The Retrofit Lab
DRAFT Strategic Plan

I. Introduction

The nonprofit Retrofit Lab is on a mission to improve the energy efficiency and sustainability of American homes by developing a community of stakeholders with the tools, knowledge, and resources necessary to transform the current stock of housing. Our community-based approach provides training, outreach and technical assistance to create pathways for deep energy retrofits of existing single-family homes. Our goal is to increase the accessibility and affordability of energy-efficient upgrades and normalize these methods of home renovation by transforming our single-family retrofit projects into classrooms for homeowners, architects, and construction professionals.

II. The Retrofit Challenge

A 2022 report by the UN International Panel on Climate Change has sounded the alarm: the health of our planet has been rapidly deteriorating and insurmountable destruction can only be slowed through massive and immediate efforts to reduce greenhouse gas (GHG) emissions. [1] In response to this growing threat, the Biden Administration has set an ambitious nationwide goal of 50% reduction in GHG emissions by 2030.[2] In the United States, residential buildings consume nearly one-fifth of all non-renewable energy.[3] Thus, any strategy to reduce GHG emissions must include substantial energy-efficiency upgrades to the current stock of American homes.

There are an estimated 120 million households in the United States, the vast majority of which predate any modern conservation building codes. For example, in the Northeast US, about 70% of homes were built more than 40 years ago.[4] Aging homes often lack proper insulation and air sealing, are heated and cooled by outdated inefficient mechanical equipment, and rarely utilize renewable energy sources. In addition to wasting electricity and other fossil fuels such as natural gas, older homes are often

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[1] Porter, Hans-O, et al. (27 February 2022). Climate Change 2022: Impacts, Adaptation and Vulnerability. Geneva: Intergovernmental Panel on Climate Change. Retrieved 3/21/22 from https://report.ipcc.ch/ar6wg2/pdf/IPCC_AR6_WGII_FinalDraft_FullReport.pdf .

[2] The White House, 2021. Fact Sheet: President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target. Retrieved 1/20/2022 at https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-president-biden-sets-2030-greenhouse-gas-pollution-reduction-target-aimed-at-creating-good-paying-union-jobs-and-securing-u-s-leadership-on-clean-energy-technologies/ .

[3] EIA, 2020. “U.S. Energy Information Administration. Monthly Energy Review.”

[4] Lauren Shwisberg, Mark Dyson, Genevieve Lillis, Avery McEvoy, and Jon Creyts, Bringing Clean Energy Home: Unlocking Innovation and Policy to Align US Household Energy Use with Ambitious Climate Targets, RMI, 2021, https://rmi.org/insight/bringing-clean-energy-home/

For More Info, Contact: Nicole Tysvaer (nicole@symbihomes.com)

uncomfortable and unhealthy with imbalanced temperatures, humidity problems, and poor indoor air quality.[5]

Yet, despite our aging housing stock, less than 1% of American homes currently receive any sort of energy-saving upgrades each year,[6] a tiny slice of the $400 billion home remodeling industry. [7] RMI estimates that the US will need to retrofit at least 4 to 6 million homes annually to reach our 50% GHG reduction target by 2030.[8] Retrofitting at this scale will require a massive home restoration initiative with aggressive targets for insulation, air sealing, new mechanical equipment and appliances, window replacements, and installation of renewable energy systems.

The recently passed Inflation Reduction Act of 2022 (IRA) will provide billions in financial incentives for homeowners to pursue energy-efficient upgrades such as heat pump HVAC and hot water systems, solar panels, and electric appliances.[9] This unprecedented level of funding to support retrofits can help pave the way towards dramatically reducing fossil fuel consumption in the built environment. However, distribution of these incentives will require overcoming a multitude of implementation obstacles.

Research by the Rocky Mountain Institute highlights some of these obstacles such as low homeowner demand, lack of information on retrofit options, unknown benefits and payback period, and the complexity of decarbonization solutions.[10] A 2020 national survey of contractors completing deep energy retrofit projects (minimum 50% reduction in annual energy consumption as a result of upgrades) underscores the friction in the process, as the respondents cited "lack of reliable, trained home performance workforce," "customer acquisition and education," and "complexity of work scope" as barriers to growing the retrofit demand.[11] Several responses alluded to homeowners' reluctance to trust the process, a reminder that advancements in home performance technology, as with all new technologies, must overcome significant hurdles to market adoption.

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[5] Tan, Yu Ann and Bomee Jung (2021). Decarbonizing Homes Improving Health in Low-Income Communities through Beneficial Electrification. Basalt, CO: Rocky Mountain Institute.
[6] Tan et al (2021).
[7] Joint Center for Housing Studies (2021). Improving America's Housing. Boston: Harvard University.
[8] Lauren Shwisberg, Mark Dyson, Genevieve Lillis, Avery McEvoy, and Jon Creyts (2021). Bringing Clean Energy Home: Unlocking Innovation and Policy to Align US Household Energy Use with Ambitious Climate Targets, Rocky Mountain Institute. Retrieved 1/4/2022 at https://rmi.org/insight/bringing-clean-energy-home/.
[9] See summary of efficiency incentives at https://www.rewiringamerica.org/policy/inflation-reduction-act.
[10] Shwisberg et al, 2021.
[11] Chan, Wanyu, Less, Brennan, and Walker, Iain (2021). *DOE Deep Energy Retrofit Cost Survey.* Berkeley, CA: US Department of Energy Lawrence Berkeley National Laboratory. Retrieved 2/7/2022 at https://eta-publications.lbl.gov/sites/default/files/doe_deep_energy_retrofit_cost_survey_-_lbnl_report.pdf.

III. Deep Energy Retrofit Defined

The term "retrofit" in the construction industry describes any measure taken to improve the energy conservation, thermal performance, or maintenance of an existing building.[12] Retrofit projects may include upgrades to mechanical systems, insulation or air sealing the building envelope[13], and installation of energy-efficient appliances, lighting or plumbing fixtures. This process of reducing energy consumption and increasing comfort in homes is also sometimes referred to as "weatherization" or "home performance upgrades."

State and local government agencies have implemented retrofit programs to encourage utility companies and homeowners to conserve energy, offering rebates and other incentives to subsidize improvements to residential buildings. For example, the Maryland EmPOWER program mandates that utility companies offer free and low-cost energy audits and subsidized home improvement projects through certified contractor networks. Over the program's 12-year history, EmPOWