of Representatives Washington, D.C.

RE: Statement for the Record from the American Chemistry Council to the House Committee on Energy and Commerce Subcommittee on Energy hearing "Building the American Dream: Examining Affordability, Choice, and Security in Appliance and Buildings Policies."

Dear Chair Latta and Ranking Member Castor:

The American Chemistry Council (ACC), acting on behalf of its Plastics Division, is appreciative for the opportunity to provide the following Statement for the Record as part of the Committee on Energy and Commerce's Subcommittee on Energy hearing titled "Building the American Dream: Examining Affordability, Choice, and Security in Appliance and Buildings Policies." Highlighting and prioritizing energy efficiency in the built environment will provide significant environmental, economic and cost-saving benefits to American people and businesses.

ACC is a national trade association representing chemicals and plastics manufacturers in the United States. Chemistry is essential to the U.S. economy and plays a vital role in driving innovations that make our world safer, more sustainable, and more productive. Chemistry supports over 25% of the U.S. GDP and 10% of U.S. goods exports – a $633 billion enterprise. 554,000 skilled American jobs are provided by the business of chemistry and 18% of the total construction spending by the U.S. manufacturing sector involves the business of chemistry.

The chemical industry supplies many products and materials to the building and construction value chain, including those that deliver energy efficiency such as high-performance building insulation and sealants that reduce energy bills and help reduce air leakage, roof membranes and coatings that protect against moisture and help keep roofs cooler in hot weather. ACC's members are also large users of energy, so the responsible use of energy is important to the industry's economic health and competitiveness. Energy efficiency is widely seen as the lowest cost option for meeting energy demand. Energy efficient buildings create economic opportunities for businesses and industry by promoting new energy efficient technologies and reducing energy waste.

Energy efficiency has been shown to lower energy costs for residential and commercial buildings such as multi-family housing, reducing the high burden of utility bills on low-income households, reducing the strain on the electric grid, particularly at peak usage periods, and increasing national energy security.

Urgency of Rising Energy Demand: Peak electricity demand is expected to grow 128 gigawatts in the next four years. Demand is driven by data centers and AI and advanced manufacturing and U.S. electricity demand is projected to surge 8.2% over the next five years—highlighting the critical role of efficiency in managing costs and reliability.

Small Business Success: Energy costs are one of the top three business expenses in more than a third of small businesses, with heating and cooling expenses being the primary energy costs for a third of them, according to the National Federation of Independent Businesses (NFIB).

Housing Affordability: Energy efficiency programs reduce energy costs. Research shows that about two-thirds of low-income households in the United States face a high or severe energy burden. (Drehobl, Ross, and Ayala 2020). According to the U.S. Energy Information Administration, across the United States, high utility bills are costing homeowners a significant portion of their monthly incomes. According to the most recent EIA Residential Energy Consumption Survey,[1] about one in five households reported reducing or forgoing basic necessities like food and medicine to pay energy bills. Stronger energy codes and more widespread code compliance can help families afford the basics and avoid rising energy costs.

Occupant Health: Energy efficiency measures such as improving ventilation, insulation and sealing building envelopes can help to address conditions that contribute to many illnesses. Poorly sealed building envelopes allow pests, moisture, and air pollution to infiltrate. These can harm respiratory health through mold growth and allergens, while leaky windows and poor insulation can lead to cold drafts and extreme temperatures in a home during summer and winter months. (ACEEE Advancing Equity through EER Stds, 2023).

Security: Prioritizing energy efficiency in the building sector will contribute to improved energy security. Enabling individuals and businesses to defray upfront capital costs to improve energy efficiency offers a strong value proposition for federal dollars, helping deliver efficiency and cost-saving returns over time. Improving energy efficiency helps to

[1] See Residential Energy Consumption Survey (RECS) - Energy Information Administration (eia.gov)

insulate Americans from price fluctuations in energy markets due to inflation, rising demand from data centers, and natural disasters.

National model building energy codes are but one policy tool to support implementation of efficiency measures that are cost effective. The 2018 IECC, 2021 IECC, and 2024 IECC were evaluated by the US DOE to reduce both energy use and energy costs, offering a positive payback for homeowners. As a participant in the code development process, ACC is both familiar with and supports the consideration and adoption of the IECC by federal agencies, states, and local jurisdictions.

Energy efficiency in the built environment has a long-standing history of bipartisan support as the benefits of efficiency accrue to individual homeowners, renters, and businesses, as well as to the nation as whole. We strongly encourage the Committee to maintain a strong posture of support for building energy efficiency.

Sincerely,

Indya Rogers
Director, Plastics Building & Construction

ICC INTERNATIONAL CODE COUNCIL®

September 8, 2025

The Honorable Bob Latta
Chairman, Subcommittee on Energy
Committee on Energy and Commerce
2123 Rayburn House Office Building
Washington, DC 20515

The Honorable Kathy Castor
Ranking Member, Subcommittee on Energy
Committee on Energy and Commerce
2123 Rayburn House Office Building
Washington, DC 20515

Re: Hearing Entitled: Building the American Dream: Examining Affordability, Choice, and Security in Appliance and Building Policies

Dear Chairman Latta and Ranking Member Castor –

The International Code Council (ICC) shares the subcommittee's interest in examining policies impacting housing affordability, energy costs, grid reliability, national security, and consumer choice. As the Subcommittee considers this critical cross-section of policy issues, we appreciate the opportunity to outline how consensus-based energy codes save residents and governments money, preserve wealth, and enhance our nation's resilience to disasters.

Modern, up-to-date building codes and standards are at the core of building innovation, which involves cross-cutting materials and products, adaptation and resilient design, and innovative construction strategies. ICC is a leader in providing such solutions.

ICC is a U.S.-based nonprofit organization of roughly 700 employees, driven by the engagement of its more than 60,000 members, that is dedicated to helping communities and the building industry provide safe, resilient, affordable, and sustainable construction through the development and use of model codes (I-Codes) and standards used in design, construction, and compliance processes. Our founding strategic partners—the American Gas Association, National Multifamily Housing Council, National Association of Home Builders, Building Owners and Managers Association, and the American Institute of Architects—came together to support the Code Council's formation to streamline the development of construction codes and to enable consistency in construction across geographies, which enables economies of scale and faster and more efficient infrastructure development. Today, most U.S. states and communities, federal agencies, and many global markets choose the I-Codes to set the standards for regulating construction and significant renovations, plumbing and sanitation, fire prevention, and energy conservation in the built environment.

Private-Sector Driven, Consensus-Based Energy Codes Preserve Energy Choice

ICC supports efforts to find creative solutions to expand the nation's housing supply and bolster domestic energy resources. ICC's codes and standards, including energy codes, do not derive from government agencies in Washington, D.C. Rather, they are the final product of a consensus-based process that brings together firefighters, homebuilders, building safety professionals, architects, engineers, and others—individual citizens working together to ensure the safety of the built environment.

Consistent with the robust private sector-led standards development system in the United States, and as recognized and directed by the Office of Management and Budget[1] and Congress,[2] model energy codes and standards provide federal agencies, states, and localities with a common starting point for their development and adoption processes. This starting point also benefits the construction industry by ensuring code requirements from state to state are generally consistent, supporting manufacturers, designers, and builders in accessing markets across states and localities.

The International Energy Conservation Code (IECC) is identified in federal statute to serve as the basis for state-level energy codes[3] as well as the minimum requirements for federal buildings[4] and building programs.[5] The IECC is updated on a three-year cycle, with the 2024 IECC being the most updated version currently in use. Several states and localities have adopted or are in the process of adopting the 2024 IECC, including Nevada, Rhode Island, Virginia, Maryland, Idaho, New York, Austin, Nashville, and Phoenix. The 2024 IECC reflects revisions from the 2021 iteration. Every contractor representative on the IECC committee voted in support of its finalization. A National Association of Home Builders (NAHB) blog explained: "[the 2024 IECC] offers home builders more compliance paths and lower building costs compared to the 2021 IECC, according to a cost analysis by Home Innovation Research Labs...and provides for increased design flexibility and improved compliance options."[6] DOE has determined that the 2024 IECC reduces energy costs by 6.6% over the 2021 IECC edition.[7]

ICC has demonstrated a commitment to continuously improving its code and standard development processes to promote the strong competitive landscape that its efforts have facilitated. The Code Council has repeatedly made clear that the provisions of the IECC "shall not promote or penalize specific types of equipment or fuel sources."[8] As the American Gas Association recently noted, "[a]s a Founding Strategic Partner of the ICC, the AGA has consistently supported the ICC's mission to enhance energy efficiency in building construction while ensuring that all types of energy are recognized."[9] AGA has reiterated its view of the IECC as a fuel neutral efficiency code, stating that "the 2021 IECC [is] fuel neutral and offer[s] various paths forward to

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1 https://www.whitehouse.gov/wp-content/uploads/2020/07/revised_circular_a-119_as_of_1_22.pdf
2 https://www.nist.gov/standardsgov/national-technology-transfer-and-advancement-act-1995
3 https://www.govinfo.gov/content/pkg/USCODE-2023-title42/pdf/USCODE-2023-title42-chap81-subchapII-sec6833.pdf
4 https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-433, https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-435
5 https://www.govinfo.gov/content/pkg/USCODE-2023-title42/pdf/USCODE-2023-title42-chap130-subchapI-sec12709.pdf
6 https://www.nahb.org/blog/2025/02/2024-iecc-cost-analysis
7 https://www.energycodes.gov/sites/default/files/2024-12/2024_IECC_Determination_TSD.pdf#page=[7]
8 https://www.iccsafe.org/content/2027-iecc-scope-intent-and-board-commentary-final-public-notice/.
9 American Gas Association, *The ICC's Board of Directors Made the Right Call,* AGA News: True Blue Blog (Mar. 26, 2024).

meet compliance," and "do[es] not attempt to eliminate onsite fossil fuel usage."[10] By the conclusion of the 2024 IECC's development, AGA heralded its engagement in the IECC's development as "protect[ing] the integrity of the code as a leading energy efficiency resource for states."[11]

A Cost-Saving Mechanism that Enhances Financial Security

Lower-income households spend more than 15% of their income on energy bills.[12] The latest federal data shows that electricity costs are 5.5% higher today than a year ago.[13] Buildings designed and constructed to the latest IECC edition provide significant opportunities to save energy and money.

The U.S. Department of Energy (DOE) estimates that implementing modern energy codes and standards will save the nation $182 billion (cumulative 2010-2040).[14] Energy consumption in the U.S. would be around 60 percent higher today without the energy efficiency technologies and improvements adopted since 1980. This corresponds to an estimated savings of approximately 60 quadrillion BTUs of energy per year, equivalent to around $800 billion in energy costs using today's prices

Adopting energy codes and standards can also reduce mortgage default rates by roughly one-third, as homeowners with lower utility costs have more money in their pockets each month.[15] Most home buyers (87 percent) finance their purchase through traditional mortgages. This means that to the extent there is an ascertainable increase in initial costs, it is distributed over many years. In contrast, the energy code-generated cost savings on utility bills kick in immediately, creating positive cash flow and enhancing financial stability for the American family. Creating a national stock of housing built to a modern energy code will help reduce poverty nationwide.

In addition to the cost-of-living benefits, studies have repeatedly demonstrated that modern model building codes have no appreciable implications for housing affordability.[16,17] **No peer-reviewed**

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[10] American Gas Association, *Comments on DOE's Supplemental Notice of Proposed Rulemaking on Clean Energy for New Federal Buildings and Major Renovations* (Feb. 21, 2023) (stating that "Standard 90.1–2019 and the 2021 IECC are fuel neutral and offer various paths forward to meet compliance," and that the standards "do not attempt to eliminate onsite fossil fuel usage").

[11] American Gas Association, *The ICC's Board of Directors Made the Right Call,* AGA News: True Blue Blog (Mar. 26, 2024).

[12] https://www.aceee.org/press-release/2024/09/study-one-four-low-income-households-spend-over-15-income-energy-bills

[13] https://www.bls.gov/news.release/cpi.nr0.htm

[14] https://www.energy.gov/eere/buildings/saving-energy-and-money-building-energy-codes-united-states#:~:text=Building%20energy%20codes%20are%20projected,translates%20directly%20to%20increased%20comfort.

[15] https://imt.org/wp-content/uploads/2018/02/IMT_UNC_HomeEEMortgageRisksfinal.pdf#page[14]

[16] Simmons, K. & Kovacs, P., Real Estate Market Response to Enhanced Building Codes in Moore, OK, Investigative Journal of Risk Reduction (Mar. 2018) (stronger building code had no effect on the price per square foot or home sales).

[17] NEHRP Consultants Joint Venture, Cost Analyses and Benefit Studies for Earthquake-Resistant Construction in Memphis, Tennessee, NIST GCR 14-917-26 (2013) (adopting stronger codes would add less than 1-percent to the construction while reducing annualized loss—in terms of repair cost, collapse probability, and fatalities—by approximately 50-percent).

research has found otherwise. A just-published National Bureau of Economic Research study found that since 2000 (the same year the International Residential Code was first published), there's been "very little, if any" correlation between construction costs and home prices, with home price increases frequently doubling construction costs.[18] Another study found no significant statistical evidence that California's energy codes affected home construction costs.[19]

With each model code or standard update, DOE must analyze it for energy savings compared to the prior edition. The Pacific Northwest National Laboratory (PNNL) conducts this analysis through DOE's Building Energy Codes Program. PNNL's analysis of the 2024 edition of the IECC showed that the average homeowner could save almost $3,000 for single-family homes.[20]

Adopting a modern energy code or standard can also decrease construction costs. This is driven by the building of thermal envelopes that allow for smaller (and less costly) HVAC systems to condition the building effectively. Additional savings are realized through high-efficacy lighting and enhanced lighting systems, among other measures.[21]

Overall, codes and standards benefit the American taxpayer. Evidence suggests that adopting modern energy codes serves this purpose: government buildings constructed to modern standards cost the taxpayers less money in utility bills each month. In addition, standards development by private organizations saves taxpayers money and alleviates the administrative burden the government would otherwise face in developing unique federal analogs. The U.S. government's use of ICC energy standards benefits taxpayers, as this public-private partnership leverages the rigorous, consensus-based standards process without replicating it through government bureaucracy, saving taxpayer dollars.

Updated Energy Codes Increase Disaster Resilience

The United States continues to experience increasingly extreme temperatures, destructive weather patterns, and more frequent power outages. Constructing buildings with modern energy codes and standards increases household preparedness for disasters while ensuring individuals' everyday health and safety.

For instance, three U.S. Department of Energy National Laboratories recently found that during prolonged weather-induced power outages coupled with extreme heat or cold, the IECC can reduce deaths due to extreme heat by 80 percent and extreme cold by 30 percent.[22] Unfortunately, Texas has twice experienced this tragic combination in recent memory: first, in February, 2021, during a winter storm, which resulted in 161 deaths from extreme cold exposure related deaths due to a lengthy power outage (of 246 total storm-related deaths);[23] second, following Hurricane Beryl this summer, which resulted in at least ten deaths caused by heat exposure due to an extended

[18] https://www.nber.org/papers/w33958
[19] California Statewide Utility Codes and Standards Program, Report – New Home Cost v. Price Study (2015).
[20] https://energycodes.gov/sites/default/files/2024-12/2024_IECC_Determination_TSD.pdf, https://energycodes.gov/sites/default/files/2025-01/2024_IECC_CostEffectiveness_Residential_Final.pdf
[21] https://www.energycodes.gov/sites/default/files/2021-07/Cost-effectiveness_of_ASHRAE_Standard_90-1-2019-Florida.pdf
[22] U.S. Department of Energy (DOE), Enhancing Resilience in Buildings Through Energy Efficiency (July 2023).
[23] Texas Department of State Health Services, February 2021 Winter Storm-Related Deaths – Texas (Dec. 2021)

power outage.[24] While several factors contributed to these tragic losses of life, DOE's research demonstrates the important role energy codes can play in life safety.

In general, adopting up-to-date energy codes provides additional household resilience against all hazards: highly efficient windows can reduce the impact of projectiles, some insulation applications can enhance building strength and stiffness, controlled ventilation strategies can reduce the infiltration of outdoor contaminants, and pipe insulation can reduce the need to run water to achieve the desired temperature.

Energy codes and standards also improve indoor environmental quality, reduce mold and mildew incidents, and slow the spread of fire and smoke.

Lastly, energy codes and standards enhance grid resilience and prevent power outages. More efficient buildings that result from building to a modern standard pull less power from the grid, so when there is high demand, like during a winter storm or a heatwave, there is more power to supply critical infrastructure during disaster response and recovery operations. Less energy demand improves grid reliability and keeps the power on. This is particularly important as demands on the grid are expected to grow significantly with the expansion of data centers and other high-demand sectors. Maintaining American competitiveness will require a coordinated energy policy that leverages available opportunities to use our energy resources efficiently and cost-effectively.

<u>Conclusion</u>

Our team would be honored to meet with you or committee staff in the near future to further elaborate on the points outlined in this letter. ICC supports efforts to remove or minimize burdensome federal regulations that drive up housing costs, reduce quality of life, and enhance our dependence on goods, materials, and energy resources from hostile countries. We stand ready to partner with Congress to find innovative solutions to these challenges.

Sincerely,

Aaron Levy

Aaron H. Levy
Vice President, Federal Relations

Ryan Colker, J.D., CAE
Executive Director, Energy, Resilience & Innovation

Cc: Members of the U.S. House Energy and Commerce Subcommittee on Energy

[24] Houston Public Media, Two more deaths attributed to Hurricane Beryl as Houston-area death toll rises to 38 (Aug. 27, 2024).

September 8, 2025

The Honorable Bob Latta, Chairman
The Honorable Kathy Castor, Ranking Member
Subcommittee on Energy
House Committee on Energy and Commerce
U.S. House of Representatives
Washington, D.C. 20515

Re: Geothermal Exchange Organization Statement for the Record; Hearing entitled "Building the American Dream: Examining Affordability, Choice, and Security in Appliance and Buildings Policies," September 9, 2025

Dear Chairman Latta and Ranking Member Castor:

On behalf of the Geothermal Exchange Organization (GeoExchange), thank you for the opportunity to submit this statement for the record for the September 9, 2025, hearing before the Subcommittee on Energy of the House Committee on Energy and Commerce on the subject of "Examining Affordability, Choice, and Security in Appliance and Building Policies." It is our understanding that the hearing will in part examine the impact of appliance policies on energy costs, grid reliability, national security, and consumer choice.

As the non-profit trade association promoting the manufacture, design, and installation of geothermal heating and cooling systems, GeoExchange hopes to assist the Subcommittee with the important mission of the hearing. Geothermal heating and cooling delivers unmatched efficiency, strengthens American energy independence, and fortifies the electric grid at a moment when data centers, reshoring industries, and new demands press hard upon it, directly supporting the nation's economic and security priorities.

There can be little doubt that broader deployment of geothermal systems stands squarely within the Trump Administration's energy vision: reducing costs, building domestic strength, and ensuring reliable power. Whether offsetting HVAC demand or supplying electricity, geothermal is a proven, American resource.

It is therefore no surprise that the President's January 20, 2025, National Energy Emergency Declaration recognized the acceleration of geothermal technology as an appropriate response. Moreover, in February, Department of Energy Secretary Chris Wright issued a "Secretarial Order" to advance "American Energy Dominance," explicitly including geothermal, while DOE continued funding research, development, and demonstration. As Secretary Wright affirmed, a mature geothermal industry "could better energize our country, improve the quality of life for everyone. It could help enable AI, manufacturing, reshoring and stop the rise of our electricity prices."

1. Why Geothermal Heating & Cooling Enhances Grid Reliability

Geothermal heating and cooling systems, including district-scale networks, harness the earth's steady subsurface temperature to provide efficient heating and cooling year-round. Instead of generating heat or exchanging it with volatile outdoor air, these systems move heat to and from the ground, where temperatures remain relatively constant. This stability reduces electricity use during peak summer and winter demand and prevents the sharp spikes that strain the grid during extreme weather. By shifting HVAC load away from those peaks, geothermal heating and cooling reduces stress on the grid, defers costly new infrastructure, and strengthens reliability for homes, businesses, and institutions.

- ***Lower infrastructure costs***: Widespread adoption of geothermal heating and cooling systems can reduce the need for new generation plants, transmission lines, and storage, lowering costs for utilities and ratepayers. A recent Oak Ridge National Laboratory (ORNL) study found that large-scale deployment could avoid 24,500 to 43,500 miles of new transmission by 2050—enough to span the country up to 16 times—saving tens of billions and sidestepping permitting delays that often stall energy projects.

- ***Improved resilience during outages:*** Geothermal systems can be part of a distributed energy solution, and thermal energy networks can continue to function in the event of an electric grid outage if supported by a small amount of on-site generation. According to the ORNL study, during the 2021 Texas winter storm, roughly 38% of anticipated demand went unmet, causing widespread blackouts, but mass geothermal retrofits could have cut that shortfall to 15–21%, substantially reducing the severity of the outage.

- ***Thermal energy storage:*** Large-scale geothermal heating and cooling networks can serve as thermal energy storage. For example, in summer, a network can use the ground to store excess heat from commercial cooling processes, which can then be drawn upon to help heat buildings in the winter. ORNL found that geothermal deployment could reduce peak demand by up to 28% in some regions, demonstrating the ability of ground loops to store and shift thermal loads across seasons.

- ***Workforce development and drilling expertise***: Every geothermal project begins with a borehole, work that cannot be outsourced or automated. The industry draws on the same drilling skills and equipment long relied upon in the oil and gas sector, creating continuity for American drillers while expanding into new markets. With stable demand supported by incentives, these jobs provide steady employment for crews, strengthen local economies, and ensure that a skilled domestic workforce is available to build out geothermal at scale.

- ***National security and global competitiveness:*** Strengthening the grid with geothermal heating and cooling also strengthens America's position in the global technology race. ORNL found that widespread deployment could reduce annual U.S. electricity generation needs by up to 585 terawatt-hours by 2050—the equivalent output of more than 60 large nuclear plants. Freeing this scale of capacity shields U.S. utilities from costly overbuilds, ensures reliable power for advanced computing and defense facilities, and keeps America ahead of China, which has already installed tens of gigawatts of low-temperature geothermal capacity at a pace five times faster than the United States.

In short, without relying on federal, state, or local mandates or building codes, market-based approaches can drive deployment of geothermal heating and cooling systems in ways that help grid operators balance rising electricity demand with the demand-side flexibility these systems provide. As more data centers come online, geothermal will become indispensable as a reliable and cost-effective energy offset. The industry also sustains a skilled American workforce—drawing on drillers and trades with deep roots in oil and gas—to deliver projects that cannot be outsourced. In doing so, geothermal strengthens America's energy independence and ensures that critical industries, from advanced manufacturing to artificial intelligence, have the reliable power they require to thrive.

2. Geothermal as a Market-Viable Solution, Without Mandates

Encouragingly, diverse developments across the United States, from utility-driven district systems to community deployments, demonstrate that geothermal can thrive through market incentives and consumer-friendly models:

- ***Framingham, Massachusetts:*** A utility-led pilot connects 37 homes and businesses to a shared underground geothermal loop. Participants are projected to see average utility bill reductions of about 20 percent, achieved through market-driven deployment rather than regulatory mandates.

- ***Whisper Valley, Texas:*** In this 7,500-home development, geothermal systems are expected to keep average summer utility bills below $70. Adoption is rooted in efficiency and affordability supported by incentives—not regulatory compulsion.

These cases exemplify how market-based deployment, aided by tax incentives and utility models, can deliver results at scale.

3. Policy Recommendations: Market-Centered, Low-Barrier Advancement

GeoExchange respectfully urges the Subcommittee to pursue the following market-enabling policies:

- ***Clarify and implement tax policy:*** The One Big Beautiful Bill Act (OBBBA) specifically preserved the geothermal investment tax credit in Section 48 of the Internal Revenue Code. Treasury and the IRS should issue a domestic content safe harbor table for low-temperature geothermal systems. This would give taxpayers a clear mechanism for complying with OBBBA's domestic content requirements. Congress preserved the geothermal heating and cooling credit and related domestic content credit because the technology reduces peak demand, lowers energy costs, supports U.S. manufacturing and jobs, and helps meet rising data center and AI demand.

- ***A domestic content safe harbor table is essential:*** Modeled on the safe harbor tables in Notice 2024-41, a draft table for geothermal heating and cooling already exists. It identifies manufactured products and components of a typical low-temperature geothermal system. Most systems fall into two categories: central or distributed. They may also integrate supplemental heat rejection equipment in hybrid systems. With the Subcommittee's support, proceeding to release the table as guidance could be readily facilitated. The industry's supply chain, production, and skilled installation workforce reflect overwhelmingly domestic content.

- ***Support utility-led and third-party models:*** Encourage utilities and private sector actors to pilot district-scale geothermal systems, with mechanisms such as leasing, bulk procurement, or utility financing to drive adoption without imposing technical mandates.

- ***Streamline permitting and workforce support:*** Reduce administrative barriers by aligning permitting processes and supporting workforce development, not through standards, but through enabling frameworks that facilitate cost-effective market entry.

- ***Educate consumers and stakeholders:*** Sponsor outreach and education campaigns showcasing real-world projects that highlight energy savings, reliability gains, and local job creation to build consumer and developer confidence.

4. Conclusion

Geothermal heating and cooling stands as a proven American resource that delivers unmatched efficiency, strengthens energy independence, and fortifies the grid. It provides a durable domestic solution that enhances reliability, supports jobs, and secures resilience as data centers, manufacturing, and defense place unprecedented demands on the system. The industry also anchors a skilled U.S. workforce, particularly drillers whose expertise from oil and gas translates directly into geothermal deployment, ensuring that these projects create jobs that cannot be outsourced. The full potential of geothermal technologies will be realized not through new regulations or mandates, but through market-based adoption driven by incentives, utility innovation, and consumer awareness.

GeoExchange stands ready to support the Subcommittee with data, testimony, or technical assistance. Thank you for your leadership in ensuring that American energy solutions are effective, affordable, and uniquely domestic.

Respectfully yours,

Ryan Dougherty
Executive Director
Geothermal Exchange Organization
312 South 4th Street, Suite 100
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September 8, 2025

The Honorable Bob Latta
Chair, Energy Subcommittee
Energy and Commerce Committee
House of Representatives
Washington, D.C. 20515

The Honorable Kathy Castor
Ranking Member, Energy Subcommittee
Energy and Commerce Subcommittee
House of Representatives
Washington, D.C. 20515

Dear Chairman Latta and Ranking Member Castor:

As your September 9th hearing on housing affordability is sure to reflect, the United States is in the grip of a housing crisis. The reasons for this crisis are multi-faceted.[1] Escalating land and material costs, permitting and zoning restrictions[2], and tight labor supply are those factors commonly highlighted as the significant drivers to the escalating cost of new home construction. It is our hope that this hearing will focus on the two sides to housing affordability in America – the cost of new home construction as well as the lifetime operating cost paid by the homeowner related to the heating and cooling of that home. For most homeowners, the utility bill is the largest monthly expense after a mortgage payment.

The National Association of Homebuilders periodically conducts "construction cost surveys" to collect information from builders on the various components that factor into the sales price of a typical newly built single-family home. The survey includes material costs as well as regulatory cost impacts. In its 2024 survey,[3] the most significant regulatory cost driver arises from the building permit, impact fees and water and sewage fees that are part of building site preparation. In total, these local regulations together with other site work costs account for about 5 percent of the cost of home construction.

Comparatively, insulation, a component driven in part by state or local energy codes that apply to new home construction as well as the practical need to limit energy waste and improve occupant comfort, accounted for only 1.6 percent of the overall cost of a new home. This comparison demonstrates that local regulations such as site work fees and other development restrictions far outweigh the cost impacts of other policies like building energy codes, which return benefits to homeowners year after year.

Just as the cost of construction has risen, so too has the cost of residential heating and cooling. The rapid expansion of data centers, electric vehicle usage and industrial reshoring is taxing our nation's existing electric generation and grid capacity. The Energy Information Agency's 2024 "Annual Energy Outlook" now projects 1.5 percent annual electric demand growth through the early 2030's with some regional electric utilities projecting 10-15 percent annual demand growth due to concentrated data center and

[1] *https://www.uschamber.com/economy/the-state-of-housing-in-america*
[2] *https://www.nahb.org/blog/2024/11/zoning-regulation-and-affordable-housing*
[3] *https://www.nahb.org/-/media/NAHB/news-and-economics/docs/housing-economics-plus/special-studies/2025/special-study-cost-of-constructing-a-home-2024-january-2025.pdf?rev=00a42a1ce63b4a22a4dba9bda8af954b*

industrial demand. This all translates into substantially higher electricity bills for homeowners, which exacerbates the housing affordability crisis.

Building more energy-efficient homes and making energy-efficient improvements to existing building stock is a highly effective hedge to the rising cost of electricity. For example, the Department of Energy projects that a home in Ohio built to the model energy code would save most households over $260 a year in electric bill savings with the additional cost of meeting that updated code paying for itself in six years.[4] In Florida, those savings amount to $225 per year with only 2 years to achieve net savings.[5]

The benefits of model energy codes go beyond these consumer savings. Research from the Pacific Northwest National Laboratory found that building to the efficiency targets of current model energy codes can significantly increase the habitability (or "days of safety") of homes that experience energy disruptions during extreme weather events.[6] For example, a home in Atlanta, Georgia, during a heat related event has an estimated 7 days of safety when constructed to current energy codes versus only 3 days for the existing building stock. At a macro level, residential homes account for approximately 20 percent of the U.S. total primary energy consumption. Reducing or capping this demand through cost-effective policies like model energy codes can positively impact U.S. energy security and global competitiveness.

Two federal tax incentives – the Section 45L Builders New Energy Efficient Home Credit and the 25C Energy Efficient Home Improvement Tax Credit – were significant federal policies in driving both the construction of energy-efficient new homes and improving the energy efficiency of existing homes. Unfortunately, both credits are prematurely terminated under the provisions of Public Law 119-21. It is our hope that this Committee will work with industry to identify the next generation of federal policies that will promote a U.S. housing stock that is affordable to both purchase and operate. We look forward to working with you toward that result.

Sincerely,

American Chemistry Council
Building Performance Association
Business Coalition for Building Efficiency
Cellulose Insulation Manufacturers Association
Insulation Contractors Association of American
North American Insulation Manufacturers Association
Polyisocyanurate Insulation Manufacturers Association
Spray Polyurethane Foam Alliance

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[4] *https://www.energycodes.gov/sites/default/files/2021-07/EED_1365_BROCH_StateEnergyCodes_states_OHIO.pdf*
[5] *https://www.energycodes.gov/sites/default/files/2021-07/EED_1365_BROCH_StateEnergyCodes_states_FLORIDA.pdf*
[6] *https://www.energycodes.gov/sites/default/files/2023-07/Efficiency_for_Building_Resilience_PNNL-32727_Rev1.pdf*

September 9, 2025

The Honorable Bob Latta
Chairman, Subcommittee on Energy
Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC 20515

The Honorable Kathy Castor
Ranking Member, Subcommittee on Energy
Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC 20515

Dear Chairman Latta, Ranking Member Castor, and Members of the Subcommittee:

BlackFlare converts stranded flare gas into on-site power for AI computing infrastructure, **reducing grid strain** while targeting **high methane-destruction efficiency** with measured slip and MRV logs. Our modular data centers, powered by **oil-free, variable-fuel linear engines** (water-miscible graphite lubrication) achieving **~40 percent prototype thermal efficiency**, provide a practical solution to America's dual challenge of wasted energy and stressed electric infrastructure.

The Grid Reliability Crisis

Data centers currently consume approximately **4–5 percent** of U.S. electricity and could reach **10–13 percent by 2030** depending on AI deployment rates. Northern Virginia hosts the world's largest concentration of data centers, with facilities requiring **50–200 MW** each; utilities report multi-year backlogs for new connections. Meanwhile, EIA data show the U.S. vents and flares **hundreds of billions of cubic feet** of natural gas annually—capturing even a portion would materially impact supply.

Our solution: deploy computing where the energy already exists. Each **5–6 MW** BlackFlare pod operates completely off-grid, preserving transmission capacity for homes and businesses while creating distributed computing infrastructure resilient to cyber and physical threats.

Proven Technology Stack

We are partnering with **Dell Technologies** on modular data-center engineering rated for **~5–6 MW per 40-foot container**, scalable to **50+ MW per site**. Our design **aligns with NVIDIA reference architectures** for both training and inference. **Intelline Power Systems** provides linear engines with real-time combustion control adapting to gas composition changes cycle by cycle, avoiding failures that plague conventional gensets in flare fields.

BlackFlare's **fuel-aware control system** integrates with Intelline's ECU to enable predictive load management. When gas flow varies, compute workloads automatically scale, maintaining stable power output **without large-scale batteries or capacitor banks** that add cost and maintenance burden.

Economic Impact

Traditional data centers face significant electricity and infrastructure costs. BlackFlare generates power using otherwise-wasted gas at **low, site-dependent LCOE**, with **zero transmission upgrade costs**. For a **20 MW** deployment:

- substantial annual energy savings through avoided grid purchases
- eliminated transmission infrastructure upgrades
- **significant CO_2-equivalent reductions** (site-dependent)
- creation of high-skill technical positions at competitive salaries

Regulatory Barriers

Despite compelling economics and environmental benefits, outdated regulations block deployment:

1. **DOE efficiency standards** assume all generated power feeds the grid. Integrated **compute-power systems** need metrics recognizing productive use at the source.
2. **Permitting processes** often treat behind-the-fence installations like large grid plants, requiring extensive studies **even when not exporting power**.
3. **Tax-credit ambiguity** leaves unclear whether **IRA §48C** covers flare-to-compute despite meeting advanced-energy property intent.

Specific Recommendations

Congress should direct agencies to:

1. Establish efficiency standards for integrated energy-compute systems within 180 days.
2. Create expedited permitting for **off-grid, non-exporting** computing infrastructure under **50 MW**.
3. Clarify that productive use of stranded gas qualifies for clean-energy incentives.
4. Include **flare-to-power** explicitly in DOE Fossil Energy & Carbon Management funding opportunities.

Urgency

Global competitors are moving quickly on methane utilization and distributed compute. Every month of delay cedes technological and economic advantage while American resources remain underused and grid constraints tighten with AI demand.

BlackFlare can **phase toward 500 MW within ~24 months** with partners and identified sites, subject to regulatory clarity—capturing significant emissions while strengthening America's AI leadership.

Respectfully submitted,

Thomas McLaughlin
Founder & CEO, BlackFlare, Inc.
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September 9, 2025

The Honorable Bob Latta
Chair
Committee on Energy and Commerce
Subcommittee on Energy
U.S. House of Representatives
Washington, D.C. 20150

The Honorable Kathy Castor
Ranking Member
Committee on Energy and Commerce
Subcommittee on Energy
U.S. House of Representatives
Washington, D.C. 20150

Dear Chairman Latta and Ranking Member Castor:

On behalf of the American Cement Association (ACA), I write in support of your hearing, *Building the American Dream: Examining Affordability, Choice, and Security in Appliance and Buildings Policies.* Our industry is supportive of modern building codes that balance affordability, energy efficiency, and resiliency, as cement & concrete is part of the solution to the issues likely to be discussed at this hearing.

Cement is essential to building and maintaining the nation's infrastructure – from highways and bridges to airports, mass transit systems, and water facilities. Our products enhance energy efficiency in buildings, improve fuel efficiency on roads, and contribute to the resilience of critical infrastructure. Cement and concrete manufacturing support over 600,000 American jobs and contribute more than $100 billion to the U.S. economy annually.

ACA supports the adoption of updated building codes that balance energy efficiency, affordability, and above all, life-safety through disaster resilience. According to the National Oceanic and Atmospheric Administration (NOAA), the number of billion-dollar disaster events in the United States is increasing, and the associated costs are also rising.

Improving building codes is an effective strategy that policymakers and the building design and construction industry must employ to reduce the impacts of disaster events, including loss of life, property damage, and displacement of families and businesses. There are numerous benefits to revising building codes to meet today's needs and be robust. The first tool for communities to have proper building codes is to set minimum standards for construction that improve the chances that homes, schools, businesses, and utilities can survive major catastrophes. Buildings and infrastructure that survive get people back to normalcy, which is better for quality of life and economic growth.

Further, there are economic benefits for communities that adopt strong building codes through measurable performance. These benefits include promoting cost-effective construction by providing for economies of scale in the production of building materials. Building codes are developed by engineers, architects, product manufacturers, contractors, and public officials and are grounded in sound engineering principles that have been thoroughly tested. In its study entitled "Natural Hazard Mitigation Saves," the National Institute of Building Sciences found that adopting the latest building code requirements is affordable and saves $11 per $1 invested. Additionally, building the above code can save $ 4 for every $1 invested.

We appreciate the Committee’s efforts to examine this issue and offer our assistance as the Committee considers next steps to address building codes and housing. Thank you for your consideration of this letter. If you have any questions, please contact me at soneill@cement.org or (202)719-1974.

Sincerely,

Sean O’Neill
Senior Vice President, Government Affairs
American Cement Association

SPRAY FOAM COALITION

September 9, 2025

The Honorable Brett Guthrie
Chairman
Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC 20515

The Honorable Bob Latta
Chairman
Subcommittee on Energy
Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC 20515

The Honorable Frank Pallone
Ranking Member
Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC 20515

The Honorable Kathy Castor
Ranking Member
Subcommittee on Energy
Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC 2051

RE: Building the American Dream: Examining Affordability, Choice, and Security in Appliance and Buildings Policies

Dear Chairman Guthrie, Ranking Member Pallone, Chairman Latta, and Ranking Member Castor:

Thank you for the opportunity to provide this statement for the record and for your commitment to addressing housing affordability. This issue is central to the prosperity of millions of Americans and continues to worsen under current conditions.

It is imperative for building and energy codes to strike a reasonable balance between safety, energy consumption and cost. The Spray Foam Coalition (SFC) recommends the following options to reduce the cost of new construction:

1. Promoting the IECC Performance Paths, which creates options and flexibility for builders.
2. Maintaining the IECC's scope on *conservation* and eliminating the International Code Council (ICC) goals for the International Energy Conservation Code (IECC) that prioritize achieving zero-energy buildings, electrification, and decarbonization.
3. Ensuring efforts to reduce energy use and building emissions are not limited to new construction.

These suggestions are intentionally broad as we recognize that multiple entities (standard development organizations, Congress, and State Legislatures) have a role in the development and implementation of building and energy codes.

The Spray Foam Coalition fully supports energy efficiency and the development of cost-effective energy *conservation* codes. The Coalition is concerned that the current path of the IECC's goals around "zero-energy" buildings, electrification, and a desire to arbitrarily increase energy efficiency based mainly on increasing R-values for the building envelope every three years is increasing costs and not helping consumers use less energy to heat and cool their homes.

With energy demand on the rise due to new demands from data centers, restoring the focus of the IECC to energy conservation is a key solution to ensure grid reliability over the coming years. The SFC believes it is crucial to identify opportunities for enhanced energy efficiency wherever it can be found, freeing up electrons for efforts that are key to U.S. economic and national security, a goal shared by the Congress and the Trump administration.

Promoting the IECC Performance Path

Spray foam insulation is unique. The product is applied on-site and bonds to the surface to which it is applied. The product, in addition to providing best in class R-values, is air impermeable. Traditional insulation products are permeable and need secondary products to match this increased performance.

Insulating homes is only one piece of the building envelope energy efficiency puzzle. Installing an air barrier assembly to seal the building envelope helps ensure the most energy efficient building. Gaps, holes, and air leaks can make energy bills unnecessarily high and let valuable resources (i.e. conditioned air) go to waste. The potential energy savings from air sealing a home can be as high as 30% per year.[1]

The SFC believes that energy conservation can be achieved through better building envelopes using spray foam insulation. Homes with spray foam insulation can match the energy efficiency of homes with traditional insulation with less R-value in the wall because homes with spray foam insulation are generally more airtight.

In addition to installing the right amount of insulation in the walls, roofs, and floors, superior building envelopes allow for right sizing of HVAC equipment, often at lower costs, and reduce long term electrical consumption and costs to the homeowner.

This concept is essentially the IECC Performance Path. Recognizing there are many pathways to achieve energy efficiency, the IECC created Performance Paths to provide builders with optionality and flexibility, while leaving the Prescriptive Path intact as an easy solution for builders that choose that option.

However, the IECC currently emphasizes outcomes that prioritize building homes via the Prescriptive Path. Experts developing the IECC have arbitrarily chosen to require homes

[1] https://www.energy.gov/eere/why-energy-efficiency-upgrades

built via Performance Paths to be more energy efficient than homes built via the Prescriptive Path. This decision arbitrarily limits options for builders. The Performance Paths and the Prescriptive Path should be equivalent solutions.

The prevailing logic assumes that these homes must prove they are more efficient than prescriptive-path homes as a “precaution.” This creates an uneven playing field between the two compliance options built into the IECC.

The Performance Path was designed to empower builders to achieve energy goals through innovative, project-specific strategies. Prioritizing the Prescriptive Path limits this flexibility and may stifle more efficient solutions.

The energy efficiency targets in the current IECC Prescriptive Path have increased significantly over the past two decades, often through higher R-value requirements locked in through backstops. However, these changes are not always accompanied by a rigorous cost-benefit analysis and may unintentionally crowd out alternative solutions. Simply increasing insulation R-value instead of considering other energy efficiency solutions (e.g. better mechanical systems, improved air tightness, etc.) limits realistic competition.

The seemingly minor technical differences between the Prescriptive and Performance Path of the IECC limit competition, driving costs up, not down. The SFC believes that creating truly equivalent energy targets for the Prescriptive and Performance Path will drive better outcomes from the IECC, while reducing costs for builders.

Maintaining the IECC’s scope on conservation

In recent cycles of review and revision, the ICC has suggested the IECC should include targets or requirements around the following topics:

- Electric vehicle chargers,
- Electrification of homes,
- “Zero energy” homes,
- Decarbonization, and
- Low embodied carbon building materials.

These suggestions are outlined in the ICC’s *LEADING THE WAY TO ENERGY EFFICIENCY: A Path Forward on Energy and Sustainability to Confront a Changing Climate*.

The potential expansion of the scope of the IECC will increase the cost of new construction without a reduction in energy consumption – the primary intent of the IECC.

Requiring residential properties to include electric vehicle charging infrastructure or other electrification options imposes additional costs that may not be utilized by every homeowner. In contrast, investing in an improved building envelope delivers immediate enhancements in energy efficiency, resulting in reduced homeowner expenses from the outset. Spray foam insulation, when used as part of the performance path of the building code, enables builders to achieve superior levels of efficiency and comfort that not only meet, but can exceed prescriptive code requirements, providing a practical solution for reducing energy consumption and optimizing long-term savings for homeowners.

While efforts to expand the scope of the IECC have generally not been included in more recent revisions, several states have adopted electrification and decarbonization requirements. These requirements are increasing costs for builders.

Existing Buildings vs New Construction
The energy efficiency requirements for new construction have been steadily increasing for several decades. New homes built via the Energy Rating Index (ERI) path of the 2024 IECC are required to be between 46% and 49% more efficient than the 2006 IECC (depending on climate zone).

Building homes that have increased energy efficiency by 50% in less than 20 years should be viewed as a successful outcome. However, the drive towards "zero-energy," and decarbonization forces the IECC to suggest that this outcome is not sufficient.

The reality is simple. If the goal is to reduce emissions and "fight climate change," the country cannot build its way to a green economy. A recent study by Stanford University has suggested that a 5% increase in energy efficiency in existing homes is equivalent to 10 years of building "zero-energy" homes in California.

Spray foam insulation is an ideal solution for creating unvented attics – in new construction *and* retrofitting existing homes. Unvented attics allow all the HVAC mechanical equipment and duct work to operate inside the building envelope. Building unvented attics is like putting a hat on your home. Unvented attics were named as a Top Innovation by the U.S. Department of Energy.

Conclusion
The Spray Foam Coalition stands ready to work with Congress, federal agencies, and standards organizations to advance building energy codes that are logical, responsible, and economically feasible for American families.

Sincerely,

Stephen Wieroniey

Stephen Wieroniey
President

NATIONAL MULTIFAMILY HOUSING COUNCIL

NATIONAL APARTMENT ASSOCIATION

September 9, 2025

The Honorable Bob Latta, Chairman
Subcommittee on Energy
Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC 20515

The Honorable Kathy Castor, Ranking Member
Subcommittee on Energy
Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC 20515

Dear Chairman Latta and Ranking Member Castor:

On behalf of the members of the National Multifamily Housing Council (NMHC) and the National Apartment Association (NAA), we thank the Subcommittee for exploring the impacts of new building and energy efficiency standards on the availability and affordability of America's housing. We are committed to delivering high-performing and quality homes nationwide and support efforts that help us improve the energy and environmental profile of our buildings. However, recent changes to energy efficiency and environmental policies have failed to balance the nation's housing affordability and supply needs and risk undermining efforts to address America's acute housing challenges.

Th House Energy and Commerce Committee serves an important role in ensuring that federal policies support America's housing goals. As the Subcommittee on Energy holds a hearing on "Building the American Dream: Examining Affordability, Choice, and Security in Appliance and Buildings Policies," we urge you to consider the obstacles facing housing providers in containing rising costs and delivering much-needed supply.

One-third of all Americans rent their housing, and we represent the $3.9 trillion apartment industry and its more than 40 million residents. Our industry plays a critical role in meeting the nation's housing needs and we caution against policies that create barriers to new housing production and renovation of existing properties. In particular, we urge review of recent Department of Energy (DOE) appliance efficiency standards and federal efforts to mandate one-size-fits-all national energy codes, which can create serious, and sometimes cost-prohibitive, challenges for housing providers.

The Nation's Critical Housing Shortage

Today's Subcommittee action rightly acknowledges the acute housing affordability and availability needs facing the nation. **The U.S. needs to build 4.3 million new apartment homes by the year 2035 to meet the demand for rental housing.**[1] This underproduction of housing has translated into higher housing costs – resulting in a consequential loss of affordable housing units (those with rents less than $1,000 per month), with a decline of 4.7 million affordable apartments from 2015-2020. In fact, the total share of cost-burdened apartment households (those paying more than 30% of their income on housing) has

[1] "Estimating the Total U.S. Demand for Rental Housing by 2035," Hoyt Advisory Services (2022), https://www.weareapartments.org/.

increased steadily over several decades and reached 57.6% in 2021.[2] During this same period, the total share of *severely* cost-burdened apartment households (those paying more than half their income on housing) increased from 20.9 to 31.0%.[3]

Costly regulations exacerbate these conditions. This harms the millions of Americans who depend on rental housing, and deters the rapid investment, innovation and development critical to the growth and success of the rental housing industry. Indeed, recent empirical research confirms that **regulation accounts for an average of 40.6 percent of multifamily development costs**, adding significantly to the costs of operating multifamily rental housing, negatively impacting all aspects of the industry, including rental housing affordability for millions of Americans.[4]

Impacts of New Appliance Efficiency Standards in Multifamily Housing

Our organizations have long been engaged in the rulemaking process for DOE appliance efficiency standards, ensuring that the unique needs of the apartment industry and America's renters are recognized. Apartment providers are bulk purchasers of consumer appliances and are responsible for ensuring our residents' homes are well-equipped with safe, effective and affordable products that meet their performance expectations and consumer preferences. At the same time, higher appliance costs, design complications and installation barriers in multifamily buildings and operational changes driven by new appliance efficiency requirements have a direct impact on the cost of housing.

The last Administration pursued an aggressive series of rulemakings, seeking to change performance standards for essential residential appliances and equipment that prompted concern from the housing industry. We offered formal comments to DOE on a broad range of these and other proposals including water heaters,[5] clothes washers,[6] refrigerators and freezers,[7] conventional cooking products,[8] distribution transformers,[9] and furnaces,[10] explaining that these new regulatory burdens will inevitably raise housing

[2] "NMHC tabulations of 1985 American Housing Survey Microdata," American Housing Survey, U.S. Census Bureau (2021).
[3] *Id.*
[4] "NMHC-NAHB Cost of Regulations Report," NMHC and National Association of Home Builders (June 2022), https://www.nmhc.org/research-insight/research-report/nmhc-nahb-cost-of-regulations-report/. See also "Behind the High Cost of Rent: How Local Rules and Regulations are Increasing Expenses for Multifamily Operators," Daniel Shoag and Issi Romem, MetroSight (Feb. 2025), www.metrosight.com/articles/behind-the-high-cost-of-rent.
[5] Energy Conservation Program: Energy Conservation Standards for Consumer Water Heaters, 88 FR 49058 (https://www.regulations.gov/comment/EERE-2017-BT-STD-0019-0996).
[6] Energy Conservation Program: Energy Conservation Standards for Residential Clothes Washers, 88 FR 13520 (https://www.regulations.gov/document/EERE-2017-BT-STD-0014-0060).
[7] Energy Conservation Program: Energy Conservation Standards for Refrigerators, Refrigerator-Freezers, and Freezers, 88 FR 12452, (https://www.regulations.gov/comment/EERE-2017-BT-STD-0003-0061).
[8] Energy Conservation Program: Energy Conservation Standards for Consumer Conventional Cooking Products, 88 FR 6818, (https://www.regulations.gov/comment/EERE-2014-BT-STD-0005-2265).
[9] Energy Conservation Program: Energy Conservation Standards for Distribution Transformers, 88 FR 1722, (https://www.regulations.gov/comment/EERE-2019-BT-STD-0018-0097).
[10] Energy Conservation Program for Appliance Standards: Energy Conservation Standards for Residential Furnaces and Commercial

costs. Specifically, we stressed that these rules could frustrate housing production and affordability, highlighted unique compliance considerations in apartment properties, detailed technical barriers to implementation and cautioned against overly burdensome regulations.

Subsequently, we have broadly supported the Trump Administration's deregulatory efforts and submitted comments in support of the Administration's action to improve the DOE Process Rule, which establishes the general framework for DOE to develop energy conservation standards and test procedures for both consumer products and commercial equipment pursuant to the Energy Policy and Conservation Act (EPCA).[11]

Our comments raise several common concerns across many of these rulemakings. Foremost, DOE's analysis on the necessity and justification of new standards fails to balance the value of new requirements with the impacts on the nation's housing conditions. It is critically important that new regulations support the development of housing at all price points, which is essential to address the nation's critical housing challenges and ensure economic stability for American households.

We therefore urge this Subcommittee to support changes to EPCA or other legislative action that promotes the inclusion of an analytical framework for the development of appliance efficiency standards formalizing consideration of housing sector impacts to both the single- and multifamily industry and takes unique multifamily and rental housing conditions into account.

In addition, we encourage the Subcommittee to recognize the importance of preserving product choice and ensuring there's flexibility to select those appliances that reflect the unique characteristics and wide array of housing and residential construction types. We specifically caution against efficiency standards that may significantly reduce our product options based on a particular fuel source. While DOE has oft stated that its intention is not to preclude the use of gas-fueled products, several of these rulemakings nevertheless promote building electrification, potentially heavily steer buyers towards electric equipment options and have the practical effect of restricting the use of gas appliances in favor of electric versions in certain applications.

Moreover, we have urged DOE to consider the collective impacts of these rulemakings and recognize that the effect of even relatively modest, individual pricing increases are magnified when housing providers are forced to manage cost escalations across multiple product classes at once. Importantly, essential residential appliances are already highly energy efficient, and the multifamily buildings they service have made significant energy performance gains in recent years, with many properties achieving EPA EnergyStar certification or other recognition of their distinguished efficiency. Efforts that result in only marginal efficiency increases should be balanced against the costs and burdens of equipment changes, appliance performance differences and production or supply chain disruption. Such challenges can result in undue delays or cancellation of construction and renovation efforts that would result in broader building performance improvements.

As this Subcommittee considers the impacts of new appliance efficiency standards, we urge you to address the analytical deficiencies that jeopardize the affordability and availability of housing. In particular, recent

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Water Heaters 84 FR 33011 (https://www.regulations.gov/comment/EERE-2018-BT-STD-0018-0080).

[11] Energy Conservation Program: Procedures, Interpretations, and Policies for Consideration of New or Revised Energy Conservation Standards and Test Procedures for Consumer Products and Certain Commercial/Industrial Equipment 90 FR 16093 (https://www.regulations.gov/comment/EERE-2025-BT-STD-0001-0029).

rulemakings lacked sufficient attention to the distinct nature of multifamily construction and operations including:

- **Fails to Address the Diversity of Multifamily Building Types.** The supporting information provided by DOE in their appliance rulemaking analysis has lacked important perspective on the diversity of multifamily housing and is inadequate to properly analyze the proposed rules' implications on apartments. DOE's analysis has not accounted for the breadth of multifamily building configurations, construction types and materials and equipment use and does not well-address distinctions within the multifamily landscape including high-rise versus low-rise buildings, historic structures and adaptive reuse projects (i.e. commercial to residential conversions). Such features can significantly influence appliance installation, operations and consumer satisfaction, and DOE's impact analysis would benefit from a broader consideration of the multifamily marketplace.

- **Ignores the Unique Characteristics of Multifamily Design.** DOE's appliance rulemakings often pose unique challenges for multifamily dwellings given small unit size, typical design considerations and the dense construction inherent in multifamily construction. Recent policy changes fail to address obstacles in appliance relocation or reconfiguration of supporting infrastructure in small or interconnected dwelling units. DOE failed to properly consider material impacts on rentable square footage or undesirable impacts on multifamily unit design where appliances will need to be placed in different areas than normally expected or relocated in the case of equipment replacement or unit renovation.

- **Underestimates or Overlooks Impacts on Existing Buildings.** DOE's analysis has not properly distinguished the needs of the existing building market, as the existing apartment stock is a key source of affordable and work force housing nationwide. DOE's cost-effectiveness analysis routinely fails to adequately address retrofit challenges that make certain product choices untenable, force product switching and/or necessitate expansive reconstruction efforts in multifamily buildings.

- **Lacks Housing Impact Analysis for All Income Levels.** It is essential that we build and renovate housing at all price points to address the nation's housing needs. DOE's existing analysis affords consideration of new standards' impacts on "low-income households," but Americans at all income levels are facing out-of-reach housing costs. A recent report shows that renters nationwide need to earn more than $80,000 to comfortably afford the typical rent, up from $60,000 needed just five years ago, and those earnings need to rise to six figures in eight major metro areas.[12]

- **Misjudges Requisite Product Switching and Cascading Equipment Replacement in Multifamily.** Although new appliance efficiency standards do not compel retrofitting of existing equipment, DOE's analysis often fails to consider the multifamily design and operational conditions that can nonetheless force housing providers to replace equipment that has not yet reached the end of its useful life. Multifamily properties commonly use venting, piping, shafts and other building systems that serve multiple dwelling units. We have detailed how compliance with new efficiency standards can necessitate changes to these features that force a cascade of system or equipment replacements to accommodate these shared-use situations. We have also identified circumstances where product switching is probable in multifamily construction, usually driven by space limitations or unit configurations in existing buildings. Moreover, we have identified scenarios where retrofit costs associated with new appliance efficiency standards in multifamily properties will not only promote product switching, but incentivize replacement with lower efficiency appliances. In these

[12] "Renters Need to Earn $100K in Twice as Many Markets Than in 2020 (April Rent Report)," Zillow (April 2025), https://www.zillow.com/research/april-2025-rent-report-35152/.

instances, DOE has failed to examine the breadth of product switching costs and real-world installation expenses that face apartment housing providers.

- **Underestimates Impacts of Increased Electrification.** Where product switching is required as discussed above, it is predictable that recent appliance efficiency proposals would result in the greater use of electric products. We specifically cautioned against moving forward with new efficiency standards that may significantly reduce our product options based on a particular fuel source, with more onerous requirements or compliance demands being imputed on products using fossil fuels. Increased building electrification requires more interconnectivity, changes to power systems and upgraded electrical infrastructure that poses significant cost and constructability barriers for the existing apartment stock that was unaddressed in DOE's analysis.

Building Codes are a Significant Driver of Regulatory Burdens and Costs in Housing

Building codes and standards are an essential component of housing construction. However, onerous code requirements are a major barrier to new housing development and renovation. In fact, in our previously cited research on the cost of regulation in housing development, **the highest average regulatory cost in multifamily development is the result of changes to building codes over the past 10 years** (11.1 percent of total development costs).[13] In a separate survey, 89% of respondents agreed or strongly agreed that building code requirements in general impact the cost and viability of construction projects.[14]

While we support cost-effective and technically-feasible codes and standards, building codes have increasingly been used to advance policy goals unrelated to building safety or basic building performance requirements. In particular, the previous Administration sought a more expansive federal role in the use of building energy codes, principally as a tool to advance climate change goals. This included an aggressive push for the adoption of specific building energy codes and standards, including "zero energy" codes that would generally prohibit the use of fossil fuels in buildings.

In a recent survey, nearly 70 percent of respondents (66%) agreed or strongly agreed that compliance with energy performance and efficiency requirements caused significant challenges for their business and 63% of respondents indicated challenges with electrification or net-zero emissions-related provisions.[15] About half of respondents (49%) specifically indicated that their business would be less likely to develop, build or invest in a project where the latest energy code edition was required.

There has been a push to use federal policy efforts and significant federal funding opportunities to enforce specific codes through federal program participation or induce jurisdictional adoption of particular energy codes and standards. In fact, the previous Administration's use of grants and other funding to impose specific energy codes was an expensive endeavor, with the DOE spending hundreds of millions of dollars to promote codes that mandate expensive construction requirements, restrict or otherwise influence fuel

[13] *Id.* at 4.
[14] "NMHC Pulse Survey: Analyzing the Impact of Building Codes on Rental Housing Development & Affordability," NMHC (May 2024) https://www.nmhc.org/research-insight/survey/nmhc-pulse-survey-analyzing-the-impact-of-building-codes-on-rental-housing-development-affordability/.
[15] *Id.*

choices and force property owners to fund electrification, electric vehicle charging and other features that may not be compatible with the actual market conditions of a project or area. This included $225 million in funding from the Infrastructure Investment and Jobs Act to implement updated building energy codes,[16] and $530 million in funding from the Inflation Reduction Act to for states, territories and local governments to adopt the latest model energy codes, zero energy codes or innovative codes.[17]

We encourage a reexamination of these policies, programs and grant opportunities and urge changes to measures that establish one-size-fits-all energy code requirements or incentivize jurisdictions to adopt specific energy code editions or those that compel use of particular fuel sources or unduly burden housing costs.

Conclusion

The apartment industry supports building and appliance efficiency goals. At the same time, improving housing affordability and availability are key national priorities. We are committed to working with policymakers to further energy efficiency goals while supporting the creation of more housing, preserving affordability and ensuring that every American has a safe, quality place to call home.

Sincerely,

National Multifamily Housing Council
National Apartment Association

C.C. Chairman Brett Guthrie
Ranking Member Frank Pallone, Jr.
Members of Subcommittee on Energy, House Committee on Energy and Commerce

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DO ENERGY EFFICIENCY INVESTMENTS DELIVER? EVIDENCE FROM THE WEATHERIZATION ASSISTANCE PROGRAM

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ABSTRACT

Conventional wisdom suggests that energy efficiency (EE) policies are beneficial because they induce investments that pay for themselves and lead to emissions reductions. However, this belief is primarily based on projections from engineering models. This paper reports on the results of an experimental evaluation of the nation's largest residential EE program conducted on a sample of more than 30,000 households. The findings suggest that the upfront investment costs are about twice the actual energy savings. Further, the model-projected savings are roughly 2.5 times the actual savings. While this might be attributed to the "rebound" effect – when demand for energy end uses increases as a result of greater efficiency – the paper fails to find evidence of significantly higher indoor temperatures at weatherized homes. Even when accounting for the broader societal benefits of energy efficiency investments, the costs still substantially outweigh the benefits; the average rate of return is approximately -9.5% annually.

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1 Introduction

Energy efficiency investments are widely believed to offer the rare win-win opportunity. Detailed engineering projections, such as those summarized by the well-known McKinsey curves (McKinsey & Company, 2009), routinely project that investments pay for themselves through the energy saved alone (win #1). Moreover, by reducing the energy necessary to achieve a given level of energy services (e.g., indoor heating), these investments promise to decrease the greenhouse gas emissions causing climate change and other pollutants that compromise human health (win #2).

Despite these apparent opportunities, there is a large and persistent difference between the levels of investment in energy efficiency that are projected to save consumers money and the investments that individuals actually pursue. This has become known as the "efficiency gap." Over the last three decades, a wide variety of explanations have been offered for this apparent failure of consumers to avail themselves of profitable investment opportunities. The most popular explanations have emphasized the possibility of market failures, such as imperfect information, capital market failures, split incentive problems, and behavioral explanations, including myopia, inattentiveness, and prospect theory and reference-point phenomena (see, for example, Allcott and Greenstone, 2012; Gillingham and Palmer, 2014; Gerarden et al., 2015). In contrast, relatively little attention has been paid to the more pedestrian possibility that the real world returns on energy efficiency investments are lower than the engineering models indicate.[1]

Mounting concern about climate change has increased the urgency of understanding this phenomenon. Governments around the world are pursuing a wide range of policies designed to narrow or close this gap. For example, the International Energy Administration has outlined a suite of policies that do not harm economic growth and limit warming to the 2 degrees C recommended by climate scientists; in this scenario, end-use energy efficiency improvements account for 49% of the greenhouse gas emissions abatement in 2020 (IEA, 2013).[2] Further, energy efficiency investments are a critical part of the U.S. government's proposed Clean Power Plan (ICF, 2014), U.S. electric

[1] Early work by Joskow and Marron (1992) raised concerns about overstated efficiency potential and underscored the importance of using ex post measures of consumer behavior to estimate energy savings. Subsequent work uses panel data on household energy expenditures to estimate realized returns on efficiency investments (see, for example, Metcalf and Hassett, 1999; Jacobsen and Kotchen, 2013; Graff Zivin and Novan, 2015).

[2] Indeed, energy efficiency is a central plank for virtually all serious climate mitigation plans (Loftus et al., 2015).

utilities are rapidly expanding their energy efficiency programs (Barbose et al., 2013), and federal and state regulators routinely tighten energy efficiency building codes, appliance standards, and fuel economy standards for automobiles and trucks.

This paper provides the first large-scale field evidence on the returns to energy efficiency investments from a randomized controlled trial. Specifically, we use experimental, as well as quasi-experimental, variation in participation in the federal Weatherization Assistance Program (WAP), to identify the returns to these investments. WAP is the nation's largest residential energy efficiency program and has provided over 7 million low-income households with weatherization assistance since its inception in 1976. Recipient households in our study received approximately $5,150 worth of home improvements on average, at zero out-of-pocket costs. The most common measures included furnace replacement, attic and wall insulation, and infiltration reduction. Importantly, WAP only pays for energy efficiency measures that pass a cost-benefit test, based on ex ante engineering estimates, with the aim of ensuring that only beneficial investments are undertaken.

The randomized encouragement design experiment was conducted on a sample of over 30,000 Michigan households that were presumptively eligible for participation in WAP. Approximately one quarter of these households were randomly assigned to a treatment group that was encouraged to apply for the program and received significant application assistance. The control households were free to apply for WAP but were not contacted or assisted in any way by our team.

There are three primary findings. First, an aggressive encouragement intervention increased WAP participation from less than 1% in the control group to about 6% in the encouraged group. The encouragement was implemented by a firm with extensive experience managing outreach campaigns and neighborhood canvassing operations, including among low-income populations. The field activities included almost 7,000 home visits, more than 32,000 phone calls, and 2,700 follow-up appointments. Ultimately, these extensive efforts only managed to increase the participation rate by 5 percentage points at a cost of more than $1,000 per weatherized household (Fowlie et al., 2015), revealing low demand in the eligible population for a program with considerable potential benefits.

Second, the findings suggest that the benefits of these investments are substantially less than the upfront costs. We estimate that the WAP energy efficiency investments reduce monthly energy consumption by 10-20% on average. Although this surely provides a substantial assist to participating low-income households in the form of reduced energy bills, the upfront investment costs are about twice the realized energy savings. Further, the model-projected savings are roughly 2.5 times the actual savings.

Third, while the modest energy savings might be attributed to the "rebound" effect, when demand for energy end uses increases as a result of greater efficiency, the paper fails to find evidence of significantly higher indoor temperatures at weatherized homes. This finding comes from a novel survey of measured indoor temperatures and thermostat set points that we conducted in the study population. Though the existence of the rebound effect has been the subject of much debate (Gillingham et al., 2013), our study is the first to provide a direct field test of this phenomenon for a broad spectrum of residential energy efficiency investments.[3]

Across a variety of metrics, the WAP energy efficiency investments appear to be poor performers on average. While these investments were free to participating households, we can nevertheless estimate the private returns if households had been responsible for the upfront costs, which is the case for households that do not qualify for WAP. Counting private returns - a household's reductions in energy bills and willingness to pay for any change in indoor temperatures – the annual internal rate of return that would rationalize these efficiency investments is -2.2%. This finding of low, indeed negative, returns suggests that, at least for residential home retrofits, there may not be much of an efficiency gap to explain. Rather just like in all other sectors of the economy, investments with low returns are not taken-up frequently. Importantly, the engineering model used by WAP is similar, and in some cases identical, to those used to develop recommended residential efficiency investments in the broader population (i.e., not just low-income households).

These investments could still be beneficial socially, although this turns out not to be the case, on average, with the measures we evaluate. In contrast to the private calculation, the social one accounts for the benefits of reduced greenhouse gas and local pollutant emissions and the fact that part of households' energy savings is a transfer from other energy consumers, rather than genuine

[3]Davis (2008) - a study of clothes washers - is a notable exception.

social savings. When the monetized reduction in environmental damages are added to the private benefits, the annual internal rate of return that would justify these investments is -0.8%, still far from what is considered an attractive rate of return. The annual social internal rate of return that also removes transfers from the calculation of benefits is -9.5%. Finally, we also calculate the average cost per ton of avoided CO_2 under a range of assumptions. The most plausible estimates are $329/ton, which is about an order of magnitude larger than the U.S. government's estimate of the social cost of carbon of roughly $38 (Greenstone et al., 2013).

The paper proceeds as follows. Section 2 introduces a conceptual framework useful for valuing energy efficiency investments, including any behavioral adjustments they may cause. Section 3 outlines key details on the Weatherization Assistance Program and describes our study design. Section 4 describes the data sources and provides summary statistics. Section 5 reports the main results on actual savings and on observed rebound effects. Section 6 develops measures of the return to energy efficiency investments based on the previous section's findings and Section 7 concludes.

2 Conceptual Framework

The standard definition of the 'energy efficiency gap' refers to the difference between actual and cost-effective energy use. In other words, a gap exists if individuals systematically overlook energy efficiency investments that confer benefits in excess of costs. Our primary objective is to estimate the value of ex post realized benefits derived from a set of policy-induced efficiency investments. This section introduces the conceptual framework underlying our valuation exercise.

Gains from an investment in energy efficiency are realized through two main channels: reduced energy consumption and increased consumption of energy services (e.g. lighting, space heating, air conditioning) due to reductions in the price of energy services. With respect to the first channel, any reduction in dollars spent on energy can be allocated to other forms of welfare-enhancing consumption. The second channel becomes important when an efficiency-induced reduction in energy end-use costs leads to an increase or "rebound" in the demand for the energy service. For utility-maximizing agents, any re-optimization of consumption that occurs in response to an efficiency improvement will be (weakly) welfare improving.

These basic ideas are illustrated in the upper quadrant of Figure 1, which plots consumption of a particular energy service, home heating, on the horizontal axis and consumption of the numeraire (i.e., all other goods), X, on the vertical axis. The figure focuses on home heating because it is a particularly important end-use in our empirical setting; over 93% of projected energy savings from the weatherization investments we analyze are heating related.

The two downward sloping lines in the upper quadrant of the figure reflect budget constraints, the lower before the efficiency improvement (i.e., the status quo) and the higher after weatherization. The budget constraint pivots post-weatherization because the price of heating services (e.g., the price of keeping the house at a certain indoor temperature in winter) has fallen; energy efficiency improvements reduce the cost of purchasing any given level of thermal comfort.

The figure also illustrates a family of indifference curves for a representative consumer, each of which trace out the bundles of the numeraire, X, and heating services, H, that deliver the same level of utility. The shape of the indifference curves reflects that households do not like to be too hot or too cold. In the status quo (i.e., absent an efficiency improvement), the representative agent will maximize utility through the choice of H_0 and X_0. The weatherization-induced expansion of the budget constraint allows the agent to move to a higher level of utility associated with the bundle of H_1 and X_1. In the figure, status quo consumption occurs below the satiation point for thermal comfort. Thus, when the price falls, demand for heating services increases by $H_1 - H_0$. The positive income effect also increases consumption of the numeraire by $X_1 - X_0$.

The paper's empirical challenge is to measure the welfare gains conferred by weatherization investments. Our empirical setting allows us to develop a measure of willingness to pay (WTP) for weatherization that accounts for both reductions in energy expenditures and the increased consumption of heating services. The effect of energy efficiency improvements on other consumption can be measured using data on monthly energy expenditures which vary one-for-one with the consumption of the numeraire. Put another way, a $1 decrease in energy expenditures allows for a $1 increase in consumption of all other goods. Measuring willingness to pay for the increase in heating services (i.e., the direct rebound effect) is more challenging because demand for energy services, such as heating, is not readily observable in household energy consumption or expenditure data.

To obtain an estimate of the efficiency-induced increase in demand for heating ($H_1 - H_0$ in the figure), we conduct a survey of indoor temperatures in weatherized and non-weatherized homes. With this estimate of the treatment-induced change in indoor temperatures in hand, we can construct bounds for the welfare consequences of any observed increase in warmth by imposing some structure on the relationship between energy demand and heating services.[4] The bottom quadrant of Figure 1 plots a representative building-specific relationship between heating services and the energy required to achieve that temperature, E, holding constant outdoor temperatures and building characteristics, Z.[5] Efficiency improvements to the building envelope (e.g., insulation improvements, window sealing, a furnace upgrade) reduce the energy required to deliver any given level of heating services. This implies that the slope of the relationship between heating services and energy consumption becomes less steep following an efficiency improvement, depicted as the pivot in the function that determine energy consumption from $E(H; SQ, Z)$ to $E(H; W, Z)$ in the figure. Section 5.3 details our approach to empirically estimating the relationship between energy consumption and heating demand, which, in practice, is measured as indoor temperature.

We use the empirical relationship between indoor temperatures and energy consumption to construct bounds on the utility gains from any efficiency-induced increase in the demand for indoor temperature using revealed preference logic. Since the agent chooses to increase heating services from H_0 to H_1 following the efficiency improvement, it follows that a lower bound for the increased utility derived from this increase is the associated increase in heating costs incurred after weatherization. This value is represented by P_E*($E_{1,W}$-$E_{0,W}$) in the figure, where P_E is the exogenous price of energy. Note that the agent chose less heating than H_1 prior to the efficiency

[4]Our measure of the returns to weatherization investments accounts for a household's valuation of increased warmth, but we do not account for any increase in comfort conditional on indoor air temperature. Researchers have noted that improvements in insulation enhance comfort by reducing drafts and increasing humidity (Schwarz and Taylor, 1995). If a home is less drafty and more humid, a consumer may be able to achieve the same comfort at a lower indoor temperature. Consequently, what we measure here is the net effect of efficiency improvements on heating demand. We return to this point below.

[5]We assume a linear relationship between air temperature and energy demand over the relevant range of temperatures; we provide empirical support for this assumption in Section 5. Also, for ease of exposition, this figure depicts the limited range of indoor air temperatures over which energy consumption is increasing in indoor temperatures. This range is bounded from below by the outdoor air temperature (if the thermostat is set below the outdoor air temperature, no heating services are required). The lines stop where the capacity of the home heating system binds. Beyond this point, increased energy consumption ceases to generate heating services.

improvement. Thus, the cost of the change in heating services prior to weatherization, measured by $P_E{*}(E_{1,SQ} - E_{0,SQ})$, provides an upper bound on the welfare gain. Preferences revealed prior to the efficiency improvement suggest that the agent values the increase in heating services less than this incremental cost.

With this conceptual framework as a guide, the paper will estimate the causal effect of WAP participation on annual energy consumption and willingness to pay for changes in heating services.

3 Background and Study Design

This section provides background information on WAP. It also details the quasi-experimental and experimental designs that we use to evaluate the consequences of the energy efficiency measures for WAP participants.

3.1 Weatherization Assistance Program

The Weatherization Assistance Program (WAP) is the nation's largest residential energy-efficiency program. WAP supports improvements in the energy efficiency of dwellings occupied by low-income families. Since its inception in 1976, over 7 million low-income households have received weatherization assistance through the program. Proponents credit the program with saving energy, creating jobs, reducing emissions, and assisting low-income households. The American Recovery and Reinvestment Act PL111-5 (ARRA) dramatically increased the scale and scope of WAP.[6] Our analysis seeks to estimate the impacts of weatherization assistance over the ARRA-funded time period.

WAP funds are distributed to states based on a formula tied to a state's climate, the number of low-income residents, and their typical energy bills. The states distribute WAP money to over 1,000 local sub-grantees, which are typically community action agencies (CAAs) or similar nonprofit groups. These sub-grantees are then tasked with identifying and serving eligible households. Participating WAP households receive free energy audits and a home retrofit that typically includes some

[6] Funding increased from $450 million annually in 2009 to almost $5 billion for the 2011-2012 program years. Under the ARRA-funded program, all owner-occupied households at or below 200% of the poverty line were eligible to apply for assistance.

combination of insulation, window replacements, furnace replacement, and infiltration reduction. The average participating household in our data received an average of $4,143 of energy efficiency investments and over $1,000 worth of additional house improvements at zero out-of-pocket costs.[7]

Before implementing a weatherization retrofit, CAA program staff conduct an energy audit of the home. The purpose of the audit is to make recommendations regarding which efficiency improvements should be implemented at the home. During the visit, program auditors collect detailed information about the building structure and other construction details, heating and cooling systems, appliances, ventilation, etc. This information is combined with local climate conditions and retrofit measure costs, then fed into a computer-based audit tool: the National Energy Audit Tool (NEAT). This tool uses engineering algorithms to model the energy use of single-family and small multi-family residential units. NEAT is the most widely used tool for weatherization audits; it is used by state and local WAP sub-grantees, utility companies, and home energy auditors (EERE, 2010).

NEAT produces an estimate of the energy savings and costs associated with different combinations of efficiency measures. The present value of energy savings are calculated using a discount rate of 3% and an engineering estimate of the lifespan of the measures. The 3% discount rate is consistent with OMB guidance on how to evaluate benefits of federal spending but is substantially lower than the cost of borrowing for most households, especially low income ones. The WAP program requires that all recommended measures return a minimum of $1.00 in incremental savings for every $1.00 expended in labor and material costs. The process of applying for weatherization is highly onerous and time intensive, at least partially to prevent fraud. Applicants must submit extensive paperwork documenting their eligibility, including utility bills, earnings documentation, social security cards for all residents of the home and deeds to the home. The process that determines which applicants receive weatherization assistance is not purely random. Local agencies often identify potential applicants from the pool of households that are receiving other social services, although walk-in clients are routinely admitted. Local agencies screen potential applicants

[7]During the course of the retrofit, additional costs are incurred to ensure the safe and effective installation of the weatherization measures. For example, electric wiring updates or asbestos removal may be required to ensure a safe working environment. Once these safety measures are accounted for, the average cost per household is $5,150.

for eligibility. Eligible applicants are then prioritized following guidelines that recommend CAAs assign the household a high rank if it has an elderly resident, a person with disabilities or children, or where the occupants typically face a high energy burden (energy as a share of income) or have high residential energy use (see 10 CFR 440.16(b) (1-5)).[8] Given the nature of the process by which households end up in the program, any comparisons of energy consumption across weatherized and un-weatherized households risks confounding the effect of the program with pre-existing differences in determinants of energy consumption.

3.2 Research Design

The paper's empirical challenge is to obtain causal estimates of the effect of participation in the WAP program on energy consumption and indoor heating. We use both quasi-experimental and experimental approaches to address the potentially confounding effects of non-random selection into the WAP program and compare the results across specifications.

Our analysis focuses on a sample of low-income Michigan households. Michigan is one of the largest recipients of WAP program funding on account of its cold winters and large low-income population. Further, we were able to secure collaborative agreements with a major Michigan utility and five Community Action Agencies (CAAs) working in this utility's service territory. This allowed us access to detailed, household-level energy consumption and weatherization program data. A close collaboration with two of these agencies allowed us to implement a large-scale field experiment.

Michigan received over $200 million in ARRA funding for weatherization assistance. A series of bureaucratic delays - for example, ensuring that contractors were paid prevailing wages - delayed spending until early 2011 (Radnofsky, 2010). Around March 2011, weatherization activities in Michigan increased markedly. All stimulus funds had to be spent by March 2012. After that point, the pace of weatherization activity dropped precipitously. We stopped collecting data in April 2014. A number of households that applied for WAP had not yet received services by the end of our study period.

[8]Given the high ARRA funding levels during our study period, the prioritization scheme was less binding as compared to lower funding periods.

3.2.1 Quasi-Experimental Design

The quasi-experimental research design uses data on all of the households that applied for WAP after March 2011 with one of the five CAAs that shared data with us. In this sample of households, we compare patterns in energy consumption among weatherized households and households that applied for WAP but had not been weatherized by mid-2014, when our data ends. Forty percent of applicants were weatherized through WAP during this period.

A critical issue for the validity of the estimates from this design is how households in this sample were chosen for weatherization. The road from application to energy efficiency investments is long and there are many potential off-ramps. Applicant households may fail to complete the necessary – and involved – paperwork or may be deemed ineligible based on the information they provide. Once paperwork is completed successfully, households are put on a list where the waiting times can exceed one year. After rising to the top of the list, homeowners must accommodate scheduling of energy audits. Households may fail to receive weatherization if they miss an audit appointment, or if the auditors discover risks to WAP contractors (e.g., asbestos in the home). Because of significant delays in ramping up weatherization activities under ARRA, the agencies were unable to complete the weatherizations they anticipated prior to the March 2012 ARRA deadline, which helps to explain why fewer than half of the applicants in our sample were weatherized by mid-2014. Some of the explanations for variation in treatment status among applicants are orthogonal to household characteristics that determine energy consumption patterns, while others clearly are not.

We estimate the following equation designed to control for the effects of unobservable factors that determine energy consumption trajectories at households that apply for weatherization assistance:

$$ln\left(y_{imt}\right) = \beta \mathbf{1}\{WAP\}_{imt} + \alpha_{im} + \alpha_{mt} + \epsilon_{imt}, \tag{1}$$

where $ln\left(y_{imt}\right)$ measures the natural log of energy consumption (natural gas, electricity, or a combined measure) at household i in month m and year t. The WAP indicator variable switches from zero to one in the month after a household's weatherization retrofit is complete.[9] The equation

[9] For approximately 70% of households we observe the date that the work is reported complete, the post-inspection is complete, and the job is finally "closed out." For those households for whom we observe all three dates, these dates

includes household-by-month-of-year fixed effects, α_{im}, to account for permanent differences in a household's energy consumption across months. It is possible to include such a rich set of fixed effects that account for household-specific seasonal variation in energy consumption because we observe households across multiple years. The model also includes month-by-year fixed effects, α_{mt}, to adjust for the average effects of time-varying factors (e.g., winter temperature) that generates variation in average consumption across all households.[10]

The parameter of interest is β, which measures the mean difference in energy consumption subsequent to the completion of WAP energy efficiency investments, after adjustment for the fixed effects. It is a difference-in-differences estimator that compares the change in energy consumption after weatherization to before, relative to consumption among households that have either not yet weatherized through WAP or never did during our sample period.

In equation (1), the primary threat to consistent estimation of β is the possibility that time-varing factors that affect household demand for energy also influence WAP participation. For instance, households may push forward their WAP application more aggressively when they anticipate an increase in their demand for energy as would be the case when the number of people in their household increases or they lose a job and expect to spend more time at home. While the quasi-experimental approach does not have a direct solution to this threat to identification, we take steps to balance observable characteristics and trends across weatherized and unweatherized households. To evaluate the robustness of our findings, we re-estimate equation (1), using alternative sets of controls and regression weights. Our preferred quasi-experimental specification re-weights control observations in order to achieve covariate balance across weatherized and un-weatherized controls, explained in more detail below.

typically fall within a month of each other, although we observe gaps between the complete date and the final close-out date as long as five months. For less than three percent of households, only a final close-out date is reported. For these households we assume that the weatherization work was completed the month before.

[10]We also estimate more highly saturated specifications that include month-by-year-by county and month-by-year-by-billing segment fixed effects.

3.2.2 Randomized Encouragement Design

The paper's primary empirical estimates are derived from an experimental research design. The basis of the experiment is a randomly assigned encouragement intervention that aims to increase the probability of treatment households' participation in WAP through recruitment and significant application assistance. The recruitment and assistance was conducted by FieldWorks LLC, a private company that specializes in running neighborhood canvassing operations and managing outreach campaigns. Importantly, we chose them because they had substantial experience working with low-income populations and their staff had generated millions of phone calls and knocked on millions of doors in previous engagements.

The experimental sample comprised 34,161 households that were both presumptively eligible for WAP and located within the counties served by the two CAAs that we established a close partnership with. Beyond sharing data, these agencies agreed to work with our field staff to process the applications we helped households complete. Approximately one quarter of these households were randomly assigned to our encouragement "treatment." FieldWorks encouraged the treated households to apply for WAP and offered them extensive application assistance. For the remaining households assigned to the control group, we simply observe energy consumption and program participation decisions. The Data Appendix and Fowlie et al. (2015) provide more details on the encouragement and application assistance programs.

The encouragement campaign got underway as ARRA funds began flowing to the implementing agencies. Encouragement activities ran from March to May 2011. Table 1 summarizes our encouragement and enrollment activities in detail. During the encouragement phase, field staff made almost 7,000 initial, in-person house visits.[11] These ground operations were complemented with 23,500 targeted "robo-calls" to raise awareness of both the weatherization program and our encouragement campaign.

After an initial encouragement phase designed to generate interest in the program, we transitioned to an enrollment phase, which lasted through February 2012. The application process requires households to provide extensive documentation, including utility bills, social security cards

[11] Most- but not all- houses assigned to the treated group were contacted. A small fraction were deemed inaccessible (e.g., because of a locked gate).

for all household members, and the deed for the house. Further, a minority of applicants were required to provide further documentation or to correct something on their initial application. Our staff made over 9,000 personal phone calls to provide assistance and to coordinate in-person meetings. Over the course of 2,720 home visits, our field staff helped individuals assemble documentation and complete paperwork. In some cases, our field staff provided transportation to and from the program agency offices.

The final row of Table 1 reports that we spent around $475,000 on the encouragement or a little more than $55 per household in the treatment group. It is noteworthy that we did not initially intend to devote such extensive efforts and resources to the encourage and enrollment phases. However, the early results suggested that we were failing to have a substantial impact on applications and concerns about the ultimate precision of our estimated treatment effects motivated us to raise additional funds to expand the share of treated households.[12]

We use the random assignment to encouragement as an instrumental variable for weatherization status. In a first stage, we use OLS to estimate:

$$\mathbf{1}\{WAP\}_{imt} = \theta \mathbf{1}\{Encouraged\}_{imt} + \delta_{im} + \delta_{mt} + \eta_{imt}, \tag{2}$$

where the dependent variable is as described in the previous subsection. The indicator variable, $\mathbf{1}\{Encouraged\}_{imt}$ is set to zero for all households prior to the encouragement intervention. After March 2011, this indicator switches to 1 for the 25% of the households randomly assigned to the treatment group.

We substitute $\mathbf{1}\{W\hat{A}P\}_{imt}$ from the estimation of equation (2) to fit equation (1) and obtain $\hat{\beta_{IV}}$. In this instrumental variables (IV) framework, $\hat{\beta_{IV}}$ is identified using the exogenous variation in program participation that is generated via the random assignment of encouragement.

If there is heterogeneity in how weatherization retrofits impact residential energy consumption, the expectation of unbiased quasi-experimental and experimental estimates of β need not be

[12] On the one hand, our encouragement costs may have been higher than necessary. To our knowledge, ours was the first encouragement program for WAP, and we learned by doing. On the other hand, the costs in Table 1 do not reflect the time that the research team devoted to overseeing the encouragement effort.

equivalent. Our quasi-experimental approach is designed to provide an estimate of the average treatment effect on all treated households (ATET), or an average across the full distribution of treatment effects. In contrast, the randomized encouragement design estimates the so-called local average treatment effect (LATE), or the average effect for the subset of the population who must be encouraged to participate in the program (i.e., the compliers) (Angrist, Imbens, and Rubin, 1996). In other words, significant differences in the quasi-experimental and experimental estimates could be due to bias in the former or differences in the LATE and ATET.

4 Data Sources and Summary Statistics

4.1 Data Sources

The data collected to support this analysis correspond to two overlapping groups of households. The first group comprises the 34,160 households in our experimental sample drawn from the counties served by two agencies. The second group of households corresponds to our quasi-experimental research design. As this design did not require the same degree of coordination with our agency partners, we were able to expand the scope of this sample by collecting detailed data from three additional implementing agencies. The quasi-experimental sample includes the 7,304 households that applied for weatherization assistance at these five agencies. The quasi-experimental sample is smaller overall but has a larger number of applicants and weatherized households, relative to the experimental sample. The two groups overlap as 1,773 applicant households are also part of our experimental sample.

4.1.1 Energy Consumption Data

We obtained monthly natural gas and electricity consumption data over the period June 2008 to May 2014. This period includes at least two years of pre-retrofit data for all weatherized households in our sample.[13] The utility data track monthly kilowatt-hours (kWh) of electricity and thousand cubic feet (Mcf) of gas used at the dwelling. We convert both of these variables to million British

[13] We identify a household as a particular account number at an address. For a small number of addresses, we have data on multiple accounts if one household moved out and another moved in.

thermal units (MMBtu) using the standard conversion factors employed by the WAP program.[14]

Energy consumption records obtained from the utility are merged with households in our experimental sample and the applicant data obtained from the five implementing agencies. Data are merged using detailed name and address information. Not all households find an exact match in consumption records. Match rates are 85% and 69% in our experimental and quasi-experimental samples, respectively. The higher match rate in our experimental sample is to be expected; when selecting this sample we focused exclusively on zip codes within the territory of our partner utility.

4.1.2 Energy Efficiency Measures

The primary output of the household-level energy audits, which are part of the WAP implementation as described above, is the list of energy efficiency measures for which projected energy savings exceed costs. These are the measures that are eligible for implementation through WAP. In addition to the household-specific list of recommended measures, we also acquired the work summaries that are filed after the work at each house is completed. These data allow us to confirm that the recommended measures were installed and to compare realized costs with projections.

4.1.3 Indoor Temperature Data

Two years after the encouragement effort was initiated, we randomly selected a subset of weatherized and unweatherized households for a field survey. These households were selected from the quasi-experimental sample. The primary purpose of the survey was to collect measurements of thermostat set points and indoor temperatures that can be used to test for a direct "rebound effect."

Michigan field staff attempted to contact 6,400 households on cold days (projected maximum temperature below 45 degrees Fahrenheit) in March and early April 2013. Survey questions were

[14]We also reconfigure the data to account for the fact that consumption records correspond to billing cycles or segments versus calendar months. The utility assigns households to one of 21 billing portions. In a given month, each portion maps to a different set of calendar days. For example, one household's June bill may reflect consumption in all of June, whereas another household's June bill captures the last half of May and the first half of June. The utility provided us with a detailed mapping of billing segments to calendar days over the duration of our study period. For each customer and for each billing cycle, we divide meter reads evenly across days in the cycle. These "meter-day" measures are then aggregated by calendar month to construct estimates of monthly consumption at the household. We also estimate regression equations that include month-by-year-by-billing segment fixed effects using unadjusted data. Coefficient estimates are unaffected.

designed to collect information about thermostat set points and, where applicable, household's experience with weatherization. With the homeowner's permission, surveyors entered the home, closed the door, moved to the center of the room, and recorded multiple indoor air temperature measurements using two different thermometers. Of our initially targeted sample, surveyors spoke with 1,658 homeowners. Of these, 899 allowed us to enter their homes and record their thermostat set point and 688 allowed us to close the door, and collect two or more indoor thermometer readings. We obtained thermometer readings from a slightly larger share of the weatherized households in the survey compared to households that did not participate in WAP.

4.2 Summary Statistics

Table 2 summarizes pre-treatment information on the households in both the RED and quasi-experimental samples. The top panel summarizes monthly energy consumption during the two years immediately preceding the treatment period. The first two columns summarize means for the randomized encouragement and experimental control groups, respectively. The third column reports differences between the treatment and control groups as well as the standard error of the difference (in parentheses).

There are seasonal patterns in energy consumption that differ for natural gas and electricity. Across all groups, winter natural gas consumption (which is dominated by space heating) is significantly higher than summer gas use (comprised primarily of hot water heating and cooking). Electricity usage, also measured in MMBtu, is fairly consistent across seasons.[15]

Because households in the experimental sample were randomly assigned to the encouraged and control groups, it is unsurprising that differences in pre-March 2011 natural gas and electricity consumption across these two groups, reported in column 3, are all small and statistically indistinguishable from zero. The table also provides an opportunity to judge the credibility of the comparisons that underlie the quasi-experimental estimates that complement the paper's experimental estimates. The fourth column reports on all weatherized households in the territory covered

[15]Overall, the lower income households in our sample consume less energy on average than the typical household served by our partner utility. In our sample, average monthly natural gas consumption is approximately 7.33 MMBtu. Across the entire service territory, the annual residential natural gas consumption averages 7.75 MMBtu per month.

by the five community action agencies that provided us with data. The fifth column summarizes households in these territories that applied for weatherization but had not received weatherization assistance as of April 2014. In practice, the variation in the weatherization dates means that the identification of the quasi-experimental estimator is not just based on comparisons between the samples summarized in columns (4) and (5), but also relies on within household comparisons. It is nevertheless informative to compare these two sets of households.The mean differences in column (6) show that weatherized households have historically consumed significantly less natural gas than the unweatherized applicants during both winter and summer months

Panel B of Table 2 summarizes the detailed demographic information and dwelling characteristics that are collected for most clients as part of the application process and also documents important differences between the weatherized and unweatherized applicant subsamples. Our summary of these variables focuses exclusively on program applicants because these data are not available for the majority of households in the experimental sample that did not apply to the program. Weatherized households have higher incomes in an absolute and relative sense as compared to unsuccessful applicants.[16] Weatherized households also report having more children, are more likely to report an elderly resident, and are more likely to use natural gas as their primary heat source. They are less likely to report a disabled resident.

The significant differences between the weatherized and unweatherized applicants motivate us to re-weight observations in the control group so that observable factors are distributed similarly in the weatherized and unweatherized applicant groups. Although our preferred specifications includes household-by-month-of sample fixed effects that control for all time invariant differences between households, we are concerned that observable fixed differences might be correlated with time-varying differences. We use an estimated propensity score to balance covariates that presumably play a role in determining program take-up. Section 10.2 provides exact details on the participation equation but the set of controls includes income, demographics, and levels and trends in energy

[16]Program eligibility is based on the household's income, relative to the poverty line. The Census Bureau definition of the poverty line varies by family size and composition. To qualify for the program, a household's income cannot exceed 200% of poverty. Applicants fall well below this threshold on average. In addition to having higher incomes, applicants who ultimately receive weatherization are farther above the poverty line than the unsuccessful applicants.

consumption.[17]

Appendix Table 1 summarizes some of the detailed information collected during the household energy efficiency audits. The entries are based on 1,638 households or roughly 75% of the households that participated in WAP in the quasi-experimental sample.[18] A typical weatherization retrofit involved several measures such as furnace replacement (34% of retrofits), attic insulation (85%), wall insulation (44%), and infiltration reduction (76%). The NEAT model predicts that on average these investments will reduce natural gas consumption by 46% and electricity consumption by 15%. The average project involved over $5,100 in total expenditures. This includes materials, labor, and construction costs, but does not include any program overhead. Using a 3% discount rate, the projected net present value of energy bill savings average $10,689. The average projected savings:investment ratio (across measures) exceeds 2:1.

5 Results

5.1 Quasi-Experimental Estimates of Energy Savings

Table 3 presents the quasi-experimental estimates based on the estimation of equation (1). The dependent variable in all regressions is the log of monthly energy consumption (i.e., the sum of electricity and natural gas both measured in MMBtu). The first two columns use data from all weatherization applicants, with the second specification allowing time period effects to vary across counties. Columns (3) and (4) trim the sample to obtain estimates that are more directly comparable to the experimental estimates. Specifically, this sample is limited to the implementing agencies that participated in the experiment and to applicants that applied after the encouragement intervention was initiated. Columns (5) and (6) report estimates comparable to columns (1) and (2) reweighted by the propensity score.[19] All specifications include household-by-month fixed effects

[17] Reassuringly, none of the differences in average covariate values across weatherized households and propensity-score weighted controls are statistically significant.

[18] Only 1,638 of the NEAT data files could be confidently matched with weatherized households (leaving 436 weatherized households in our data with no match in the NEAT audit data). We applied fairly strict matching criteria so as not to mismatch weatherized households with audit information. Occupant names were often not included in the audit files. Addresses appear to have been miscoded in several instances.

[19] Because some of the covariates included in the propensity score estimating equation (e.g., reported disability and number of children) are not reported by all households, this sample is somewhat smaller.

and standard errors are clustered by household in all specifications.

The first row in Table 3 reports the estimated average treatment effect. Across the columns, the estimates suggest that WAP participation reduces energy consumption by roughly 8-10%. This is the first indication that the realized savings from the WAP-induced energy efficiency investments are substantially smaller than the projections from the engineering model. These estimated energy savings are approximately 25% of projected savings (measured in mmbtu).

Figure 2 provides another perspective on the results in Table 3. Specifically, this figure reports on the estimation of a version of the column (1) specification, except the weatherization indicator is interacted with indicator variables for each of the potential quarters before and after weatherization was completed (the time zero effect captures energy consumption in the month of weatherization). We also interact the quarter indicators with heating degree days (HDD) and HDD squared, to account for the fact that weatherization retrofits may lead to higher energy savings during colder quarters.[20] The figure then plots the coefficients on the quarter dummy varaibles plus the coefficients on the HDD and HDD squared variables multiplied by the average HDD and HDD squared in our data. We also plot 95% confidence intervals associated with these coefficient sums. The decline in energy consumption is apparent and seems roughly constant throughout the period of our study.

Panel B of Table 3 computes the present value of the estimated energy savings under alternative assumptions about investment time horizons and discount rates. To express the estimates of monthly energy savings in dollar terms, we first construct estimates of fuel-specific savings (see Appendix). We use these estimates to construct fuel-specific savings in percentage terms. Estimates of average monthly natural gas savings are multiplied by the product of monthly gas consumption in the control group and the residential retail price of natural gas in Michigan in 2013 (EIA, 2015).[21] Similarly, average 2013 electricity savings (in percentage terms) are multiplied by the

[20] Heating degree days reflect the difference between the outdoor temperature and a base temperature of 65° F. A day's HDD equal zero for days when the hourly temperature exceeds 65° F for all hours of the day. It is equal to a weighted difference between 65° F and hourly temperatures when the temperature dips below the base. Weights are determined by the share of hours at each temperature. Quarterly HDDs sum daily HDDs over all days in the quarter.

[21] The average retail price of natural gas in Michigan in 2013 was $10.46/MMbtu (expressed in $2013). This is higher than the average price charged by this utility over the entire treatment period ($7.98/MMBtu). Natural gas prices were at historic lows over this period, so using the observed average price would likely underestimate the real

product of average monthly electricity consumption in the control group and retail electricity price ($0.11/kWh).[22] Taken together, our estimate of average energy savings is approximately $155 per year.

To compute the net present value of energy savings over the useful life of the improvements, we invoke some additional assumptions. First, we rely on the NEAT simulation program's assumptions about measure-specific lifespans. These projected lifespans range from 3 years (for a furnace tune-up) to 20 years (for attic insulation). The energy savings-weighted average lifespan for installed measures in our dataset is 16 years. In the table, we report discounted benefits with assumed lifespans of 10, 16, and 20 years. We also assume that the effect of weatherization on energy consumption - and real energy prices - do not vary over the life of the measure. Discounted benefits are calculated at discount rates of 3%, 6%, and 10% (see columns).

The energy savings are small relative to the upfront costs. The nine estimates of the present value of the savings range from just below $1,000 (high discount rate and short time horizon) to about $2,300 (low discount rate and long time horizon). These estimates are between 20% and 45% of the average upfront cost of the energy efficiency retrofits.

5.2 Experimental Estimates of Energy Savings

5.2.1 First-Stage: Program Take-Up

It may seem straightforward to encourage households to participate in a program that provides free efficiency retrofits worth an average of approximately $5,000 that are designed to significantly reduce energy expenditures. In our experience, that was hardly the case. The impact of reducing barriers to participation (e.g., information and process costs) on program uptake is of independent interest both to policymakers and researchers. This section evaluates the impact of our intervention on a multi-stage participation process.

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prices that will prevail over the life of these investments. Prices in 2013 are somewhat lower than the average real prices over the period 2000-2013. The shale gas boom has arguably ushered in a new domestic price regime, such that a longer average real price will overestimate future prices.

[22]The NEAT program audits assume an electricity price of $0.11/kWh and a natural gas price of $11.46/MMBtu. The higher gas price is presumably based on 2006 prices which averaged around $11.50/MMBtu in this service territory in 2006.

Table 4 summarizes program take-up at three separate stages. In the first stage, our goal was simply to increase the share of households filing applications. The coefficient estimate in column (1) indicates that the encouragement intervention increased the rate of application to the program by 13 percentage points from the control group mean of 2%.

Once a household's application is approved, the energy audit is the critical next step. Several months can elapse between application approval and energy audit scheduling. Audits are only scheduled when the implementing agency is in a position to hire the construction crews and allocate any other resources needed to implement a weatherization retrofit at the home. Column (2) reveals that the fraction of households who received an energy audit was 5 percentage points higher in the encouraged group (off a base of about 1%). As we discussed above, several factors can explain why so many households that submit an application are not audited, including if the household fails to follow through on requests for more information or if the submitted information indicates that the household does not meet the program's eligibility requirements.

Column (3) of Table 4 documents that the treatment increased the fraction of households that were successfully weatherized by about 5 percentage points, against a 1% rate in the control group.[23] The encouragement treatment is a statistically significant predictor of weatherization, which we will use to instrument for program participation.

The low take-up rates in the encouraged group are quite striking. Program participants recieve substantive home improvements, yet incur no out-of-pocket expenses. All households in the encouraged group received some information about the program via a phone call or door hanger. A majority of households (i.e., those who spoke with our canvassers in person or by phone) received further information about our offer of application assistance. Given that households had detailed, specific information about the program, it seems reasonable to surmise that some combination of high perceived costs of applying for the program, low expectation of an application leading to a weatherization, high unmeasured process costs, and low expected benefits of participating in the program are impediments to WAP participation. In the end, the average cost of encouragement per completed weatherization was about $1,050, which is more than 20% of the average costs of

[23] A small fraction of households get audited but not weatherized, primarily because the auditors deem the home a possible danger to weatherization contractors (e.g., due to the presence of asbestos).

measures installed. See Fowlie et al. (2015) for further details.

5.2.2 Instrumental Variables Estimates of Energy Savings

This section presents the experimental estimates of the impact of weatherization on energy consumption, using random assignment to the encouragement group as an instrument for program participation. Figure 3 provides a graphical overview of this IV design. The broken line shows the cumulative effect of the randomly assigned encouragement intervention on the monthly rate of weatherization, relative to the control group which received no encouragement. This effect increases over time as the treatment households submit applications and receive weatherization assistance. The figure also plots month-by-month estimates of intent to treat (ITT) effects on energy consumption. Conceptually, monthly estimates of the local average effect of weatherization on energy consumption can be constructed as a ratio of the monthly ITT estimates and the corresponding effect of encouragement on program participation.

Panel A of Table 5 summarizes results that relate measures of energy consumption to the WAP participation indicator. In the first two columns, the dependent variable is the log of total energy consumption (MMBtu/month). In the third and fourth columns, the dependent variables are the log of natural gas and electricity consumption, respectively.

The first column reports on the application of one conventional associational approach. Specifically, it reports on the coefficient associated with the WAP indicator from an OLS regression with month-of-sample and household-month fixed effects that is fit to the experimental sample. This specification indictes that WAP participation is associated with a 9.5% decline in energy consumption, which is similar to the quasi-experimental estimate in Table 3.

The IV estimates based on our randomized encouragement design are reported in columns (2) - (4). The estimate in column (2) indicates that WAP participation causes a reduction in monthly energy consumption of approximately 19% among households that were encouraged into the WAP program. The experimental point estimate of energy savings is twice as large the non-experimental estimate. Columns (3) and (4) report local average treatment effects for natural gas and electricity, respectively. Natural gas accounts for 94% of projected savings (measured in

MMBtu), so it is not surprising that natural gas consumption is more significantly impacted by weatherization.[24] Our IV strategy is predicated on an exclusion restriction: we assume that our encouragement activities affected energy consumption only through its effect on participation in the WAP program. To informally test whether the treatment's encouragement activities had a direct effect on energy consumption, we test for an effect of our encouragement activities on the households in the encouraged group that did not receive weatherization assistance. We fail to reject the null of no effect on energy consumption among these households.[25]

Panel B of Table 5 computes the present value of the estimated energy savings under alternative assumptions about investment time horizons and discount rates. The approach we take is similar to that described in section 5.1. One difference is that we cannot directly observe energy consumption in the post-assignment period among compliers assigned to the control group. Instead, we impute the average consumption among unweatherized compliers using average consumption among unweatherized households in the encouraged and control groups, respectively, and the estimated proportion of compliers in the population (reported in Table 4).[26]

As with the quasi-experimental results, the experimentally estimated energy savings are small relative to the projected savings and the upfront costs. Our estimates imply energy savings of 17.2 MMBtu per year, whereas the average projected savings among compliers is 43.7 MMBtu. Our central estimate of the realized average savings per household is roughly $2,400. This is

[24]The coefficient in column (2) is not a weighted average of the gas and electricity coefficients in columns (3) and (4) for two reasonse. First, the samples differ slightly across the columns, and second the coefficients on the fixed effects and other covariates are not constrained to be equal in columns (3) and (4). It is also worth noting that the effect of weatherization on gas consumption is more precisely estimated. This is not surprising, because natural gas consumption is driven primarily by the end uses targeted by weatherization (space and water heating), whereas electricity consumption is derived from many end uses that are unaffected by weatherization (e.g., lighting and appliances).

[25]To conduct this test, we drop all households receiving weatherization assistance from the experimental sample. Using the remaining households, we regress the log of monthly energy consumption on an indicator that equals zero before encouragement activities were initiated and one after they began in March 2011 for all households assigned to the encouraged group. We estimate a precise zero effect which suggests that our encouragement intervention had no effect on energy use in these households and supports the validity of the exclusion restriction. Of course, our exclusion restriction also implies that the encouragement intervention does not directly effect energy consumption among households taking up the weatherization treatment but we cannot test this assumption directly.

[26]In Table 4 we estimate the share of always takers and compliers in the population to be 1% and 5%, respectively. We directly observe the average energy consumption among unweatherized households in the encouraged group (i.e., the never takers) during the post-assignment period. We also observe the average consumption among unweatherized households during the post-assignment period in the control group. As this represents a weighted average of consumption across never takers and compliers, we can impute the average post-assignment consumption among unweatherized compliers. This is the imputed baseline consumption reported in Table 5.

significantly lower than the average net present value of savings predicted by the ex ante engineering analysis which is $9,206 among compliers (and $10,689 averaged across all weatherized households in our data).[27] The nine estimates of the present value of the savings range from approximately $1,450 (high discount rate and short time horizon) to about $3,500 (low discount rate and long time horizon). These estimates are just 32% to 77% of the upfront cost of the energy efficiency measures.[28]

The estimated local average treatment effect of weatherization on energy consumption is approximately twice as large as the quasi-experimental estimate of the average effect among all households receiving weatherization assistance. The Appendix investigates several potential explanations for this difference. We note that there are significant observable differences between the group of complier households in the experimental sample and the weatherized households in the quasi-experimental sample. Adjusting parametrically for these observable differences explains approximately 20% of the discrepancy between the experimental and quasi-experimental treatment effect estimates. The remaining difference in estimated causal effects could be due to unobservable differences between complier households and households that need no encouragement to pursue weatherization assistance. Additional explanations could be that omitted time-varying factors bias the quasi-experimental estimates towards zero or that measurement error in the WAP indicator lead to attenuation bias in the quasi-experimental estimator. Note that the last explanation is consistent with the fact that the estimate in column (1) of Table 5 is comparable to the quasi-experimental estimator.[29] Finally, given that we are using two distinct data sets, the differences in the estimated parameters could be due to sampling variation. We have no way of distinguishing between these explanations.

[27]The average present discounted savings among weatherized households in the control group was projected to be $11,215. The average projected discounted savings among weatherized households in the encouraged group is $9,490. We estimate that compliers account for 85% of weatherized households in the encouraged group. We thus impute that the average projected savings among complier households is $9,206.

[28]To compute these percentages, we use an average cost of $4,550 among compliers. To construct this average, we use our estimate that 85 percent of weatherized households in the encouraged group are compliers. We observe the average cost among always takers in the control group to be $5,123. We interepret the average cost among weatherized households in the encouraged group, $4,636, to be a weighted average across compliers and always takers. Note that the range of the percentages would likely be different if we had household-level estimates of savings and treatment costs.

[29]Results are robust to requiring more and less documentation from the CAAs to define a household as "weatherized." Measurement error could exist, for instance, if there are typos in the CAAs' paperwork.

5.3 Household Reoptimizing Behavior, Building Thermal Properties, and the Welfare Implications of Rebound

In Section 2 we introduced a utility-maximization framework that uses a revealed preference approach to bound the average willingness to pay for any efficiency-induced increase in households' consumption of energy services. In this section, we implement this bounding exercise in three steps.

5.3.1 Does Weatherization Lead to Temperature "Take Back"?

The first step tests for an effect of weatherization on household demand for space heating. Table 6 summarizes the results from our survey of indoor air temperatures and thermostat set points collected during the winter of 2013 at a subset of our quasi-experimental households. All weatherized households surveyed had received efficiency improvements at least one year before the survey was administered, allowing plenty of time for residents to observe the extent to which the weatherization retrofit affected winter heating costs. A total of 899 households allowed our survey team to enter their home to record the thermostat set point, and 688 allowed our surveyors to linger long enough to record the actual indoor temperature. Approximately half of the households for which we have thermostat or temperature data had received weatherization assistance (453/899 and 349/688). Anticipating some measurement error, we used two different devices to measure indoor temperatures at each home.

Table 6 reports results from regressing thermometer readings and thermostat set points on a binary variable indicating whether the household had been weatherized.[30] Columns (1) and (3) report results from our base specification. Survey respondents comprise a non-random subset of our sample as only a fraction of the targeted household were home and/or willing to open the door to receive our surveyors. Further only 41% of households who opened the door to our surveyors allowed us to come in and collect temperature measurements. Because we observe differences between survey respondents and the larger sample, we also estimate specifications where survey household observations are weighted to match the covariate means in the larger quasi-experimental sample

[30] If surveyors recorded temperatures from both devices, the temperature specifications include two measurements per household. Standard errors are clustered at the household level.

of weatherized households.[31] These results are reported in columns (2) and (4). All specifications control for the outdoor temperature on the day of the survey, measured by heating degree days (HDD).

Columns (1) and (2) show that, after controlling for outdoor temperatures, indoor temperatures may be slightly warmer at weatherized households. The point estimate suggests an increase of 0.65 degrees. This effect is imprecisely estimated; we fail to reject the null of zero. The coefficient associated with the HDD variable is statistically significantly negative in the temperature specifications, suggesting that indoor temperatures measure lower on colder days. Although we asked surveyors to wait several minutes before recording temperatures, this finding suggests that cold air brought with the surveyor could be affecting the measurements.[32] Because the standard errors of our estimates do not allow us to reject a small increase in indoor temperatures, we will estimate an upper bound on possible welfare gains using an estimated increase in temperature of 0.65 degrees based on the point estimate in Column (2).[33]

In contrast, Columns (3) and (4) suggest that weatherized households set their thermostats lower, on average, by approximately 0.6 degrees F. This is inconsistent with a rebound in demand for indoor heat. One possible explanation is that retrofits, by reducing cold air infiltration, allow households to maintain the same (or slightly higher) levels of indoor comfort at lower thermostat set points.

[31] For both the thermostat set point and indoor temperature samples, we developed pairwise comparisons of observable household and dwelling characteristics across weatherized and unweatherized surveyed households and the larger quasi-experimental sample. The surveyed sub-sample is observationally similar among most - but not all - dimensions. For example, for both dependent variables, survey respondents are significantly more likely to report having children or elderly family members, less likely to be unemployed, and are more likely to use gas as their primary source of heat, as compared to the larger quasi-experimental sample. Among unweatherized households, surveyed households tend to be larger.

[32] Notably, our estimated constants in columns (1) and (2) minus approximately 5° F, recognized by engineers as a typical internal heat gain (e.g., from body heat), is equal to the base temperature of 65° F used in standard HDD calculations.

[33] The positive coefficient on the weatherization dummy in columns (1) and (2) appears sensitive to outliers in our data, which may reflect coding errors by our survey team. For example, when we trim the sample by excluding the top and bottom 5% of the observations, the coefficient on a specification equivalent to column (4) is 0.01 (standard error = 0.27). The results on the thermostat set point are not sensitive to data trimming.

5.3.2 Building Energy Performance

In order to estimate how a given increase in demand for indoor space heating translates into an increase in monthly gas consumption, we need to estimate the thermal properties of a representative building. We use the so-called "degree day method" to model the energy required to increase temperatures in an average home in our data (Thorpe, 2013) . Heating degree days (HDDs) measure the difference between outdoor temperatures and a temperature that people generally find comfortable indoors. In the literature that analyzes energy use in buildings, it is common to assume a linear relationship between energy consumption and this difference (e.g., Friedman, 1987; Dyson et al., 2014). We find empirical support for this assumption in our setting. We use this estimated relationship between HDD and monthly energy consumption to estimate the effect of increased demand for indoor temperatures on energy consumption. This approach assumes that a household's choice of the indoor temperature is independent of outdoor temperatures, thus outdoor temperatures are a valid proxy for the desired level of heating services.[34]

In residential buildings where building envelope losses are the major determinant of heating energy requirements, it is standard to summarize the technical relationship between energy consumption and heating demand by regressing energy consumption on HDDs. Specifically, we estimate the following equation:

$$C_{imt} = \alpha_i + \beta_1 \mathbf{1}\{WAP\}_{imt} + \beta_2 HDD_{mt} + \beta_3 HDD_{mt} * 1\{WAP\}_{imt} \tag{3}$$

$$+\beta_4 HDD^2_{mt} + \beta_5 HDD^2_{mt} * 1\{WAP\}_{imt},$$

where C_{imt} measures the natural gas consumption at household i in month m and year t. We estimate this equation using data collected from program applicants during winter months (September-March) over the entire sample period. Panel data allow us to include household-level fixed effects in this regression. We include both a linear and a quadratic HDD term, allowing each coefficient to vary with weatherization status, as well as a separate intercept for WAP participating

[34] Note that this assumption is consistent with the results in Table 6 which fail to reject that there is no relationship between HDD and thermostat set point.

households.

All of the estimated coefficients in equation (3) are highly statistically significant and very precisely estimated. The R-squared value is 0.73. Figure 4 summarizes the relationship between energy consumption (during winter months) and HDD separately for weatherized and unweatherized observations. This figure is analogous to the bottom panel of Figure 1 (flipped into the top quadrant).

The estimated slope of the relationship is less steep among weatherized homes. That is, weatherizations effectively reduce the marginal cost of indoor space heating during the winter. Moreover, it is noteworthy that this relationship is approximately linear though we estimated quadratic terms.

5.3.3 Bounding the Average Valuation of Increased Indoor Heat

This subsection implements an approach to bounding the welfare gain from higher indoor temperatures. The product of the slope of the relationship between natural gas consumption and HDD (depicted in Figure 4) and the average natural gas price in the post-encouragement period provides a measure of the the marginal cost of gas heating. Among unweatherized households, this product is equal to approximately \$0.072 per heating degree day (or \$2.17 per heating degree month). The analogous calculation for weatherized households lead to an estimated marginal cost of \$0.056 per heating degree day (or \$1.67 per heating degree month). This implies that weatherization led to a reduction in the marginal cost of approximately 20%.[35]

These estimates of the marginal costs of heating among weatherized and non-weatherized households can be combined with the estimated 0.65 degree increase in indoor temperatures (see Table 6, column (2)) to bound the average welfare gain from weatherized households' reoptimization.[36] The lower bound of households' valuation of the higher temperatures is given by 0.65°F * \$1.67/degree-month or \$1.09 per winter month. At this lower bound, the utility gains from increased warmth

[35]These estimates of incremental heating costs are comparable to a "rule of thumb" popularized by the American Council for an Energy-Efficient Economy. This rule states that a household will pay approximately 3% on their gas bill for a degree increase in winter thermostat settings (see, for example, http://www.improvenet.com/a/5-easy-ways-to-lower-your-gas-bill-during-the-winter). Average natural gas bills during winter months are \$85.95 and \$57.96 at unweatherized and weatherized homes, respectively.

[36]Because the relationship between heating services and energy consumtpion is approximately linear, the average temperature increase yields the average willingness to pay for heating services.

are exactly offset by the increase in the energy expenditures incurred to achieve the temperature increase, implying a zero gain in welfare. To define the upper bound, we note that by revealed preference, unweatherized households chose not to pay 0.65°F * $2.17/degree-month or $1.41 per winter month to achieve this incremental increase in temperature. It follows that average marginal benefits from this temperature increase cannot exceed $1.41 per winter month. Since increasing indoor temperatures by 0.65 °F costs the average weatherized household $1.09 per winter month, the average net gain from the weatherization-induced increase in warmth does not exceed $0.32 per winter month. Assuming 6 full winter months in Michigan, this implies an upper bound on the annual welfare gain of roughly $1.92 from higher indoor temperature. In sum, this bounding exercise suggests that the welfare gains from any efficiency-induced rebound in heating demand are very small, likely less than 0.1% of the energy expenditure savings. Put another way, the efficiency induced rebound in demand for indoor heating appears to be inconsequential in this setting. Our methodology also allows us to calcualte the potential welfare gains from much larger increases in indoor temperatures. Note that even a 10 degree F increase in indoor temperatures would lead to a welfare gain of less than $30 per year.

6 Interpretation

This section evaluates the returns to energy efficiency investments in residential retrofits from private and social perspectives. We also provide an alternative summary measure of cost effectiveness, which is the cost per ton of carbon abated. To conduct this part of the analysis, we use the experimental estimates of the effect of weatherization on energy consumption to estimate average energy savings.

6.1 Returns on Residential Energy Efficiency Investments

Panel A of Table 7 evaluates the internal rate of return (IRR) on investment from a private perspective. More precisely, we report the discount rate at which the discounted value of average avoided energy expenditures exactly equals the average upfront investment. While these investments were free to participating households, it is nevertheless informative to estimate the private returns if households had been responsible for the upfront costs because most households that consider the exact same investments do not qualify for WAP. That is in the broader population, the IRR is a critical factor in determining take-up of energy efficiency investments.

Column (1) computes the internal rate of return using the average upfront investment costs[37] and the average reductions in annual energy expenditures projected by the WAP program audit. These savings are monetized or valued by using the average retail residential natural gas and electricity prices in 2013 as reported by the EIA.[38] Over a range of time horizons, the estimated IRR is quite high, as they should be given the investment rule that required projected savings exceed costs. The rate of return associated with the savings-weighted average lifespan (i.e., 16 years) is approximately 12%. By this measure, efficiency investments supported under WAP appear to be very attractive investments that greatly exceed typical returns available in equity, real estate, and bond markets.

The second column of Table 7 replaces the projected savings with an estimate of realized welfare benefits. This is calculated as the sum of the actual energy savings (in monetary terms), derived from the randomized encouragement design, and the estimated upper bound of the monetized value of the net welfare gain from higher indoor temperatures.[39] The estimate of realized savings is about \$235, which is only 36% (=\$235/\$651) of the average projected annual monetary savings.[40] When the upper bound of the monetized value of the higher indoor temperatures is added to the energy savings, the annual benefits are roughly \$237. Using this measure of annual benefits, the IRR is -10.5% for the 10 year horizon, -2.2% for 16 years and 0.3% for 20 years. This finding of low, indeed

[37]The upfront investment costs are calculated as the imputed average installation, construction, and materials costs among compliers.

[38]The average monthly residential gas price in Michigan is \$10.46/MMBtu. The average residential electricity price is \$0.11/kWh.

[39]By adding the upper bound, we use a generous estimate of the welfare gain associated with heating demand rebound as the lower bound is zero. Because the estimated rebound effect is so small, the decision to use the upper versus lower bound estimate has little impact on these calculations. It is important to note that there may be additional benefits and costs to households that received weatherization assistance that are not reflected in increased indoor air temperatures. For example, consumers may realize health benefits associated with reduced draftiness. At the same time, there are speculations in the public health literature that the program may increase health risks as less drafty homes may trap indoor air pollutants such as radon.

[40]The experimental estimate of average energy savings (measured in MMBtu) is 39% (17.2 MMBtu/43.7 MMBtu) of projected energy savings. This is modestly larger than our estimate of the ratio of realized annual monetary savings to projected annual monetary savings, because 2013 energy prices are modestly lower than the prices assumed by the audits.

negative, returns suggests that, at least for residential home retrofits, there may not be much of an efficiency gap to explain as investments with these returns are infrequently taken-up in the broader economy.

Panel B conducts a similar exercise but adds the value of avoided emissions to the benefit side. Avoided emissions of CO_2 are valued at \$38 per ton of (Greenstone et al., 2013). Nitrogen oxide and sulfur dioxide emissions from residential gas consumption are valued at \$250 per ton and \$970 per ton, respectively (Muller and Mendelsohn, 2009).[41] The IRRs for the 10, 16, and 20 year horizons are -8.8%, -0.8%, and 1.5%, respectively.

The societal perspective is an especially important one to judge these investments, because a wide set of policies encourage residential energy efficiency investments. Panel C reports estimates of the social internal rate of return that are calculated by using the social value of avoided fuel consumption, rather than the retail prices, to monetize the energy savings and adding the monetized value of the avoided emissions (as in Panel B). The retail electricity and natural gas prices used in Panels A and B include a fixed cost component that covers connection costs; these fixed costs are not avoided when efficiency investments reduce residential natural gas and electricity consumption (Davis and Muehlegger, 2010). Since most electricity and natural gas distribution utilities are subject to cost-plus regulation, the fixed costs recovery will be shifted to other customers; thus, households that reduce energy consumption receive a transfer from other households. We use the average of the 2013 spot prices (\$3.73/MMBtu) set at the Henry Hub distribution point, a standard reference price for natural gas in North America, to reflect the true marginal cost of natural gas over the lifetime of the measures.[42] To value reductions in electricity consumption, we use the average wholesale electricity price in the midwest electricity market.

These adjustments lead to a meaningful decrease in the IRR, relative to the IRRs in Panels A and B. For example, the social IRR for the 16 year time horizon is -9.5%; it is -20.0% and -6.1% for

[41] We assume that burning natural gas emits 116.39 lbs CO_2 per mmbtu, 0.092 lbs NOx per mmbtu, and 0.000584 lbs SO2 per mmbtu. We assume a marginal operating emissions rate of 0.916 lbs CO_2 per kWh in the Midwest power sector (Callaway et al., 2015). Sulfur dioxide and nitrogen oxide emissions from residential natural gas consumption are monetized using the median marginal damage estimates in (Muller and Mendelsohn, 2009). NOx and SO2 emissions from electricity generation are subject to a (barely) binding cap.

[42] This is lower than the average gas recovery charge reported by the utility in regulatory proceedings over the post-weatherization period (\$5.54), but the utility's recovery charge rolls in contract positions.

the 10 and 20 year horizons, respectively. Overall, these residential energy efficiency investments have a negative rate of return across all reasonable time horizons.[43]

An alternative method to summarize the return on WAP energy efficiency investments is to estimate the cost per ton of CO_2 avoided. This is calculated as the ratio of the net cost of the investments (i.e., the annual rental cost of the upfront investment less the value of annual energy savings) and the tons of CO_2 emissions reduced per year. Panel D uses a 3% discount rate to calculate the annual rental cost of capital, while Panel E uses 7%. Both panels report results based on assumptions of 10, 16, and 20 year lifespans for the investments and use wholesale energy prices as above.

As in Panels A through C, the conclusions differ starkly depending on whether one uses *projected* or *realized* energy savings. Using projected energy savings values generated by the NEAT program audits and the 16 year lifespan, the cost per ton of CO_2 avoided is -$19 with a 3% discount rate and $14 with a 7% discount rate. With these estimates, the energy efficiency investments would be judged beneficial because they are less than the United State Government's offical value of the social cost of carbon (i.e., the monetized value of the avoided damages from a ton of abated CO_2 emissions) of $38. Indeed, the Panel D cost of -$19 supports the claims that energy efficiency investments are win-win because the engineering estimates suggest that it is possibly to simultaneously reduce households' energy costs and carbon emissions.

However, the estimates that are based on actual energy savings again tell a different story. When the experimental estimates of actual natural gas and electricity savings are used in column (2), the analogous costs per ton of CO_2 avoided are $329 (3% discount rate) and $484 (7% discount rate). These costs exceed the United States Government's social cost of carbon by roughly an order or magnitude, suggesting that, at least in this study's context, residential energy efficiency investments are an inefficient approach to mitigating climate change.

[43] An alternative approach would be to calculate the social internal rate of return from the government's perspective. This approach would require accounting for the social cost of public funds, administrative costs of the program, and costs of the encouragement design.

6.2 What Explains the Low Rate of Return on These Efficiency Investments?

It is natural to ask why the returns to residential energy efficiency investments are so low. After all, WAP is designed so that the only measures implemented are ones with projected savings to costs ratios greater than one.

An important factor leading to negative returns on investment is the incomplete realization of projected energy savings. The projected savings are about 2.5 times the preferred experimental savings estimate. Further, the projected savings are roughly 4 times the quasi-experimental estimates of energy savings. There are relatively few ex-post estimates in the academic peer-reviewed literature, with Davis et al. (2014) and Dubin et al. (1986) serving as notable exceptions.[44] Both of those papers similarly find low realization rates, although they largely attribute it to behavioral responses (i.e., the rebound effect) which we have shown plays at most a minor role in this paper's setting. Moreover because energy efficiency programs are implemented by regulated utilities, there are a number of regulatory filings that estimate ex post program savings and it is hardly unusual for them to find that the programs deliver estimated savings considerably lower than projected.[45]

Having ruled out the rebound effect as the primary explanation for the gap between projected and realized energy savings, we conclude that the efficiency audit tool must systematically overstate the real returns to these investments. Along these lines, we explore some alternative sources of this bias. First, we compare the distribution of temperatures observed during our study period against the typical weather patterns on which engineering calculations are based. Although we do observe some moderate spells in our timeframe, on average we observe colder than average temperatures and higher than average degree day measures in our sample; these colder temperatures should lead to greater than average savings.

A second potential source of bias concerns the over-statement of baseline energy use. Several studies and utility reports have documented how software-based energy analysis of existing homes

[44] A recent working paper with a nonexperimental design finds that, for residential energy efficiency investments similar to those in the WAP program, projected energy savings are about 2 times larger than actual energy savings (Allcott and Greenstone, 2015).

[45] See, for example, CPUC (2015), which summarizes findings across California programs implemented from 2010-2012 and reports realization rates from below 30% to above 100%, though the estimated savings are mainly derived from observational approaches that produce associational evidence. Findings appear similar in other jurisdictions. An early analysis of several thousand home retrofits in Hood River, Oregon similarly found realization rates below 40% (Hirst, 1987).

tends to over-predict pre-retrofit energy use and retrofit energy savings.[46] Indeed, we found in our data that the NEAT program predicts baseline natural gas consumption that exceed actual consumption by more than 25% prior to weatherization. This suggests that the auditing tool could be under-estimating the efficiency properties of the average home prior to weatherization, which may partly explain the over-statement of the benefits of upgrading to a given efficiency standard.

Overall, our findings suggest that the NEAT audit tool over-estimates returns by a significant margin. Further, this overestimation of savings does not appear to be due to behavioral responses. This is an important finding in its own right; NEAT is widely used by state and local WAP sub grantees, utility companies, and home energy audit firms.[47]

7 Conclusion

We conducted a large-scale randomized encouragement design experiment on a sample of over 30,000 households presumptively eligible for participation in WAP in the state of Michigan. Approximately one quarter of these households were randomly assigned to a treatment group that was encouraged to apply for the program and received significant application assistance. The control households were free to apply for WAP but were not contacted or assisted in any way by our team. We also analyze corroborating evidence from a quasi-experimental analysis covering over twice as many weatherizations as well as a survey of indoor conditions at weatherized and unweatherized homes.

We document three primary findings. First, the aggressive encouragement efforts were disappointing. This encouragement increased take-up rates from less than 1% in the control group to about 6% at a cost of over $1,000 per weatherized household. Second, we find that WAP participation reduced energy consumption by 10-20% among participating households. However, the upfront cost of the energy efficiency investments are about twice the cost of the realized energy savings. Further, the projected savings are about 2.5 times the actual savings. Third, while the

[46]For example, a recent report found that modeling software consistently overestimated energy consumption; mean modeled total annual use was 40% greater than billed use (SBW, 2012).

[47]While more sophisticated building simulation models exist, an appeal of NEAT is that it can be inexpensively used by the thousand of implementers who have a wide range of skills and technical training. Indeed, the DOE cites one of the primary benefits of NEAT as its accessibility to non-technical users (EERE, 2010). While more complex models exist, they are very likely to be more expensive to use.

modest energy savings might be attributed to the rebound effect, when demand for energy end uses increases as a result of greater efficiency, the paper fails to find evidence of economically or statistically signicant increases in indoor temperature at weatherized homes.

Overall, the energy efficiency investments we evaluate are poor performers on average across a variety of metrics. From a household's perspective, the annual internal rate of return that would rationalize these efficiency investments is -2.2%. The household's perspective differs from society's because it fails to recognize the benefits of greenhouse gas and local pollutant emissions reductions and because the retail prices for natural gas and electricity exceed their marginal costs of delivery. Accounting for these two factors, the annual social internal rate of return that would justify these investments is -9.5%, which is even less favorable. Finally, we also calculate the average cost per ton of avoided CO_2 under a range of assumptions. The most plausible estimates are approximately $329/ton, which is about an order of magnitude larger than the U.S. government's estimate of the monetized benefits of avoided emissions (i.e., the social cost of carbon) of roughly $38.

This study demonstrates that the returns to common residential energy efficiency investments are negative both privately and socially among low-income households in Michigan. The results are striking because Michigan's cold winters and the likelihood that the weatherized homes were not in perfect condition suggests that it may have been reasonable to expect high returns in this setting. Regardless of one's priors, this paper underscores that it is critical to develop a body of credible evidence on the true, rather than projected, returns to energy efficiency investments in the residential and other sectors. The findings also suggest that the last several decades may have seen too much investigation into the why of the energy efficiency gap and not enough into whether there really was one.

From a policy perspective, WAP does not appear to pass a conventional cost-benefit test, although its full-set of goals may not be reflected in such tests. On the broader question of optimal climate change policy, this paper's findings indicate that residential energy efficiency retrofits are unlikely to provide the least expensive carbon reductions. Future research should examine whether the real world returns to energy efficiency investments differ so starkly from engineering projections in other settings.

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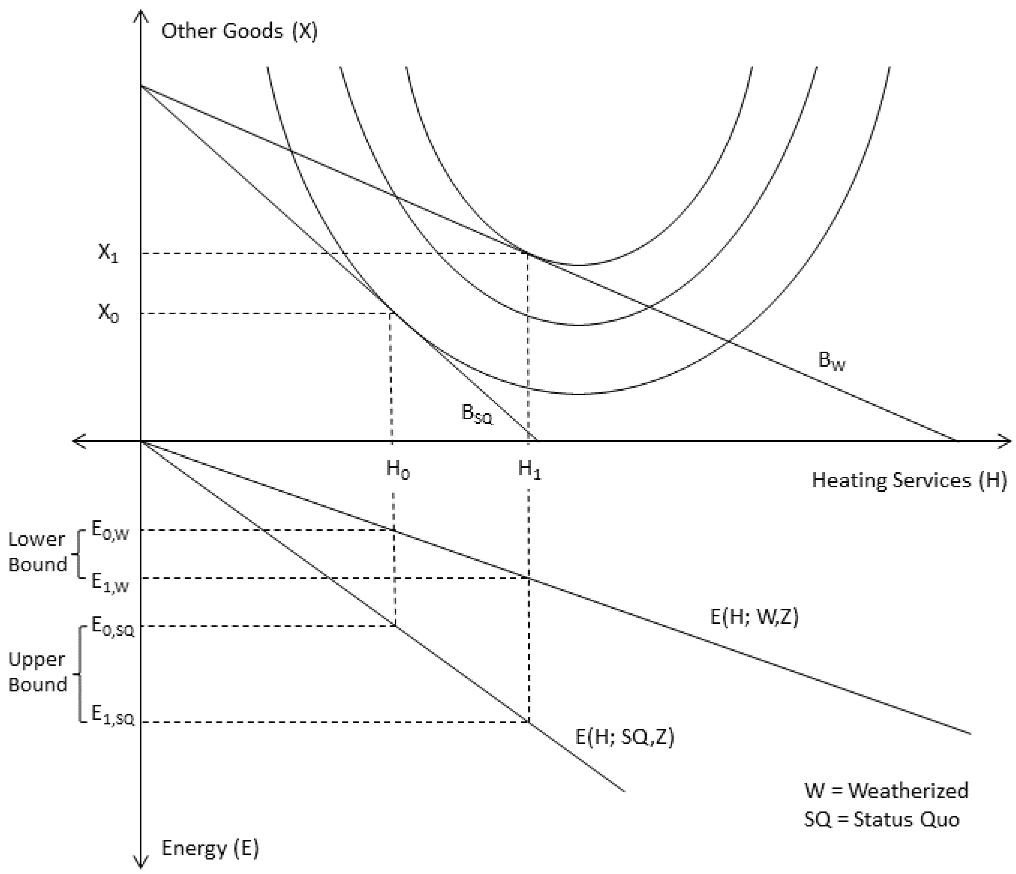
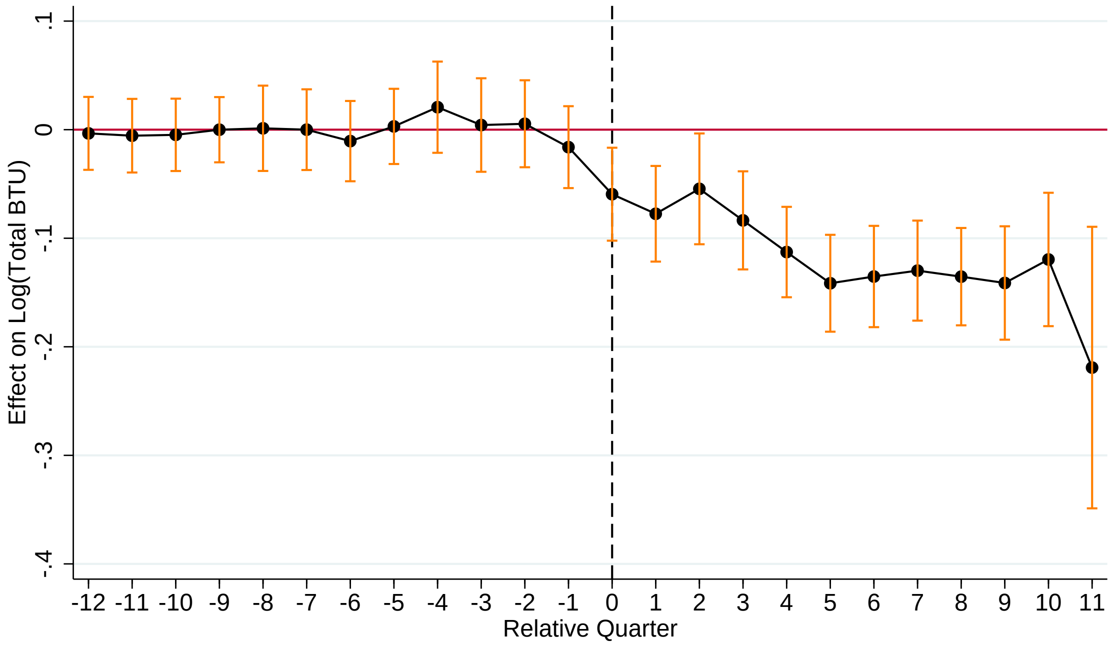
8 Figures

Figure 1: Household-level re-optimization in response to an efficiency improvement



Note: Budget constraints and indifference curves of a representative consumer are plotted in the top quadrant. A linear relationship between heating services and building energy consumption (over a range where heating demand is strictily positive, and heating technology constraints do not bind) are plotted in the bottom quadrant. Please see text for details.

Figure 2: Event study analysis: Matched quasi-experimental sample

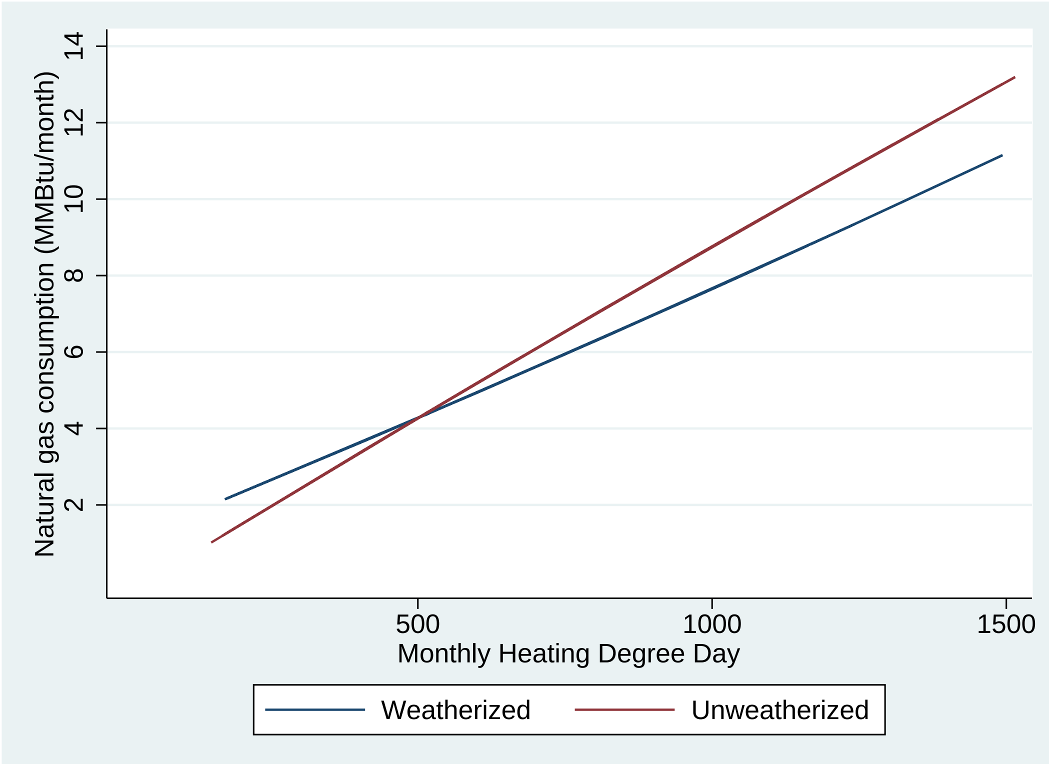


Notes: This figure reports estimated weatherization effects by quarter before and after the weatherization was completed based on the quasi-experimental estimates reported in column (1) of Table 3. The time zero effect captures energy consumption in the month of the weatherization. The effects are also allowed to vary by the realized weather in the quarter. See text for details.

Figure 3: Effect of encouragement on participation and energy consumption

Notes: This figure provides an overview of the local average treatment effect estimates. The broken line tracks the cumulative difference in participation rates across the encouraged and control groups. The circular markers plot the monthly estimates of the intent to treat effects on household energy consumption (in logs).

Figure 4: Building energy performance at weatherized versus unweatherized homes



Notes: This figure plots the estimated relationship between monthly natural gas consumption and heating degree days during winter months at weatherized and unweatherized households, respectively. See Equation (3) in the text.

9 Tables

Table 1: Randomized encouragement intervention

Encouragement activity	
Encouraged group (households)	8,648
Initial home visits	6,694
Robo-calls	23,500
Personal calls	9,171
Follow up appointments	2,720
Average cost/encouraged hh	$55.00

Note: The table summarizes efforts to encourage a group of Michigan households to take up weatherization assistance. These households were selected randomly from a sub-population of households who were located in the service territory of our partner utility and presumptively eligible based on ex ante available income information.

Table 2: Differences in Sample Means Between Groups of Households

	Experimental encouraged (1)	Experimental control (2)	(1) - (2) (3)	All weatherized (4)	Unweatherized applicants (5)	(4) - (5) (6)
Panel A: Pre-treatment period monthly energy consumption						
Winter gas (MMBtu)	10.40	10.38	0.02	9.88	11.63	-1.75**
			(0.07)			(0.16)
Summer gas (MMBtu)	2.84	2.79	0.06	1.80	2.16	-0.36**
			(0.03)			(0.05)
Winter electricity (MMBtu)	2.12	2.10	0.02	2.24	2.30	-0.06
			(0.02)			(0.04)
Summer electricity (MMBtu)	2.17	2.17	0.00	2.23	2.20	0.03
			(0.02)			(0.04)
Panel B: Demographics and dwelling characteristics						
Household income ($)				19,617	17,509	2,108**
						(417.16)
Percent of poverty (%)				115	104	11**
						(1.96)
Household size (#)				2.56	2.47	0.09
						(0.06)
Children (share of households)				0.24	0.15	0.10**
						(0.01)
Reported disability (share of households)				0.04	0.03	0.01*
						(0.00)
Elderly (share of households)				0.23	0.13	0.09**
						(0.01)
Heat with natural gas (share)				0.79	0.57	0.22**
						(0.01)
Age of home (years)				59.15	62.08	-2.93
						(5.34)
Households	7,549	21,339		2,074	2,973	

Note: Columns numbered (1), (2), (4) and (5) report average values. Columns (3) and (6) report differences in means (with standard errors in parentheses). Columns (1) and (2) report sample means for the randomized encouraged and the experimental control groups, respectively. Column (4) reports the sample means for all weatherized households in the quasi-experimental sample while column (5) reports the the sample means for households in the quasi-experimental sample that applied for weatherization but did not receive assistance as of April 2014. Household counts summarize energy consumption data. Panel B focuses exclusively on program applicants because this demographic data is not available for the majority of households in the experimental sample that did not apply to the program.
* Significant at the 5 percent level
** Significant at the 1 percent level

Table 3: Quasi-experimental estimated impacts of weatherization on household energy consumption

Panel A: Dependent variable is monthly energy consumption (in logs)

	(1)	(2)	(3)	(4)	(5)	(6)
WAP	-0.08**	-0.09**	-0.08**	-0.09**	-0.10**	-0.10**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Average consumption control group (MMbtu/month)	8.48 [8.29]		12.20 [10.36]		9.79 [7.32]	
month-of-sample FE	Y	N	Y	N	Y	N
month-of-sample x county FE	N	Y	N	Y	N	Y
P-score matched sample	N	N	N	N	Y	Y
Adjusted R-squared	0.85	0.86	0.83	0.83	0.80	0.81
Households	5,013	5,013	3,334	3,334	3,404	3,404
Observations	282196	282196	183353	183353	188287	188287

Panel B: Present value of (discounted) savings

Time Horizon	Discount rate		
	3 percent	6 percent	10 percent
10 years	$1,321	$1,140	$952
16 years	$1,946	$1,565	$1,212
20 years	$2,304	$1,777	$1,319

Note: Panel A reports estimates of the reduction in monthly energy consumption following weatherization. The dependent variable is the log of monthly household energy consumption (electricity and natural gas) measured in MMBtu. All columns include houshold-by-month-of sample fixed effects. Columns (1) and (2) use data from all weatherization appplicants while columns (3) and (4) use a sample limited to implementing agencies that participated in the experiment as well as applicants that applied after the encouragement intervention was initiated. Columns (5) and (6) report estimates comparable to columns (1) and (2) reweighted by the propensity score. Standard errors (in parentheses) are clustered at the household level. Panel B reports the net present value of energy savings implied by the preferred estimate reported in column (6). Reductions in energy bills associated with the estimates in column (6) are assumed to accrue over the life of the measure using a range of discount rates and assumed time horizons.

* Significant at the 5 percent level

** Significant at the 1 percent level

Table 4: Randomized encouragement: return on effort

	Application (1)	Efficiency audit (2)	Weatherization complete (3)
Base Rate	0.02**	0.01**	0.01**
	(< 0.01)	(< 0.01)	(< 0.01)
Encouragement	0.13**	0.05**	0.05**
	(< 0.01)	(< 0.01)	(< 0.01)
Households	28889	28889	28889

Note: The table shows the effect of our encouragement on program applications, efficiency audits, and weatherization. Indicators of program participation status are regressed on an encouragement indicator and a constant. The unit of observation is a household.
* Significant at the 5 percent level
** Significant at the 1 percent level

Table 5: Experimental estimated impacts of weatherization on household energy consumption

Panel A: Dependent variable is monthly energy consumption (in logs)

	Total Energy		Gas	Electricity
	(1)	(2)	(3)	(4)
	OLS-FE	IV-FE	IV-FE	IV-FE
WAP	-0.10**	-0.20*	-0.21**	-0.10
	(0.01)	(0.08)	(0.08)	(0.10)
Imputed baseline consumption MMbtu/month	7.52		6.38	2.19
F-statistic	.	267.41**	260.10**	266.78**
Households	27,990	27,229	26,054	27,115
Observations	1662781	1653583	1528526	1638337

Panel B: Present value of (discounted) savings

Time Horizon	Discount rate		
	3 percent	6 percent	10 percent
10 years	$2,003	$1,728	$1,443
16 years	$2,949	$2,373	$1,837
20 years	$3,493	$2,693	$1,999

Note: Dependent variable measures log of monthly household energy consumption. Panel A reports regression coefficients. With the exception of the first column, all specifications are estimated using 2SLS. Standard errors (in parentheses) are clustered by household. Panel B reports the net present value of energy savings implied by the savings estimates in columns (3) and (4) using a range of discount rates and assumed time horizons. Reductions in energy bills associated with the estimates are assumed to accrue over the life of the measure. All regressions include month-of-sample and household-month fixed effects.

* Significant at the 5 percent level

** Significant at the 1 percent level

Table 6: Indoor temperature survey results

Indoor temperature response to weatherization

	Thermometer		Thermostat	
	(1)	(2)	(3)	(4)
Base temperature	72.36**	72.17**	69.26**	68.91**
	(0.95)	(1.24)	(0.96)	(1.29)
Weatherized home	0.57	0.65	-0.57	-0.56
	(0.41)	(0.44)	(0.29)	(0.33)
Heating Degree Days	-0.16**	-0.15**	0.04	0.05
	(0.03)	(0.04)	(0.03)	(0.04)
Propensity Score Weights?	N	Y	N	Y
R-squared	0.02	0.02	0.01	0.01
Observations	1359	1359	899	899

Note: The table reports measured indoor temperature differentials across weatherized (WAP) and unweatherizedhouseholds. Columns (1) and (2) have the indoor thermometer temperature reading as a dependent variable while columns (3) and (4) use the survey thermostat readings. Columns (2) and (4) are weighted so that surveyed population better represents total quasi-experimental sample. Standard errors clustered at the household level.

* Significant at the 5 percent level

** Significant at the 1 percent level

Table 7: Estimated returns on investments in energy efficiency

Time horizon	Ex ante projections (NEAT) (1)	Empirical estimates (2)
Panel A: Private internal rate of return		
10 years	7.0%	-10.5%
16 years	11.8%	-2.2%
20 years	12.8%	0.3%
Panel B: Private internal rate of return, adding avoided emissions damages		
10 years	11.3%	-8.8%
16 years	15.5%	-0.8%
20 years	16.4%	1.5%
Panel C: Social internal rate of return		
10 years	-1.0%	-20.0%
16 years	5.4%	-9.5%
20 years	7.0%	-6.1%
Panel D: CO_2 abatement cost - 3 percent discount ($/ton CO_2)		
10 years	$29	$552
16 years	-$19	$329
20 years	-$35	$255
Panel E: CO_2 abatement cost - 7 percent discount ($/ton CO_2)		
10 years	$61	$701
16 years	$14	$484
20 years	$0	$417

Note: All calculations use the average retrofit cost of $4,581. This is the ex post realized average expenditure per household as reported by the implementing agencies. Column (1) reflects engineering projections of annual energy savings. In Panels B and C, column (1) also incorporates the value of estimated emissions reductions (valued using a social cost of carbon value of $38 per ton CO_2 and values for avoided local pollutants as described in the text). Column (2) replaces the engineering estimates of energy savings with our experimental estimates of energy savings. Column (2) also incorporates the upper bound on the net welfare gain from increased heating demand using our very small and statistically insignificant point estimate of the upper bound on the efficiency-induced increase in welfare associated with warmer indoor air temperatures.

10 Appendix

10.1 Background on Experimental Research Design

Our experimental research required close collaboration with both our partner utility and the community action agencies that serve households in the utility's service territory. We established these formal partnerships with two large implementing agencies. The experimental research design includes only households living in the counties served by our partner agencies.

To implement the recruitment and assistance, we issued a request for proposals from organizations specializing in grassroots organizing and mobilization. We selected FieldWorks LLC, a private company that specializes in designing communications strategies, running neighborhood canvassing operations, and managing outreach campaigns. Prior to our project, their staff had generated millions of phone calls and knocked on millions of doors in previous engagements. We found them to be highly focused and innovative in their approach to educating households about weatherization assistance, and helping individuals to navigate the application and enrollment process.

To select the study sample, we first identified census blocks within the counties served by our partner utility and implementing agencies that had high rates of home ownership, high rates of natural gas heating, and household incomes that would qualify for weatherization assistance. FieldWorks then used additional data purchased from InfoUSA to identify specific households within these census blocks that they believed met the income qualifications and owned their home. FieldWorks also focused exclusively on relatively dense neighborhoods to reduce the costs of their canvassing operations. These households comprised our study population. From this population, we randomly selected 34,161 households for our study sample. Approximately one quarter of these households were randomly assigned to our encouragement "treatment." These treated households were encouraged to apply for WAP and offered extensive application assistance. We provide no recruitment, outreach, or assistance to the remaining 25,513 households. For households assigned to the control groups, we simply observe energy consumption and program participation decisions.

We worked closely with FieldWorks to develop a persuasive recruit and assist strategy for the approximately one quarter of the sample households that were assigned to the treatment group. Fieldworks personnel, together with our field manager, coordinated field operations in Michigan. Individuals selected from the targeted communities were hired to conduct the bulk of the door-to-door canvassing and outreach activities.

10.2 Modeling Selection into the Weatherization Assistance Program

Although our household by month-of sample fixed effects will control for any time invariant differences between households, differences in time-varying factors could confound the quasi-experimental comparisons across weatherized and unweatherized households. This creates the potential for bias in the quasi-experimental estimates. We thus take some additional steps to ensure that the comparison groups are similar along dimensions we can observe. To the extent that observable differences across households are correlated with omitted, time-variant determinants of energy consumption, balancing covariates across comparison groups can mitigate omitted variable bias.

We estimate the probability of receiving weatherization assistance as a function of observable covariates that presumably play a role in determining program take-up: number of children in the home, elderly residents, income level, primary heating fuel, and trends in historic energy use. Estimated propensity scores are used to construct inverse probability weights. Equation (1) is re-estimated as a weighted regression, using inverse probability weights for the control households. Estimated treatment effects are robust to alternative specifications of the selection equation.

10.3 Fuel-Specific Treatment Effects

In the paper, we report the quasi-experimental results that define the dependent variable in terms of total monthly energy consumption (i.e. natural gas plus electricity). To compute the discounted present value of energy savings, we need to estimate fuel-specific savings in levels. There are two ways to construct these estimates. We can estimate these directly, estimating equation separately for electricity and natural gas, defining the dependent variable in equation in terms of levels. Or we can estimate these two equations using the log transformed dependent variable and calculate levels as a percentage of the control group consumption. Because the timing of the weatherization retrofits vary across participant households, we can at best approximate baseline average consumption.

Appendix Table 2 reports estimation results for specifications in which the dependent variable is defined in levels and in logs. The table also reports the average consumption (natural gas and electricity, respectively) in the control groups in 2012-2014. We use this to approximate the average counterfactual energy consumption. We obtain very similar estimates of monthly reductions in natural gas and electricity consumption using either approach. This is reassuring insofar as our savings estimates are robust to alternative functional form assumptions.

10.3.1 Comparing Experimental and Quasi-Experimental Estimates of Energy Consumption Impacts

We estimate that efficiency improvements reduced monthly energy consumption by 20% on average among those households who were induced by our encouragement to seek out weatherization assistance. This is twice as large as the quasi-experimental estimates of the average effect among all households receiving weatherization assistance from these same agencies. The difference in these point estimates is economically significant, but not statistically significant due to the imprecision of the experimental estimate. This appendix summarizes steps we have taken to investigate possible explanations for this difference.

One possible explanation is that relatively more funds were invested in energy efficiency retrofits at households in our experimental sample. However, when we compare measures of dollars spent and measures installed, we find that the average investment per household was significantly smaller among weatherized households in our encouraged group (as compared to the larger quasi-experimental sample). Thus, it is not the case that differences in energy consumption impacts can be explained by higher investment rates at complier homes.

Another explanation is that the effects of weatherization on energy consumption vary significantly and systematically across households, and that compositional differences in the complier households versus other weatherized households explains the observed differences in average treatment effects. Appendix Table 3 compares households receiving weatherization in the encouraged group with weatherized households that were not part of the experimental sample. The table reveals significant differences along important dimensions. For example, we find that weatherized households in the encouraged group are significantly more likely to report using natural gas as their primary heating source. As mentioned above, we drew our experimental sample from counties associated with high degrees of gas heating so that we could track heating fuel consumption in our natural gas and electricity data. Among weatherized households in the experimental sample, over

96% report using natural gas as the primary heating fuel, 3% use electric heat, and the remaining 1% report heating with a fuel other than natural gas or electricity (i.e., propane, fuel oil, or wood). In contrast, almost 18% of weatherized households outside the experimental sample report using a heating fuel other than electricity or natural gas as their primary heating fuel. Because we do not observe propane, wood, or fuel oil consumption in our data, we observe only a fraction of the weatherization-induced energy savings at these households. This will bias our quasi-experimental estimates towards zero. We also find that weatherized households outside the experimental sample are larger, less likely to receive a furnace replacement as part of the weatherization, and less likely to report an elderly resident as compared to weatherized households in the encouraged group.

To assess whether these observable differences could explain the differences in treatment effect estimates, we estimate a more flexible specification of Equation (1) that allows both average energy consumption in the post-treatment period and the average effect of weatherization on energy consumption to vary along a number of observable dimensions. Appendix Table 4 summarizes the results of estimating these alternative specifications. To make the comparison between quasi-experimental and experimental treatment effect estimates as direct as possible, we use a subset of the quasi-experimental data that includes only those households that applied for weatherization with the two agencies we partnered with in our experiment.

We find that the estimated average treatment effects varies significantly with several of the variables that are distributed differently in the experimental and quasi-experimental groups of weatherized households. In particular, quasi-experimental treatment effect estimates are significantly higher among households that heat with natural gas. We also find that savings are significantly higher among households that report an elderly resident. We find no significant differences in estimated effects in other dimensions such as household size. Column (3) reports a specification that includes variables that are not randomly assigned, but could determine savings (furnace replacement and retrofit costs).

The estimated coefficients in column (2) are used to construct a treatment effect for a household that resembles the average complier household along observable dimensions. This yields an average treatment effect of -0.13. These results suggest that less than a third of the difference between the quasi-experimental and experimental treatment effect estimates can be explained by observable differences across the different groups of weatherized households.

11 Appendix Tables

Table 1: Projected costs, savings, retrofit measures at weatherized households

	Weatherized households
Energy savings (projected)	
Natural gas savings: heating (annual MMBtu)	50.36
	(45.96)
Electricity savings: cooling (annual MMBtu)	4.22
	(50.45)
Projected energy savings/ baseline	0.46
	(0.20)
Investment costs and projected savings	
Investment cost: reported ($)	5,151
	(3,137)
Investment cost: projected ($)	5,306
	(2,823)
Projected NPV savings ($)	10,689
	(11,857)
Projected savings:investment ratio	2.01
	(2.48)
Key measures	
Furnace replacement	0.34
	(0.47)
Attic insulation	0.85
	(1.06)
Wall insulation	0.44
	(1.16)
Infiltration reduction	0.76
	(0.43)
Households	1,638

Notes: This table summarizes data from all weatherized households that could be exactly matched with audit data. Average values reported, standard deviations appear in parentheses.

Table 2: Quasi-experimental estimated impacts of weatherization on household gas and electricity consumption

Panel A: Dependent variable is monthly natural gas consumption

	(1)	(2)	(3)	(4)	(5)	(6)
WAP	-0.12**	-0.97**	-0.12**	-1.07**	-0.11**	-0.97**
	(0.01)	(0.08)	(0.01)	(0.09)	(0.01)	(0.08)
Average consumption control group (MMbtu/month)	8.74 [8.48]		8.47 [8.25]		7.52 [7.10]	
Trimmed sample	N	N	Y	Y	N	N
P-score matched sample	N	N	N	N	Y	Y
Dep. variable	log	levels	log	levels	log	levels
Adjusted R-squared	0.85	0.86	0.85	0.85	0.84	0.84
Households	3,405	3,406	2,864	2,864	3,404	3,404
Observations	183851	188291	153339	156594	183848	188287

Panel B: Dependent variable is monthly electricity consumption

	(1)	(2)	(3)	(4)	(5)	(6)
WAP	-0.06**	-0.17**	-0.05**	-0.13**	-0.06**	-0.12**
	(0.01)	(0.03)	(0.01)	(0.04)	(0.01)	(0.04)
Average consumption control group (MMbtu/month)	2.57 [1.86]		2.53 [1.77]		2.33 [1.44]	
Trimmed sample	N	N	Y	Y	N	N
P-score matched sample	N	N	N	N	Y	Y
Dep. variable	log	levels	log	levels	log	levels
Adjusted R-squared	0.66	0.55	0.64	0.53	0.63	0.63
Households	4,909	4,914	3,308	3,313	3,300	3,303
Observations	276022	293548	181565	194384	182113	194372

Note: Table reports estimates of the reduction in monthly energy consumption following weatherization. The unit of observation is a household-month. The dependent variable is monthly household energy consumption (electricity or natural gas) measured in MMBtu. The coefficient reported is the coefficient on the weatherization indicator, which switches to one from zero after a household weatherization is completed. All specifications include household-by-month fixed effects. Standard errors (in parentheses) are clustered at the household level.

* Significant at the 5 percent level

** Significant at the 1 percent level

Table 3: Differences in sample means between groups of weatherized households

	Experimental control (1)	Experimental encouraged (2)	(2) - (1) (3)	Other weatherized (4)	(4) - (2) (5)
Panel A: Pre-treatment period monthly energy consumption (MMBtu)					
Winter gas (MMBtu)	10.42	9.80	-0.62	9.82	0.03
	(3.93)	(3.47)	(0.32)	(3.86)	(0.23)
Summer gas (MMBtu)	2.94	2.97	0.03	1.32	-1.65**
	(1.47)	(1.50)	(0.13)	(1.62)	(0.09)
Winter electricity (MMBtu)	1.99	2.21	0.22*	2.28	0.07
	(0.93)	(1.10)	(0.09)	(1.36)	(0.07)
Summer electricity (MMBtu)	2.04	2.21	0.16	2.26	0.05
	(1.02)	(1.11)	(0.10)	(1.35)	(0.07)
Panel B: Demographics and dwelling characteristics					
Household income ($)	17,048	19,783	2,735**	20,041	259
	(8,840)	(12,172)	(1,016)	(12,386)	(708)
Household size (# people)	1.99	2.37	0.38**	2.71	0.34**
	(1.30)	(1.60)	(0.14)	(1.73)	(0.10)
Children (share of hh)	0.19	0.27	0.07	0.24	-0.03
	(0.40)	(0.44)	(0.04)	(0.43)	(0.02)
Elderly (share of hh)	0.28	0.38	0.11*	0.17	-0.21**
	(0.45)	(0.49)	(0.04)	(0.38)	(0.02)
Age of home(yrs)	62.87	58.92	-3.94*	58.90	-0.02
	(18.80)	(20.73)	(1.94)	(29.21)	(1.62)
Floor area (sq. ft.)	1780	1734	-26	1736	2
	(596)	(594)	(57)	(739)	(42)
Furnace replacement	0.44	0.44	-0.00	0.29	-0.15**
	(0.50)	(0.50)	(0.05)	(0.45)	(0.03)
Gas heat	0.94	0.97	0.03	0.72	-0.24**
	(0.24)	(0.18)	(0.02)	(0.45)	(0.02)
Reported cost (total)	5428.24	4635.99	-792.26**	5262.04	626.06**
	(2828.30)	(2609.83)	(281.74)	(3294.01)	(209.28)
Proj. savings (MMBtu)	63.71	55.36	-8.35*	54.84	-0.53
	(44.11)	(41.83)	(4.10)	(49.00)	(2.82)
Households	180	436		1,473	

Note: Columns numbered (1), (2), and (4) report average values and standard deviations (in parentheses). Columns (3) and (5) report differences in means (standard errors are in parentheses).
* Significant at the 5 percent level
** Significant at the 1 percent level

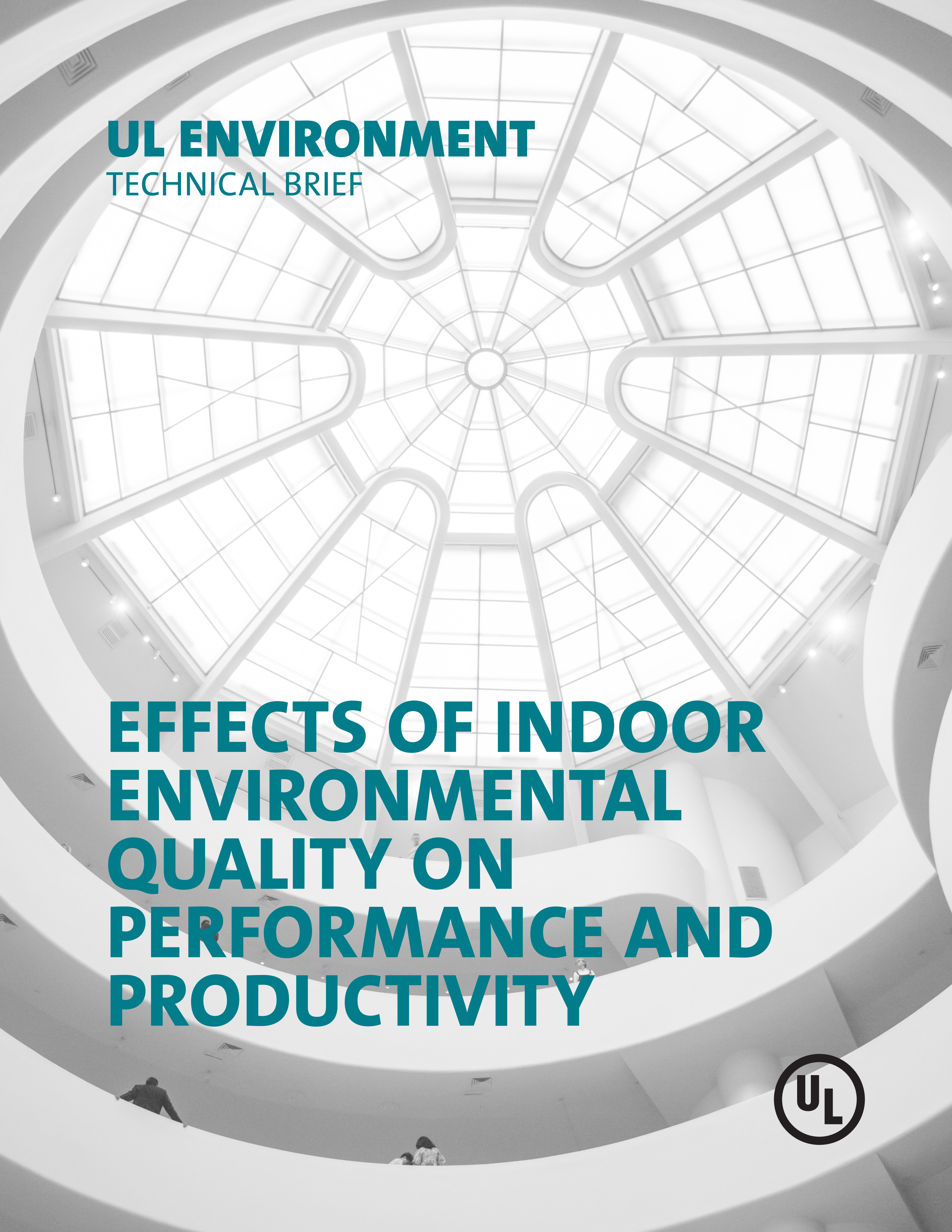
Table 4: Heterogeneity in weatherization impacts on energy consumption

Dependent variable is monthly energy consumption (in logs)	(1)	(2)	(3)
WAP	-0.09**	< 0.01	0.04
	(0.01)	(0.02)	(0.02)
Gas heat x WAP interaction		-0.10**	-0.10**
		(0.02)	(0.03)
Elderly x WAP interaction		-0.05*	-0.04*
		(0.02)	(0.02)
Income x WAP interaction		< 0.01	< 0.01
		$<$ (0.01)	$<$ (0.01)
Age of house x WAP interaction		< -0.01	< 0.01
		$<$ (0.01)	(< 0.01)
Furnace x WAP interaction			-0.07**
			(0.02)
Retrofit cost x WAP interaction			< -0.01
			(< 0.01)
Adjusted R-squared	0.83	0.84	0.84
Households	3,334	2,541	1,117
Observations	183,353	141,938	64,477

Note: The unit of observation is a household-month. The dependent variable is the log of monthly household energy consumption measured in MMBtu. All specifications include un-interacted covariates, household-month fixed effects, and month-year-county fixed effects (not shown). Standard errors (in parentheses) are clustered at the household level.

* Significant at the 5 percent level

** Significant at the 1 percent level



UL ENVIRONMENT

TECHNICAL BRIEF

EFFECTS OF INDOOR ENVIRONMENTAL QUALITY ON PERFORMANCE AND PRODUCTIVITY

Effects of Indoor Environmental Quality on Performance and Productivity

Introduction

In the developed world, humans spend about 90% of their time indoors.(EPA, 1989) That time is spent sleeping, working, attending school, cooking, eating, and all related tasks. In the last 150 years, the indoor environment has changed dramatically, from soot and dust filled rooms lit by candles and heated by wood or coal to the modern office and residential spaces with state of the art materials and invisible systems to provide heat, cooling, humidity control, and particle filtration. Since we spend so much time indoors, it is in our best interest that the environments we create for working and learning are designed to maximize productivity and performance, or at the very least, minimize the negative effects these spaces may incur on the inhabitant.

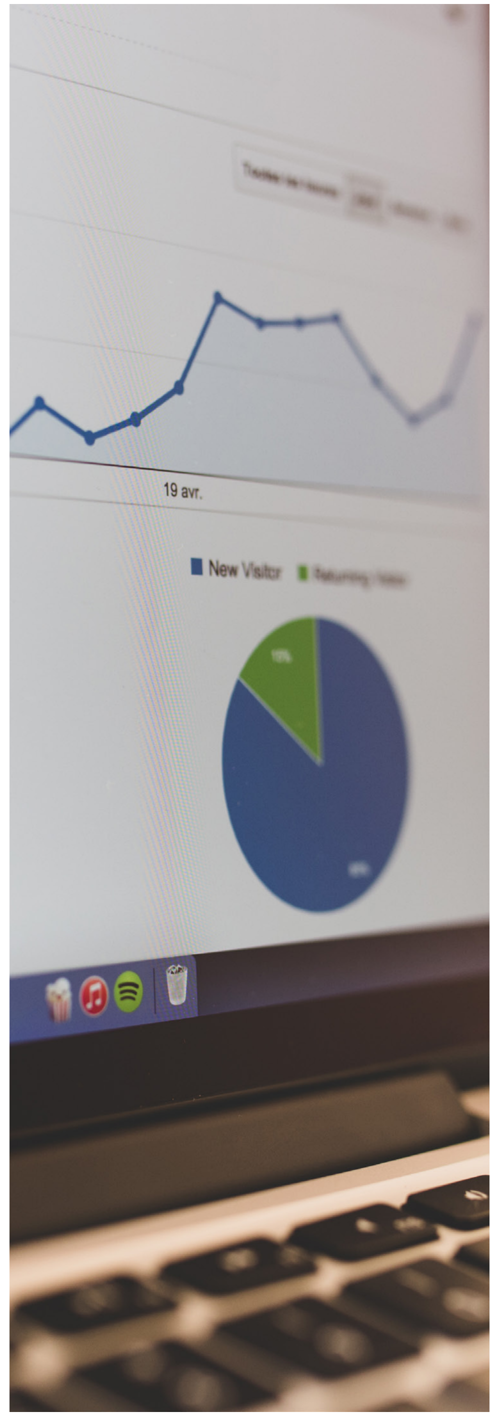
Over the past 50 years, there has been a growing body of research surrounding optimal indoor conditions. This research has been conducted from several fronts: architects and designers tweaking indoor plans to make spaces aesthetically pleasing, mechanical engineers modifying designs of heating, ventilation, and air conditioning (HVAC) equipment to make spaces more comfortable, and environmental health practitioners performing studies of different indoor environment pollutants and their effects on occupants.

Today, 14 percent of healthcare costs are driven by conditions related to Indoor Environmental Quality (IEQ), including asthma and allergies; headaches; respiratory disease; eye, nose and throat irritation; reproductive and developmental defects; neurological disease; cardiovascular disease; and some forms of cancer. Poor IEQ in commercial buildings can lower worker productivity, while conversely improving IEQ can significantly reduce absenteeism and improve productivity. (Underwriters Laboratories, 2014)

This report is an attempt to summarize the main tenets linking IEQ and human performance and productivity.

Both the exposure (IEQ) and outcome (performance/productivity) are defined differently depending on the source. According to the National Institute for Occupational Safety and Health (NIOSH), "Indoor environmental quality (IEQ) refers to the quality of a building's environment in relation to the health and wellbeing of those who occupy space within it. IEQ is determined by many factors, including lighting, air quality, and damp conditions."(NIOSH, 2015) The complexity of environmental parameters is also complex, as "building occupants may be exposed to a variety of contaminants (in the form of gases and particles) from office machines, cleaning products, construction activities, carpets and furnishings, perfumes, cigarette smoke, water-damaged building materials, microbial growth (fungal, mold, and bacterial), insects, and outdoor pollutants. Other factors such as indoor temperatures, relative humidity, and ventilation levels can also affect how individuals respond to the indoor environment."(NIOSH, 2015) Performance is also not an exact variable, as it may be calculated via speed of work, quality of work, presence or lack of respiratory symptoms, or absenteeism. Also, evaluating work performance is useful because the monetary costs can be extrapolated from increased productivity of occupants. (Seppanen, Fisk, & Lei, 2006) In addition, it seems like in the last several years, there has been a coalescing of thought around how to measure performance objectively, in an attempt to control for different indoor environment variables.

In this brief, we focus mostly on research into performance metrics related to IEQ in office environments. We will discuss different components of Indoor Environments that have been studied, and introduce recent research that appears to be a major breakthrough in the field related to Carbon Dioxide (CO_2) levels.



How do you measure performance?

The available literature suggests that performance can be measured in a variety of ways, depending on the subject population and the type of study being conducted. For instance, several studies used the concept of Disability Adjusted Life Years (or DALYs) which are defined by the World Health Organization as "years of healthy life lost". (Allen et al., 2015; Chan, Parthasarathy, Fisk, & McKone, 2015; Logue, Price, Sherman, & Singer, 2012) DALYs are calculated by summing the Years of Life Lost (which depends on both the number of early mortalities and lost life expectancy attributable to the early mortalities) and Years of Life Disabled (which depends on the number of incident cases of disability, length of the case and its disability weight). Other studies have evaluated speed of task completion (with metrics such as calls answered per hour in a call center, or typing speed), symptoms of Sick Building Syndrome (headaches and respiratory irritation) and absenteeism.

Several studies have also examined the relationship between outdoor pollution and worker/student productivity, measuring work output or cognitive ability in the presence of ambient air pollutants like ozone, NOx, and radiation. (Almond, Almond, & Edlund, 2007; Lavy, Ebenstein, & Roth, 2012; Zivin & Neidell, 2011) Subjects are also often asked to provide subjective assessments of their performance, however this has been shown to not be a reliable source of data.(Wyon, 2004)

Based on the current literature, using an objective measurement of performance is ideal for assessing performance, so that limited bias is introduced. Several studies used the Strategic Management Simulation (SMS) software tool, which asks participants to respond to several situations with strategic thinking, scoring them in several different cognitive factors such as Information Seeking, Strategy, and Task Orientation. The SMS tool has been proven effective in a variety of exposure scenarios, such as caffeine, antihistamines, alcohol, marijuana, and tranquilizers. (Satish, Cleckner, & Vasselli, 2013)

Which components of the Indoor Environment affect Performance?

The most studied components of the Indoor Environment related to occupant performance are Ventilation, Temperature, VOCs, and CO_2. In the following pages, I will break out each of these parameters and its function on performance.

Ventilation Rates and Performance

One of the more obvious metrics of IEQ and performance is ventilation rates. Ventilation is typically measured in Liters per second per person (L/s-person). Most studies have shown a positive direct relationship between increased ventilation and productivity of occupants. Specifically, greater percentages of fresh, outdoor air are critical for this relationship to hold.

A meta-analysis performed in 2005 found that there was a 1-3% improvement in productivity for each additional 10 L/s-person of ventilation, from approximately 6.5 L/s-person up to 65 L/s-person. (Seppanen et al., 2006) Ventilation rates as a function of performance with a baseline of 6.5 L/s-person are plotted in Figure 1 below.

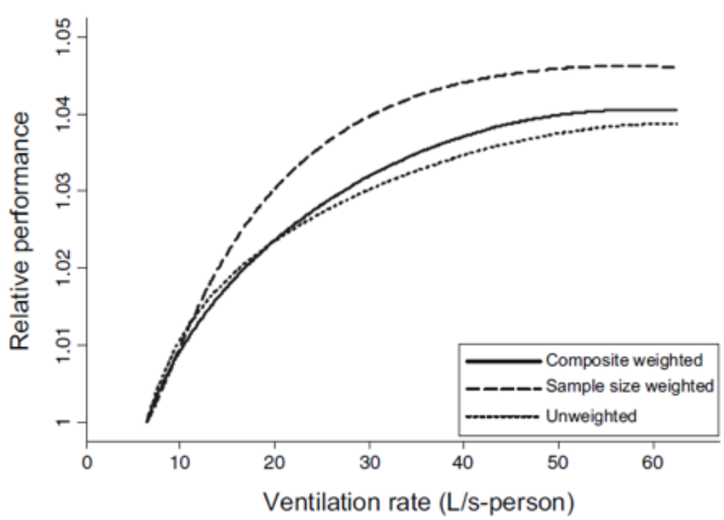
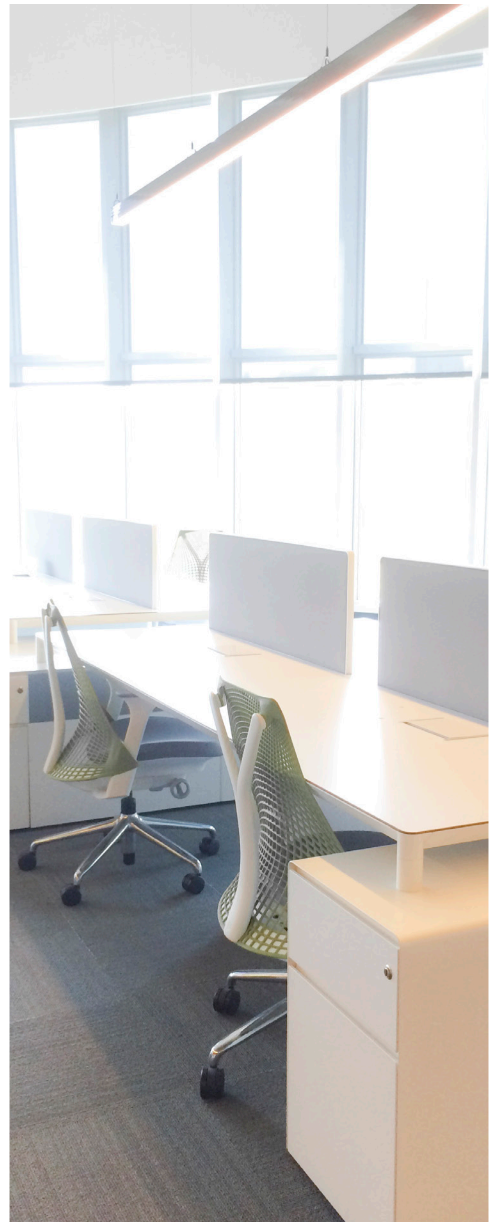


Figure 1: Relative performance in relation to the reference value 6.5 L/s-person versus average ventilation rate (Seppanen et al., 2006)

In 2013, Chan et al. provided a risk assessment for chronic exposure to volatile organic compounds (VOCs) and particulate matter (PM2.5) as a function of ventilation rates. They modeled results from previous studies connecting ventilation and concentrations of these two pollutants at 0.5x and 2x ventilation rates. They then compared the results to regulatory agency data on chronic health risks. The results of the modeling are rather intuitive: doubling ventilation rates significantly reduced the VOC concentrations and resulting modeled chronic health effects, but higher ventilation rates also increased the amounts of PM2.5 exposure (since much of PM2.5 matter is generated from outdoor air). In addition, it appears that filtration is the best solution for PM2.5 loads, independent of the ventilation rates.(Chan et al., 2015)



The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) first published ASHRAE Standard 62 in 1973. ASHRAE Standard 62 has been modified in the decades since, but it remains among the most prominent and most cited documents on ventilation. The standard lists minimum ventilation requirements for a variety of indoor spaces. The first version of Standard 62 included the purpose statement “minimum and recommended air quantities for the preservation of occupants’ health, safety, and well-being”. This statement was controversial within ASHRAE almost immediately, as many members felt that as an engineering society, ASHRAE should not be involved in occupant health. (Persily, 2015) The statement evolved over the subsequent years, and the board of directors ultimately approved a rule that IEQ and ventilation standards “shall not make any claims or guarantees that compliance will provide health, comfort or occupant acceptability, but shall strive for those objectives ...” and that “ASHRAE standards shall consider health impacts where appropriate.” (ASHRAE, 2014; Persily, 2015) The evolution of Standard 62 demonstrates the changing understanding of the relationship between ventilation rates and indoor environmental quality.(Allen et al., 2015)

Ventilation is one of the more discussed issues related to building mechanical system operation, as increased outdoor air ventilation comes with higher energy loads and therefore higher costs, and it has been shown that increased ventilation often leads to positive health outcomes for occupants.

Temperature and Performance

Indoor air temperature is one of the most noticeable aspects of any workplace or other building. Studies on the relationship between temperature and worker performance have been conducted since at least the 1920's. Early studies found a marked relationship between temperature and manual work (i.e. factories, mills, etc.). However, the correlation between temperature and mental work is more complex. A summary conducted in 1997 found that for some types of mental work, such as complex and creative tasks, optimal performance coincides when the occupants are at optimal thermal comfort. However, other types of mental work are best completed under slightly cooler temperatures. The conclusion was that performance may be increased by giving occupants individual control of local temperature settings. (William J. Fisk & Rosenfeld, 1997)

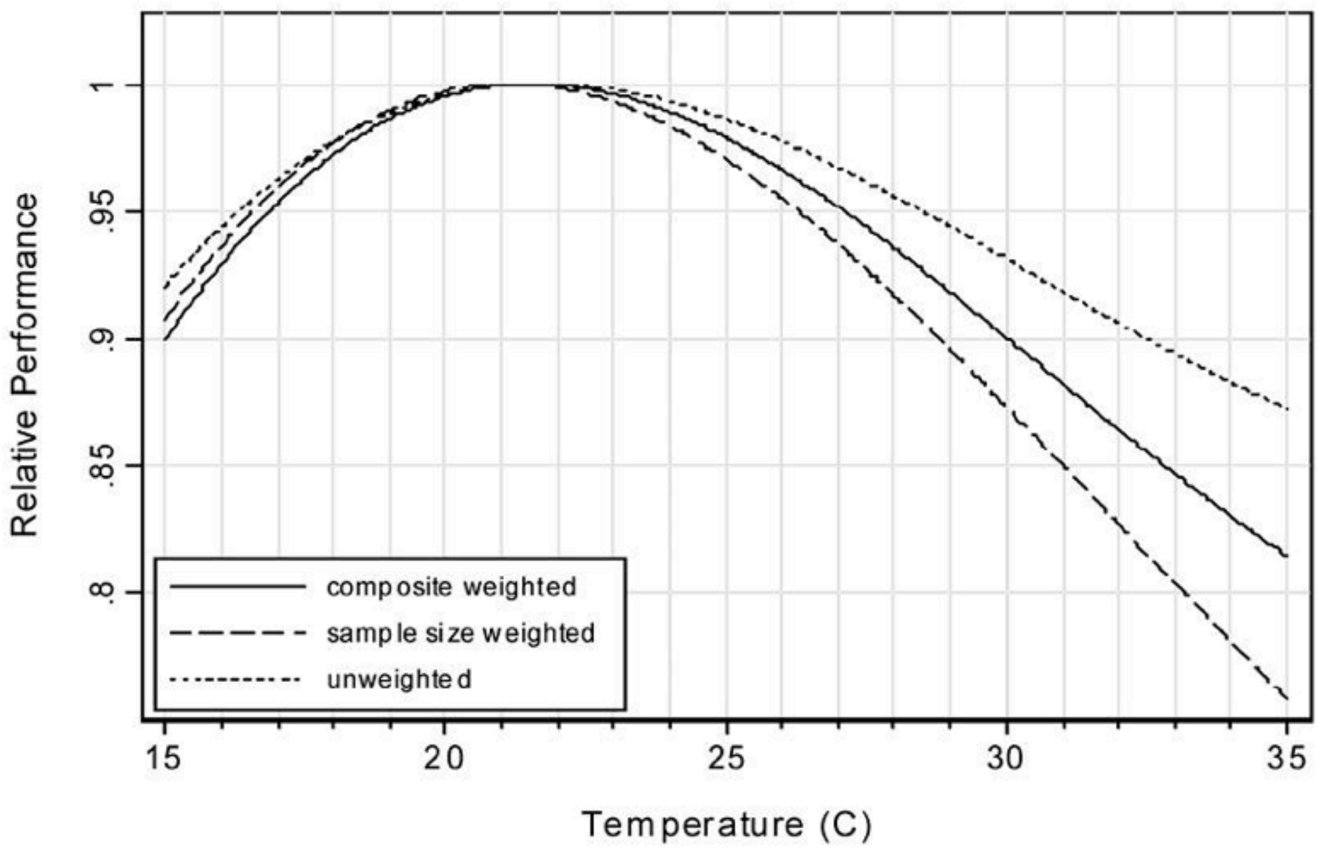


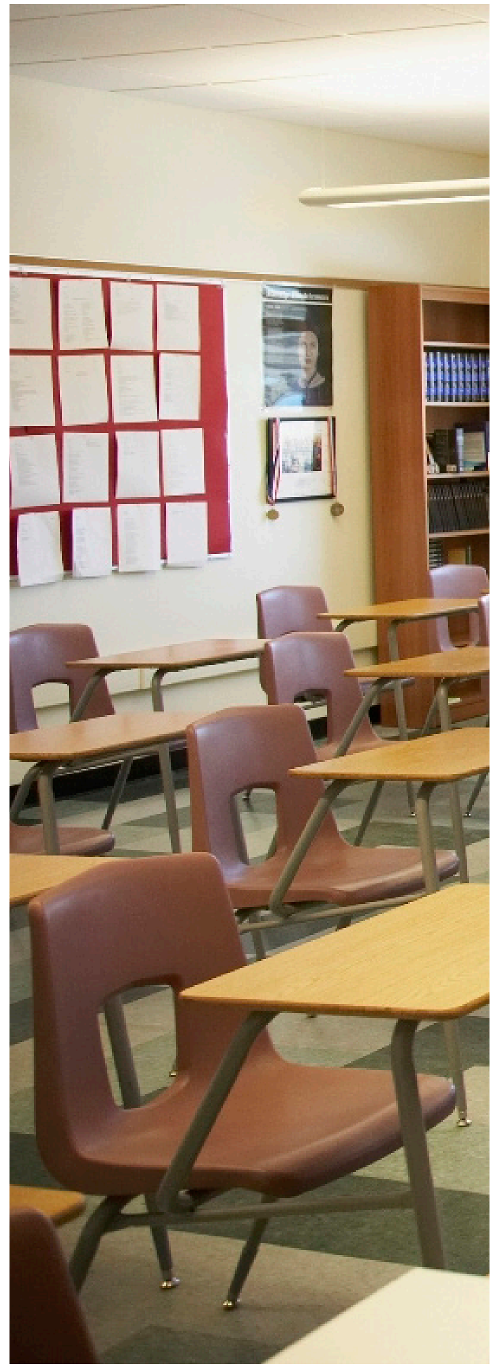
Figure 2: Relative performance versus Temperature (maximum performance is set to 1) (Seppanen et al., 2006)

VOCs and Performance

A consequence of spending so much time indoors is that the majority (more than 70%) of chemical exposures happen there. (Gokhale, Kohajda, & Schlink, 2008) Volatile Organic Compounds (VOCs) are emitted gases from certain solids or liquids. They emit from many different sources commonly found within homes and offices, including paints, aerosol sprays, cleaners, air fresheners, fuels, dry cleaned clothing, pesticides, building materials/furnishing, and office equipment such as copiers, glues, and markers. (EPA, 2015)

Studies have been conducted on exposure to VOCs emitting from paints, building materials, and other sources, showing a correlation between higher concentrations of VOCs and lower performance. A 2013 study even showed that a freshly painted room impaired the cognitive ability of occupants in a similar way to alcohol. (Satish et al., 2013) Recent research also shows that at lower levels, VOC concentration may effect decision making as well. It is not clear which VOCs are the most detrimental to performance; researchers believe that there are different VOC combinations that affect individuals uniquely, but more study on this topic is needed. (Stromberg, 2014)

In an office environment, the majority of the VOC load comes from building materials and cleaning products. Low VOC variations of these products are a significant part of high performance building systems such as the LEED standard, Living Building Challenge, and WELL, which have all recognized the need to reduce VOC exposure in general to improve occupant health and performance.



Carbon Dioxide and Performance

One of the most widely used metrics for measuring ventilation is CO_2 concentration in the space. Scientists have used CO_2 as a representative gas, and correlate that level to higher levels of VOCs, microbial contaminants, and allergens. However, recent research questions whether CO_2 itself is leading to occupant performance reduction.

The current Standard 62 guideline for CO_2 is 1,000 ppm above outdoor levels. But as discussed above, Standard 62 is first and foremost an engineering standard, rather than a health based one. As Persily pointed out, “CO_2 limits in ventilation standards are related to recommended ventilation rates for body odor control under idealized, steady-state conditions, not to the health or comfort impacts of the CO_2”. (Persily, 2015)

William Fisk of Lawrence Berkeley National Laboratory stated, “We've known for a long time that higher carbon dioxide levels were statistically correlated with reduced performance, but we assumed it was a proxy for other pollutants that varied with ventilation rates. That's basically been the dogma."(Stromberg, 2014) We also know that high levels of CO_2 can be detrimental to humans: acute exposure to 50,000 ppm leads to signs of intoxication, 100,000 ppm can cause unconsciousness, and exposure to 250,000 ppm can cause death. (Lipsett, Shusterman, & Beard, 1994) But until 2012, research was not being done on CO_2 concentrations that were conceivable in crowded rooms like elementary school classrooms. (2,500-3,000ppm)

Three studies since 2012 have started a shift in how the scientific community views CO_2 in relation to performance. The first was conducted in 2012 by a group from Budapest University of Technology and Economics, which found that spending a few hours in a chamber with CO_2 levels of 3,000 ppm made it difficult to concentrate.(Kajtár & Herczeg, 2012)

Lawrence Berkeley National Laboratory (LBNL) and SUNY Upstate Medical University performed a study in 2012, in which participants were subjected to different levels of CO_2 for 2.5 hour intervals in an attempt to see how the different concentrations affected decision making skills. 22 participants were exposed to CO_2 at 600, 1000, and 2500 ppm, and at the end of each period took a test (the SMS test discussed earlier) measuring decision making performance, health symptoms, and perceived air quality. This study found that relative to the 600 ppm level, performance on 6 of 9 scales was reduced moderately at 1000 ppm, and performance on 7 of 9 scales was greatly reduced at 2500 ppm. While concentrations approaching 2500 ppm are rarely seen in most office environments, a study of elementary schools in Texas showed that a substantial number exhibited concentrations above 2000 ppm. (Corsi, Torres, Sanders, & Kinney, 2002)

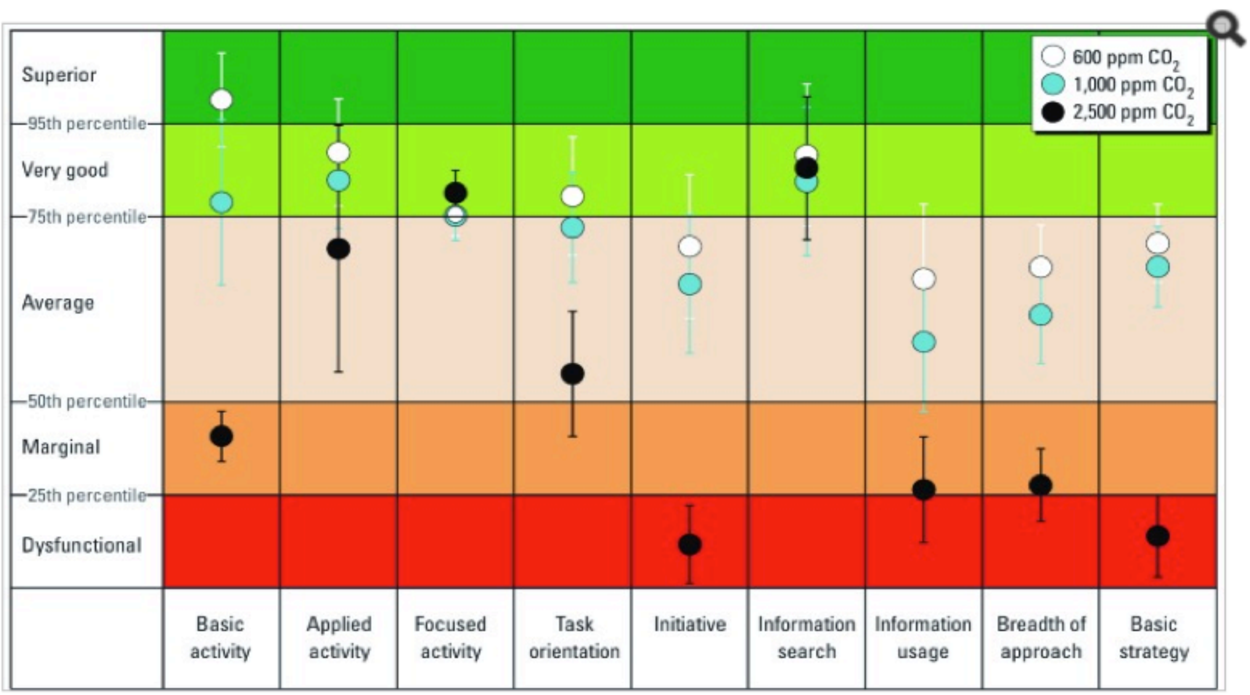


Figure 2: Impact of CO_2 on human decision making performance. Error bars indicate 1 SD.
(Satish, et al. 2012, Environmental Health Perspectives, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3548274/

In 2015, researchers from the Harvard School of Public Health, SUNY Upstate Medical School, and Syracuse University authored a paper examining the association between CO_2, Ventilation, and VOC exposure and cognitive function scores. This study was designed to build off the findings from the LBNL study to include different building types (high performance and typical), longer exposure times, and blinded participants, among other changes. In the study, 24 participants worked for 6 days in a mocked up office, where minimum ventilation standards as defined by ASHRAE were implemented. On each of the 6 days, the rates of ventilation, Total VOC, and CO_2 levels were set in different combinations, to which the participants were blinded. Building types were divided between "Conventional", "Green" (low VOC) and "Green +" ("Green" with higher ventilation rates). On two of the study days, the authors also changed the amount of CO_2 in the space, holding all other variables (ventilation and VOC concentration) constant. CO_2 concentrations varied from 550 ppm to 1400 ppm.

Each day, participants completed the SMS test, which computed scores for 9 cognitive factors. On average, cognitive scores for were 61% higher on "Green" days and 101% higher on "Green +" days.

Three areas showed the largest improvements: crisis response, information usage, and strategy. Crisis responses were 97% higher in the "Green" environment and 131% higher in the "Green +" environment compared to conventional buildings. Information usage scores were 172% and 299% higher, respectively. Scores "Green" and "Green +" buildings were 183% and 288% higher than the conventional building scenario.

Costs/Benefits

Buildings account for more than 40% of US energy consumption, with nearly half of that coming from commercial buildings. In office buildings, more than half of the energy costs are attributable to heating, ventilating, and cooling. (EIA, 2008, 2015) Therefore, building managers are incentivized to reduce energy wherever possible, which is often accomplished by reducing ventilation rates.

In the 1970s, increasing energy prices led to a change in the way buildings were constructed and operated in the United States. Buildings were built to be more air tight and energy efficient, and ventilation requirements were relaxed to conserve energy in the 1980s. Around the same time, building related illnesses and Sick Building Syndrome (SBS) were first reported. (Riesenberg & Arehart-Treichel, 1986)

While it is helpful to have scientific literature on the indoor environment's influence on occupant performance, the costs and benefits must be weighed before these changes are implemented in the real world. As Fisk et al found in a study from 2011, "estimates [of benefits], particularly the monetary estimates, also facilitate the communication of the importance of IEQ to policy makers, building professionals, and the broader public."(W. J. Fisk, Black, & Brunner, 2011)

Studies have consistently shown that increased productivity does outweigh the costs of increased energy usage in a building.

Table 1: Estimated potential productivity gains from improvements to indoor environments (Fisk & Rosenfeld, 1997)

Sources of Productivity Gain	Strength of Evidence	Potential U.S Annual Savings or Productivity Gain (1993 $U.S)
Reduce respiratior disease	Strong	$6-$19 billion
Reduce allergies and asthma	Moderate	$1-$4 billion
Reduce sick building syndrome symptoms	Moderate to Strong	$10-$20 billion
Improve worker performance: From changes in thermal environment From changes in lighting	 Strong Moderate	 $12-$125 billion

In 2015, the authors of the Harvard study also evaluated the results of their previous study in cost/benefit terms. They found that doubling the ventilation rate would cost less than $40 per person per year in all climate zones investigated, and would improve the performance of workers by 8%. This was equated with a $6,500 increase in employee productivity per year. (MacNaughton et al., 2015) They also updated the numbers presented in table 1, approximating the annual savings of $125 billion in 1993 dollars is roughly $186 billion in 2015 dollars. They also estimated that even with conservative estimates, the increased productivity of an employee is more than 150 times higher than the energy costs associated with increasing ventilation. (MacNaughton et al., 2015)

Conclusion

Based on the body of current research, it is clear that the productivity of workers is becoming more easy to measure, and the benefits of improved IEQ are becoming more obvious to policy makers, building managers, and companies occupying those buildings. It is important to note that as building envelopes become tighter, the energy required to ventilate the space effectively will be reduced. This allows for a future of buildings that are more energy efficient and healthier for the workers that occupy them. In the same way that Total Worker Health programs are moving away from merely preventing accidents to providing healthy spaces for employees, building managers and engineers should heed the research of the last 10 years showing a clear need to optimize indoor environmental conditions for occupants.

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U.S. DEPARTMENT of ENERGY

ENERGY DEPARTMENT ANNOUNCES OVER $400 MILLION IN FUNDING AND REMOVES BURDENSOME POLICY, HELPING AMERICANS SAVE ON ENERGY BILLS

WASHINGTON —The U.S. Department of Energy (DOE) today announced the disbursement of over $400 million for energy saving programs designed to help American families save money on their energy bills.

Office of State and Community Energy Programs

July 8, 2025

3 min

WASHINGTON —The U.S. Department of Energy (DOE) today announced the disbursement of over **$400 million** for energy saving programs designed to help American families save money on their energy bills. This funding helps to advance President Trump's Executive Orders on *Delivering Emergency Price Relief for American Families and Defeating the Cost-of-Living Crisis* and *Unleashing American Energy*, which terminates expensive and unnecessary New Green Deal mandates and returns the agency's focus on delivering cost savings directly to the American people.

The Department is allocating **$325 million** in Weatherization Assistance Program (WAP) funds and **$30 million** in Weatherization Readiness Funds (WRF) to 56 Grantees including all 50 states, the District of Columbia, and five U.S. Territories. These investments advance the Administration's policies and priorities to reduce energy costs for American households and generate employment opportunities for American workers by driving down energy costs for low-income families through residential energy efficiency and improved health and safety.

"Thanks to President Trump's leadership, we are able to focus on reducing energy costs for Americans that can least afford high energy prices through the efforts of Weatherization." said **Eric Mahroum, Director of the DOE Office of State and Community Energy Programs**. "Every day, President Trump empowers consumer choices while reinvigorating America's energy industry and the economy. With a commitment to reduce energy costs for all Americans, while simultaneously modernizing and reinvigorating energy dominance across all sectors, President Trump is fulfilling his promises to the American people."

In addition to the Weatherization funding, DOE is today releasing **$64 million** in State Energy Program (SEP) funds to the same 56 grantees to pursue programming that ensures energy reliability, availability, security, and cost savings for businesses and residents. State governments are a critical partner in achieving the President's vision of American Energy Dominance and SEP will continue to advance this critical mission.

Effective immediately, the department is also rescinding the Weatherization Program Notice 22-10 policy considering social cost of carbon and other non-energy impacts within WAP. Removing the provision reduces steps in the energy audit process and improves efficiency for states when using Federal resources. For more information on timelines related to this policy change, contact WAPTA@hq.doe.gov.

Since 1976, WAP has served over seven million households and delivers an average annual energy savings of $372 while reducing the Nation's dependence on imported energy supplies and cutting out-of-pocket medical expenses by an average of $514 per household. WAP's statutory requirement for cost effectiveness ensures that for every Federal dollar invested there is at a minimum one-dollar payback in energy savings while also stimulating economic growth through increased opportunities for energy and local trade jobs.

Since 1976, SEP has ensured that State Governments are enjoined in the effort to reduce America's dependence on foreign sources of energy, strengthen energy security, and perform transmission and distribution planning support activities, yielding savings and reliability for American homes and businesses.

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May 8, 2025

The Honorable Mike Lee
Chairman
Energy and Natural Resources Committee
United States Senate
Washington, DC 20510

The Honorable Brett Guthrie
Chairman
Energy and Commerce Committee
U.S. House of Representatives
Washington, DC 20515

The Honorable Martin Heinrich
Ranking Member
Energy and Natural Resources Committee
United States Senate
Washington, DC 20510

The Honorable Frank Pallone
Ranking Member
Energy and Commerce Committee
U.S. House of Representatives
Washington, DC 20515

RE: Grassroots Support Letter for the Bipartisan Weatherization Enhancement and Readiness Act of 2025 (H.R. 1355)

Dear Chairman Lee, Chairman Guthrie, Ranking Member Heinrich, and Ranking Member Pallone,

We, the undersigned coalition of nearly **750** contractors and weatherization stakeholders, write to urge you to support the **bipartisan Weatherization Enhancement and Readiness Act of 2025** (H.R. 1355), sponsored by Reps. Tonko (D-NY-20), Lawler (R-NY-17), Kaptur (D-OH-09), Riley (D-NY-19) and Del. Moylan (R-GU-AL). This legislation would reauthorize the Department of Energy's Weatherization Assistance Program (WAP) through 2030 – authorization currently set to expire at the end of this fiscal year. The legislation would also give states and local agencies flexibility to reach more low-income homeowners currently ineligible for funding under WAP due to their homes' structural, electrical, or health related issues. We urge you to support the Weatherization Enhancement and Readiness Act to ensure that eligible homeowners can access WAP funds to make their households safer, healthier, and more energy efficient.

Since its creation in 1976, WAP has helped improve the lives of over 7.2 million low-income and rural Americans - individuals particularly susceptible to high energy burdens.[1] Congress has consistently shown strong bipartisan support for this program, which enables upgrades that save households an average of $372 or more every year.[2] The bipartisan Energy Act of 2020, signed by President Trump, reauthorized the program until fiscal year 2025.[3] In the face of rising energy prices, the program's reauthorization will ensure that these benefits continue to flow directly to consumers.

In addition to reducing energy costs, WAP supports local jobs for the organizations and contractors providing weatherization services to households across the country. According to the Department of Energy, the annual funds provided by WAP support 8,500 jobs every year.[1] Much of WAP's work is on the ground—performing in-home installations or maintenance—and these jobs support local economies and cannot be outsourced.

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[1] Department of Energy, Weatherization Assistance Program, https://www.energy.gov/scep/wap/weatherization-assistance-program.

[2] Ibid.

[3] Energy Act of 2020, SEC. 1011. Weatherization Assistance Program.

The Weatherization Enhancement and Readiness Act of 2025 would also increase access to the program, ensuring program dollars go further. The legislation would authorize the Weatherization Readiness Program to address issues such as structural deficiencies, neglected repairs, outdated wiring, or health issues such as mold and asbestos, allowing more homes to qualify for WAP. The legislation would also raise the limit on how much assistance households can receive under WAP to $12,000, allowing the program keep up with rising costs of building materials, equipment, and wages while also supporting more improvements per project for maximum energy savings.

We strongly urge your support for the Weatherization Enhancement and Readiness Act of 2025 (H.R.1355) to reauthorize and strengthen this crucial program. Please contact Skip Wiltshire-Gordon (skip@anndyl.com) with any questions.

Sincerely,

220 Home Performance Contractors and Energy Efficiency Companies:

Arctic Technical Services	Fairbanks	AK
Keen Living LLC	Fairhope	AL
Balanced Temp	Birmingham	AL
Comfort Air Quality	Huntsville	AL
Home Rebate Group	Birmingham	AL
Sun Plans Inc.	Mobile	AL
AirCycler	Rector	AR
Ecoviabl LLC	North Little Rock	AR
SunCrop Solar & Energy Solutions	Helena	AR
Arizona Energy Management	Phoenix	AZ
CozyHome	Flagstaff	AZ
Luxury Electrical Services LLC	Tucson	AZ
Recon Restoration	Phoenix	AZ
1-888-HEAT-PUMPS	Berkeley	CA
Action Air Conditioning Heating & Plumbing	Fresno	CA
AIM Associates	Petaluma	CA
CARES	Eureka	CA
Eco Performance Builders	Walnut Creek	CA
Efficiency Now	San Rafael	CA
Energy Conservation Consultants	Orangevale	CA
Environmental Home Improvement	Los Angeles	CA
HomeBoost	San Rafael	CA
Liberty Mechanical, Inc.	El Cajon	CA
BrightSense LLC	Boulder	CO
Green Renewables	Fort Collins	CO
HumaNature Architecture LLC	Boulder	CO
Maiven Energy, Inc.	Boulder	CO
ReVireo	Denver	CO
Thrive Energy	Longmont	CO

Timberline Insulation Inc	Fort Collins	CO
Abstract Home Konsult	Mystic	CT
Energy Services Group Inc.	East Hartford	CT
Homeworks	Hartford	CT
Klein Properties LLC	Madison	CT
NexGen Energy, LLC	Rocky Hill	CT
Haram Restoration, Inc.	Washington	DC
Comfort & Energy Solutions	Middletown	DE
Seaside Crawl Space	Bridgeville	DE
Farrell Holdings, Inc.	Tampa	FL
Gast International	Seminole	FL
GreenCalcs for Sustainable Building LLC	Pensacola	FL
K. O. Energy Design	West Palm Beach	FL
Martin R Robert Construction	Quincy	FL
John Anderson Service Company	Calhoun	GA
Cornerstone Contracting LLC	Cleveland	GA
Energy Consulting Services	Atlanta	GA
Greenhome South	Cedartown	GA
Gwinnett Housing Corporation	Lawrenceville	GA
Ray & Son Htg & A/C Inc	Nashville	GA
Thermal Shield Insulation, LLC	Locust Grove	GA
Home Star Iowa	Cedar Rapids	IA
G&G Insulation	Meridian	ID
Sapp Enterprises	Decatur	IL
Bae Refrigeration	Rochester	IL
Cyclone Energy Group	Chicago	IL
Got Dumped Inc.	Summit-Argo	IL
Greenlink Energy Services, Inc.	Rockford	IL
Hometown HVAC	Paxton	IL
Insight Building Performance Training	Wheaton	IL
MNBE	Elizabethtown	IL
CEDA	Hammond	IN
Livable Housing, Inc.	Indianapolis	IN
Tuttle Heating and AC	Solsberry	IN
Brooks Heating and Air, Inc.	Caneyville	KY
Cumberland Energy Consultants	Somerset	KY
Home Energy Services	Cold Spring	KY
LKLP-CAC	Hazard	KY
SGP Consulting, LLC	Mount Sterling	KY
Solstice Home Performance	Fort Mitchell	KY
Weatherization HVAC	West Liberty	KY

Zembrodt Energy Audits LLC	Latonia	KY
ABC Builder Plus Inc	Abbeville	LA
Tangi Energy Conservation LLC	Ponchatoula	LA
Old Harbor HERS Raters	North Chatham	MA
Alternative Weatherization, Inc.	Fall River	MA
B. Alpha Construction	Chicopee	MA
HomeWorks Energy, Inc.	Medford	MA
Mass Save	New Bedford	MA
Rate It Green, LLC	Weston	MA
RVA	West Yarmouth	MA
Tamarack	West Wareham	MA
Comfort Kings	Chesapeake Beach	MD
DeVere Insulation Home Performance	Pasadena	MD
EDGE Energy	Beltsville	MD
Efficient Home LLC	Bethesda	MD
Elysian Energy	Silver Spring	MD
EnergyScore, Inc	Towson	MD
FLC Energy	Salisbury	MD
Hometrust Remodeling	Laurel	MD
MarketEdge	Kensington	MD
Total Home Performance, LLC	Easton	MD
Wicomico Heating & Air, Inc	Salisbury	MD
Residential Energy Dynamics, LLC	Bethel	ME
Amply Energy	Cumberland Center	ME
Energy Circle	Portland	ME
Evergreen Home Performance LLC	Rockland	ME
New England Smart Energy	Albion	ME
OptiMiser, LLC	Kennebunk	ME
RS Insulation Inc	Bucksport	ME
Ampro Construction LLC	Hamtramck	MI
Decibel Energy	Ann Arbor	MI
Eco-Environmental Solutions	Detroit	MI
Green Projects Group	Grand Rapids	MI
Heiss Consulting Services LLC	Detroit	MI
Home Services	Kalamazoo	MI
HVAC U, LLC	Southfield	MI
Mid Michigan Spray Foam	Owosso	MI
Seal Tech Insulating Inc	Belleville	MI
Three-Ply Construction & Consulting, LLC	Detroit	MI
WMGB Home Improvement	Rockford	MI
Your Home Solution Experts	Canton	MI
Energy Design Consultants	Circle Pines	MN

Environmental Energy Consultants, LLC.	Park Hills	MO
Dickens and Associates	Carthage	MS
Green Door Energy, LLC	Greensboro	NC
John Tooley, LLC	Siler City	NC
Bailey Heating and A/C	Meadowlark	NE
National Property Inspections, Inc	Omaha	NE
Sunlight Energy Technology	Omaha	NE
Horizon RES NH LLC	Concord	NH
Comeback Farm Organic Produce	Asbury	NJ
Dalmar Energy Solutions LLC	Plainfield	NJ
MaGrann Associates	Mount Laurel	NJ
Utility Advantage, LLC	Woodstown	NJ
Vanguard Building Solutions, LLC	Voorhees	NJ
William G. Severino, Architect, LLC	Little Ferry	NJ
Yadkin Valley Economic Development District, Inc.	River Rd	NJ
ConservFirst	Raton	NM
EnergyWorks	Las Cruces	NM
EverGreen Building Solutions	Chimayo	NM
Action Energy Consultants	Greenwood Lake	NY
Adirondack Efficiency	Adirondack	NY
Airtight Services, Inc.	Marion	NY
Beneficial Insulation and Exteriors	New York	NY
Bright Power	New York	NY
CMC Energy Services	Piermont	NY
DickKornbluth, LLC	Syracuse	NY
Eash Blower Door	New York	NY
Energy Conservation Services, Inc	Port Ewen	NY
Energy Evolution Inc	Spring Valley	NY
Energy Savers Inc	East Syracuse	NY
Gaia Sharbel Energy	Poughkeepsie	NY
GEO Environmental Co., Inc.	Yorktown Heights	NY
Green Building Specialists	Pine Bush	NY
Green Home Logic	Ridgewood	NY
Green Pathway Consultants	Kerhonkson	NY
GreenStar Home Services	Buffalo	NY
Halco Home Solutions	Phelps	NY
Koala Insulation of Northern Westchester	Briarcliff Manor	NY
M&D Energy Audits / Weatherization Contractor	New York	NY
NYS Energy Solutions Inc	Bethpage	NY
SunComfort Solutions	New York	NY
Three Peaks Energy	Syracuse	NY
U.S. Light Energy	Latham	NY

Wise Home Energy LLC	Rochester	NY
Sealed	Fairport	NY
Apex Lead Inspections	Youngstown	OH
COAD/OWTC	Little Hocking	OH
Frangella's Energy Services	Galion	OH
Green Building Consulting	Cincinnati	OH
My Great Escape, LLC	Toledo	OH
Summit County HWAP	Akron	OH
TruTech Tools, LTD	Mogadore	OH
Cotton Electric Cooperative	Walters	OK
Retro Tec Insulation LLC	Bixby	OK
Aladdin Heating and Air Conditioning	Gresham	OR
All Phase Weatherization	Prineville	OR
Alpha Energy Savers Inc	Clackamas	OR
Good Energy Retrofit	Portland	OR
Multnomah County Weatherization	Portland	OR
Neil Kelly Design/Build	Portland	OR
Pat Elston Construction (retired)	Ashland	OR
Resilient Retrofits	Portland	OR
Advanced Efficiency Worx	York	PA
Bruce Wilson Contracting	Coopersburg	PA
Building Performance Architecture	Pittsburgh	PA
C. Driscoll Positive Energy Consulting	Connellsville	PA
Celentano Energy Services	Glenside	PA
DMI Companies	Charleroi	PA
Earth Forward Group	Belleville	PA
Energy Efficiency Empowerment	Pittsburgh	PA
MT Building Services	Harrisburg	PA
Solaire Energy	Canton	PA
TTR General Contractors	York	PA
Tallento Corp	Chapin	SC
Total Comfort Heating & Air Conditioning, Inc.	Rapid City	SD
Energy Home Basics	Lenoir City	TN
Building Performance Consultants	Cedar Park	TX
Knauf Insulation North America	Mc Kinney	TX
Kuehne HVAC	Florence	TX
Larson Energy Research	Dallas	TX
OGM Remodel & Rehab	San Antonio	TX
Greencat Utaha	Orem	UT
Home Energy Medics	Arlington	VA
Air Resolutions	Glen Allen	VA
Beel Group, LLC	Onemo	VA

Better Building Works LLC	Roanoke	VA
Building Performance Strategies	Louisa	VA
CvS Consulting, LLC	Arlington	VA
DMI	Arlington	VA
Hancock Software	Alexandria	VA
Home Energy Assessors	Henry	VA
Home Performance Consulting	Montross	VA
Home Performance Services	Richmond	VA
ICF	Reston	VA
3E Thermal	Peru	VT
Bruce Harley Energy Consulting LLC	Readsboro	VT
jwtGroup, PC	Chittenden	VT
Energy Savers, Inc	Seattle	WA
Green Built Insulation	Edmonds	WA
KW Energy LLC	Chewelah	WA
Mighty House Construction	Seattle	WA
PTU Construction	Vancouver	WA
SynerGreen	Spokane	WA
FWC Architects	Racine	WI
Norman Bair Consulting	Madison	WI
Ultimate Insulation	La Crosse	WI
Weatherization Service LLC	Milwaukee	WI
Franklin Energy	Washington	WI
EnergySmart LLC	Afton	WY

133 Residential Energy Efficiency Organizations:

National Association for State Community Services Programs	Atlanta	GA
Habitat for Humanity	Irons	MI
Montana Weatherization Training Center	Bozeman	MT
Community Action Agency of Northeast Alabama, Inc	Rainsville	AL
Community Service Programs of West Alabama	Vestavia Hills	AL
C-SCDC	Fort Smith	AR
A New Leaf	Mesa	AZ
Community Action Human Resources Agency- CAHRA	Eloy	AZ
Foundation for Senior Living	Phoenix	AZ
FSL Home Improvements	Phoenix	AZ
Rebuilding Together	Mesa	AZ
SEACAP	Safford	AZ
WACOG	Yuma	AZ
Central Coast Energy Services	Watsonville	CA
Efficiency First California	Sonoma	CA

Electric & Gas Industries Association	Sacramento	CA
Energy Resource Center - Berthoud	Pacifica	CA
Greater Bergen Community Action, Inc.	San Francisco	CA
MAAC PROJECT	Chula Vista	CA
North Coast Energy Services, Inc.	Ukiah	CA
Project GO, Inc.	Roseville	CA
Rebuilding Together Silicon Valley	San Jose	CA
American Solar Energy Society	Boulder	CO
Energy Resource Center	Colorado Springs	CO
Energy Resource Center - Denver	Denver	CO
Energy Resource Center - Sterling	Sterling	CO
Energy Smart Colorado	Frisco	CO
Housing Resources of Western Colorado	Grand Junction	CO
Northwest Colorado Council of Governments	Silverthorne	CO
Open Arms Community Center	Olympia Heights	FL
Center for Independent Living	Orlando	FL
Centro Campesino Farmworker Center Inc	Florida City	FL
Menominee Delta Schoolcraft Community Action Agency	St. Petersburg	FL
Coastal Plain Area E.O.A., Inc.	Valdosta	GA
Southwest Georgia Regional Commission	Camilla	GA
Hawaii County Economic Opportunity Council	Hilo	HI
ICRT	Champaign	IL
Illinois Association for Community Action Agencies	Springfield	IL
Western Illinois Regional Council	Macomb	IL
Brightpoint	Fort Wayne	IN
Area IV Agency on Aging and Community Action Programs, Inc.	Winamac	IN
Community Action of Greater Indianapolis, Inc.	Indianapolis	IN
Indiana Community Action Association	Indianapolis	IN
Ohio Valley Opportunities, Inc. (OVO)	Madison	IN
East Central Kansas Economic Opportunity Corporation	Ottawa	KS
Bell-Whitley Community Action Agency	Pineville	KY
West Kentucky Allied Services Inc	Mayfield	KY
Evangeline Community Action	Broussard	LA
Quad Area Community Action Agency	Hammond	LA
Citizens for Citizens	Fall River	MA
Preservation of Affordable Housing	Somerville	MA
Weatherization	Taunton	MA
Garrett County Community Action Committee	Oakland	MD
National Center for Healthy Housing	Columbia	MD
Build Green Maine	Brooks	ME
Community Concepts Inc	Lewiston	ME

E4 the Future	Scarborough	ME
Kennebec Valley Community Action	Vienna	ME
Kennebec Valley Community Action Program	Waterville	ME
York County Community Action	Sanford	ME
Community Action of Allegan County	Allegan	MI
8 Cap	Lakeview	MI
Michigan Energy Efficiency Contractors Association	East Lansing	MI
Mid-Michigan Community Action Agency	Clare	MI
Washtenaw County Community & Economic Development	Milan	MI
Community Action Partnership of Ramsey and Washington Counties	Saint Paul	MN
Center for Energy and Environment	Minneapolis	MN
Just Housing SBC	Duluth	MN
Community Action Agency of Greater Kansas City	Kansas City	MO
Mission: St. Louis	St. Louis	MO
Delta Design Build Workshop	Greenwood	MS
Warren-Washington-Issaquena-Sharkey Community Action Agency, Inc.	Greenville	MS
Western Piedmont Council of Governments	Hickory	NC
Central Nebraska Community Action Partnership	Loup City	NE
Blue Valley Community Action	Wymore	NE
Healthy Housing Omaha	Bellevue	NE
Gateway Community Action Partnership	Bridgeton	NJ
HomeWise, Inc.	Cherry Hill	NJ
Isles, Inc.	Trenton	NJ
Rural Nevada Development Corp	Ely	NV
Rural Nevada Development Corporation	Ely	NV
Washtenaw County	Kenmore	NY
Association for Energy Affordability, Inc	Bronx	NY
Building Performance Contractors Association of NYS	Sackets Harbor	NY
Building Performance Institute	Saratoga Springs	NY
Chautauqua Opportunities	Jamestown	NY
Green Energy Times	East Berne	NY
Hanac Weatherization	Astoria	NY
Home HeadQuarters	Syracuse	NY
Joint Council for Economic Opportunity of Clinton and Franklin Counties	Plattsburgh	NY
LifeWorks Community Action	Ballston Spa	NY
New York Energy Assessments	White Plains	NY
SEVCA	Gordon Heights	NY
Sunset Park Redevelopment Committee	Brooklyn	NY
Supportive Services Corporation	Lancaster	NY

Sustainable Westchester	Mount Kisco	NY
Tioga Opportunities	Owego	NY
Community Action Commission of Fayette County	Washington Court House	OH
Community Resources Weatherization Department	Beverly	OH
North Central Community Action Program, Inc.	Portsmouth	OH
Ohio Heartland CAC	Marion	OH
Community Energy Project	Portland	OR
Multnomah County	Portland	OR
Philadelphia Solar Energy Association	Wyndmoor	PA
Central Pennsylvania Community Action, Inc.	Clearfield	PA
Agency for Community EmPOWERment of NEPA	Lake Ariel	PA
Building Performance Association	Pittsburgh	PA
Central PA Community Action	Philipsburg	PA
Pittsburgh Gateways Corp	Pittsburgh	PA
Tableland Services, Inc.	Stoystown	PA
Trehab	Montrose	PA
Keystone Energy Efficiency Alliance	Philadelphia	PA
Blackstone Valley Community Action	Pawtucket	RI
Aiken/Barnwell Counties Community Action Agency	North Augusta	SC
Waccamaw Economic Opportunity Council Weatherization	Conway	SC
Wateree Community Actions	Sumter	SC
BakerRipley	Cypress	TX
Community Action Corporation of South Texas	Alamo	TX
Community Council of South Central Texas	Seguin	TX
Economic Opportunities Advancement Corporation	Waco	TX
Panhandle Community Services	Amarillo	TX
South Plains Community Action Agency	Levelland	TX
Southface Institute	Abilene	TX
Greenbound	Richmond	VA
Benton Franklin CAC	Pasco	WA
OIC of Washington	Yakima	WA
La Casa De Esperanza	Waukesha	WI
RKCAA	Racine	WI
CHANGE, INC	Weirton	WV
Community Resources Inc	Parkersburg	WV
Community Resources Inc.	Parkersburg	WV
Energy Efficient WV	Charleston	WV
Nicholas Community Action Partnership, Inc.	Summersville	WV

394 Individual Home Performance Contractors and Stakeholders:

Dara Michels	Juneau	AK
Keith Hall	Anchorage	AK
Amy Calhoun	Montgomery	AL
David Hannah	Bryant	AR
Melissa Alumbaugh	Benton	AR
Elena Chrimat	Tempe	AZ
Joshua Manuel	Ajo	AZ
Shaun Smiley Scott	Phoenix	AZ
Carrie Nawrocki	Globe	AZ
Manuela perez	Mesa	AZ
Eva Felix	Mesa	AZ
Jessica Magee	Flagstaff	AZ
Katie Martin	Chandler	AZ
Marysol Rivera	Mesa	AZ
Michael Martinez	Mesa	AZ
Christina Camargo	San Fernando	CA
David Leanos	Bell	CA
David Parker	Aromas	CA
Derek Ryder	Los Angeles	CA
Halla Dontje Lindell	Los Angeles	CA
Joy Sledge	Oakland	CA
Ruby Ranoa	Santa Cruz	CA
Susana Apeles	Los Angeles	CA
Sydney Hannum	Camarillo	CA
Tom White	Antioch	CA
Robert Sykes	Monrovia	CA
Chandra Apperson	Sonoma	CA
Daniela Grismich	Berkeley	CA
Jason Kempen	San Francisco	CA
Keith O'Hara	Walnut Creek	CA
Leslie Koenig	Grand Junction	CO
Michelle Warren	Fort Collins	CO
Will Clagett	Fort Collins	CO
Cody Kumar	Avon	CO
Anna Ballweber	Colorado Springs	CO
David Malouff	Alamosa	CO
Dylan Townsend	Berthoud	CO
John Whetzal	Colorado Springs	CO
Jonathan Judd	Berthoud	CO
Lindsee Vidaurri	Berthoud	CO

Marcus Redden	Colorado Springs	CO
Matthew Harris	Denver	CO
Michael Mitchell III	Loveland	CO
Michelle Butler	Edgewater	CO
Sawyer Manus	Loveland	CO
William Froehlich	Berthoud	CO
Michael Frownfelter	Bridgeport	CT
Patrick McCafferty	Birmingham	CT
Frank Wilsey	Hamden	CT
Alex Aquino	Tarpon Springs	FL
Ann Huskey	Miccosukee Cpo	FL
Shawn Angell	Hollywood	FL
Bram McKinley	Bradenton	FL
Daniela Archbold	DeLand	FL
James McKinley	Bradenton	FL
Scott Patrick	Yulee	FL
Amy Shyers	Decatur	GA
Emilio Carlos	Loganville	GA
Mike Barcik	Decatur	GA
Quenton Talley	Duluth	GA
Tomorrow Bowen	Lithonia	GA
Diane Chojnowski	Fairfield	IA
Teresa Tague	Marshalltown	IA
Claude Papesh	Newhall	IA
Toby Noller	Urbana	IL
Abigail Antoniazzi	Willow Springs	IL
Alex Arellano	Chicago	IL
Bethany Ragains	Champaign	IL
Bradley Wiesneth	Westmont	IL
Carlin Witte	Peoria	IL
Cynthia Mitchell	Urbana	IL
Dan Maksymiw	Chicago	IL
Daniel Alvarez	Chicago	IL
David E Hawk	Bushnell	IL
Kristopher Chapman	Champaign	IL
Lori Shupe	Champaign	IL
Marcy Mulholland-Chandler	South Holland	IL
Matthew Canvin	Oak Forest	IL
Pete Kutcher	Chicago	IL
Krystal Rose Luie	Kankakee	IL
Alan Duden	Gifford	IL

Antonio Williams	Blue Island	IL
Donovan Herman	Chicago	IL
Ebony Buchanan	Dolton	IL
Jan Dickson	South Holland	IL
Jeanine Otte	Chicago	IL
Justin Arnold	Champaign	IL
Micheal Edwards	Kewanee	IL
Mike Berkowitz	Chicago	IL
Nathaniel Strink	Fisher	IL
Sharon Moore	Chicago	IL
Yigang Sun	Champaign	IL
Alyson Alde	Bloomington	IN
Lisa Zakowski	South Bend	IN
Rosa Tomas	South Bend	IN
Jeff Rowlett	Madison	IN
Micah Curry	Madison	IN
Robert Simms	Ottawa	KS
Linda Wood	Ottawa	KS
Nicholas Pfeifer	Lawrence	KS
Shondi Larios	Ottawa	KS
Rocky Fulcher	Vine Grove	KY
Shelby Reed	Paducah	KY
Stephanie Plumb	Mount Sterling	KY
Kent Dodd	Mayfield	KY
Wesley Melson	Columbia	KY
Michelle Hughes	Mansfield	LA
Mercedes Amador	Folsom	LA
Jeffrey Eccles	Madisonville	LA
Keith Swartz	Monroe	LA
Pam Lewandowski	Baton Rouge	LA
Debra Cassisa	Hammond	LA
Kevin Ring	Methuen	MA
Kristopher Pieper	Springfield	MA
Abbie Phillip	Westfield	MA
Abigail Chouinard	Amherst	MA
Alexander Moceri	Mattapoisett	MA
Derek Lanotte	West Boylston	MA
Emylee Patenaude	Boston	MA
Francis Cummings	Concord	MA
Joseph Panzera	Worcester	MA
Kevin Lightfield	Tewksbury	MA

Kobe Billington	Medford	MA
Michael Hathaway	Palmer	MA
Samantha Magnan	Medford	MA
Scott DeFlaminis	Medford	MA
Steven Antonini	Marlborough	MA
Stuart Zimmerman	Natick	MA
Suzanne Smith	Hyannis	MA
Zadek Burstein	Woburn	MA
Audrey Pacious	Brookline	MA
Allison Jolley	Waban	MA
Abby Kessler	Medford	MA
Alyssa Webster	Newton	MA
Bartman Wilson	Plymouth	MA
Ben Cressy	Boston	MA
Brian Foss	Sandisfield	MA
Christina Michaud	Medford	MA
Christopher Ryan	Oxford	MA
Frank Armentano	Brighton	MA
Helene Scott	Salem	MA
Jane Tekin	North Adams	MA
Jessica Levarity	Billerica	MA
Jim Brown	Waltham	MA
Kenneth Strout	Monson	MA
Kevin Cho	Medford	MA
Martijn Fleuren	Medford	MA
Natasha Lyman	Medford	MA
Rachel Surette	Medford	MA
Scott Dinsmore	Medford	MA
Amparo Rodriguez	Dundalk	MD
Anisha Carr	Silver Spring	MD
Dodie Foster	Easton	MD
Larry Price	Easton	MD
Madison Hammon	Easton	MD
Sunita Pathik	Baltimore	MD
Tara Jenkins	Williamsport	MD
Bryan Koerber	Pasadena	MD
Robert Relyea	Easton	MD
Al Schwartz	Baltimore	MD
Alex Dumont	Avenue	MD
G Andrew Bauer	Baltimore	MD
Guthrie Matthews	Easton	MD

Hunter Arthur	Easton	MD
Lluis M. Vaca Soto	Rockville	MD
Logan Smith	Easton	MD
Mark Holden	Easton	MD
Megan Murray	Laurel	MD
Robert Mullikin	Easton	MD
Shelby Vogel	Easton	MD
Tylor Deeds	Chesapeake Beach	MD
Zach Thomas	Queenstown	MD
Michelle Eaton	Winterport	ME
Sierra Powers	Waterville	ME
Brian Robinson	Rockland	ME
Ben Dueweke	Detroit	MI
Cheryl Laban	Mio	MI
Christopher Nagy	Holland	MI
Craig Levi	Clare	MI
David Anderson	Detroit	MI
Glen Butt	Harrison Township	MI
Guy Taylor	Livonia	MI
Jacob West	Allegan	MI
Jake Fryer	Harrison	MI
Jesse Heath	Clare	MI
Joe Manzella	Clinton Township	MI
Jolie Trombley Williams	Okemos	MI
Koby Grider	Stanton	MI
Krista McPhall	Clare	MI
Morgan Wykoff	Clare	MI
Rachel Lenardon	South Lyon	MI
Robert Riley	Mason	MI
Sean Metivier	Detroit	MI
Timothy Cotter	Springfield	MI
Tom Tishler	Kalamazoo	MI
Carlee Knott	Lansing	MI
Patricia Sousley	Allegan	MI
Rhonda Sweat	Burton	MI
Walter Gayeski	Traverse City	MI
Spenser Christensen	Marshall	MN
Anna Wiebe	Minneapolis	MN
Brian Fisher	Saint Paul	MN
Carl Knetsch	Minneapolis	MN
Curtis Bird	Minneapolis	MN

Elliott Cudak	Saint Paul	MN
Emily Beltt	Saint Paul	MN
Jeff Theis	Minneapolis	MN
Patrick Keiser	Bemidji	MN
Paul Cole	Minneapolis	MN
Sarah Northrup	Saint Paul	MN
Tony Beres	Saint Paul	MN
Angeline Quilt	Minneapolis	MN
Matthew Douglas-May	Minneapolis	MN
Raymond Dickson	Saint Paul	MN
Darryl Irvin	St. Louis	MO
Jason Pletz	Jefferson City	MO
John Krull	Kansas City	MO
Lake Graham	Drexel	MO
Martha Crites	Farmington	MO
Beatrice Parks	Saint Louis	MO
Frederick love	Arcola	MS
James Davis	Jackson	MS
Charity Thomas	Flowood	MS
Christopher Williams	Hattiesburg	MS
Byron Pederson	Butte	MT
Tony Mullen	Boyd	MT
Jake Perrin	Bozeman	MT
Jacob Stephens	Candor	NC
Paul Swenson	Greensboro	NC
Seth Little	Asheville	NC
Carlos Rendon	Charlotte	NC
Jayden Erdmann	Bismarck	ND
Skylar Quast	Bismarck	ND
Daryll Lawson	Bismarck	ND
Douglas Hoffman	Bismarck	ND
Katie Schultis	Fremont	NE
Tim Kruger	Loup City	NE
Shari Weber	Fairbury	NE
Craig Yergeau	Manchester	NH
Jennifer Butzgy	Phillipsburg	NJ
Katie Consales	Princeton Junction	NJ
Kevin Schwartzbach	Princeton	NJ
Matthew Mahon	Camden	NJ
Michael Tooher	Riverton	NJ
Miriam Genovesi	Elizabeth	NJ

Siegel Frederic	East Orange	NJ
Annette Coggins	Bridgeton	NJ
Martin Kushler	Farmington	NM
Anthony Natale	Reno	NV
Meg Rhoades	Ely	NV
August Ruckdeschel	Patchogue	NY
Christopher Johnson	Brooklyn	NY
John bisgrove	Auburn	NY
LeAnne Harvey	Brooklyn	NY
Mark DeChiro	Albany	NY
Mark Froloff	New York	NY
Matt Oyer	Rochester	NY
Ronald Gill	Red Creek	NY
Sage Ray	Brooklyn	NY
Thomas Platten	Canaan	NY
Will Tompkins	Falconer	NY
Zach Merrin	Schenectady	NY
Darlene Welch	Saratoga Springs	NY
Mason Donovan	Niagara Falls	NY
Becca Bostwick	New York	NY
Chelsea Jagdat	Queens	NY
Elena Ribota	New York	NY
Jake Greenbaum	Batavia	NY
Laura Natalzia	Buffalo	NY
Liston Freeman	Woodstock	NY
Lynn Franz	Saratoga Springs	NY
Michele Calabrese	Islip	NY
Scott Fitzpatrick	Queens	NY
Sebastien Desrochers	Pomona	NY
Angie Dickerson	Athens	OH
Carmillia Zion	Lima	OH
Devon Cooper	Athens	OH
Douglas Pearl	Thornville	OH
Jonathan Harrington	Columbus	OH
Kimberly Glaser	Independence	OH
Alissa Wormwood	Salem	OR
Jared Kennedy	Eugene	OR
Wesley Shorack	Eugene	OR
Francisco J. Venegas	Klamath Falls	OR
Andy Ortiz	Salem	OR
James Richmond	Portland	OR

Bethany Sowinski	Pittsburgh	PA
Charles Ilich	Ardmore	PA
Cory Merrbach	Everett	PA
James Bingley	Hatfield	PA
Jennifer Saks	Pittsburgh	PA
Kerri Weitzel	Williamsport	PA
Kristel Shearer	York	PA
Nicholas Skari	Philadelphia	PA
John Kolesnik	Philadelphia	PA
Beth Somishka	Bethlehem	PA
Mark Rich	Manchester	PA
Molly Miller	Somerset	PA
Nick Richardson	Hamburg	PA
Richard Jones	Red Lion	PA
Scott Hudach	New Castle	PA
Ted Adamerovich	Latrobe	PA
David Mello	Cranston	RI
Elija Hernandez	Pawtucket	RI
Emerson Gomez	Warwick	RI
Eric Anderson	Columbia	SC
Aaron Walker	Nashville	TN
Andrew Swallow	Blountville	TN
Felisha Nichols	Nashville	TN
Keith Canfield	Mount Juliet	TN
Matthew Kolb	Carthage	TN
Rebecca Eckman	Oak Ridge	TN
Tuesday Hampton	Antioch	TN
Nicole Feild	Memphis	TN
Vicky Campbell	Johnson City	TN
Alicia Avila-Penalver	San Antonio	TX
Carol Delgado	Seguin	TX
Doug Misenheimer	Manor	TX
Leonel Rangel	Austin	TX
Lohany Smith	Houston	TX
Manuel Peguero	Houston	TX
Mario Tamez	San Antonio	TX
Yancey Turner	Dallas	TX
Yeimy Gil	Houston	TX
Jhoanna Cardozo	Houston	TX
Andre Fuhrman	Converse	TX
Ariel Kaufman	Spring	TX

Benita San Miguel	Amarillo	TX
Brian Nickisch	Shavano Park	TX
Jabrone Laktzian	San Antonio	TX
Kari Kuiper	Lufkin	TX
Karla Ojeda	San Antonio	TX
Larry Wallace	Rowlett	TX
Nicholas LeRoy	Irving	TX
Selam Aklog	Richardson	TX
Stephanie Patrick	Houston	TX
Osvaldo Saldana	Vineyard	UT
Steven Libardi	Pleasant Grove	UT
Hillary Tipton	Springfield	VA
Marla Emmett	Roanoke	VA
Miritza Thorpe	Stafford	VA
Bill Graham	Woodlawn	VA
Brook Vernon	Marion	VA
Autumn Strom	Winooski	VT
Juliana Bortz	Colchester	VT
Keelin Banks	Groton	VT
Nora McCleary	Groton	VT
Marc Therrien	Waterbury	VT
Claudia Marken	Concrete	WA
Darrell Oakley	Tekoa	WA
John Ricci	Tukwila	WA
Kris Forck	Bellingham	WA
Regena Williams	Kenmore	WA
Terry Emelander	Tekoa	WA
Vincent Feltes	Spokane Valley	WA
Doug Elfline	Seattle	WA
Andrew Ramirez	Yakima	WA
Frank Martinez	Yakima	WA
Luisa Perez	Yakima	WA
Matt Shirer	Long Beach	WA
Michael Johnson	Tacoma	WA
Brendon Shoemaker	Madison	WI
Hung Yang	Milwaukee	WI
Jesse Cortez	Waukesha	WI
Karen Schwab	Appleton	WI
Kimberly Minks	Appleton	WI
Les Schmidt	Lancaster	WI
Lisa Fischer	Madison	WI

Marc Loeffler	Waukesha	WI
Michelle McGee	Racine	WI
Nat Peplinski	Hudson	WI
Nate Loniello	Waukesha	WI
Patrick Larkin	Waukesha	WI
Christine Wales	Neenah	WI
Alex Arcos	Greenfield	WI
Andrew Munoz	Milwaukee	WI
Dave Herlitzke	La Crosse	WI
Devin Hawthorne	Milwaukee	WI
Edwin Marquez	South Milwaukee	WI
Francisco Munoz	Milwaukee	WI
Rachel Pontius	Kaukauna	WI
Samuel Moran	Milwaukee	WI
Steve Williams	Neenah	WI
Travis Rutter	Appleton	WI
William Ureña	Milwaukee	WI
Cody Conway	Charleston	WV
Dustin Dillon	Kistler	WV
Angela Williams	Summersville	WV
Ben Shannon	Charleston	WV
Charles Chamberlain	Charleston	WV
Cindy Foster	Summersville	WV
Kevin Wynn	Charleston	WV
William Balderson	Parkersburg	WV
Diana Hedlund	Crowheart	WY

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Hon. James E. Risch (R-ID)
Hon. Steve Daines (R-MT)
Hon. Tom Cotton (R-AR)
Hon. David McCormick (R-PA)
Hon. James C. Justice (R-WV)
Hon. Bill Cassidy (R-LA)
Hon. Cindy Hyde-Smith (R-MS)
Hon. Lisa Murkowski (R-AK)
Hon. John Hoeven (R-ND)

Hon. Ron Wyden (D-OR)
Hon. Maria Cantwell (D-WA)
Hon. Mazie K. Hirono (D-HI)
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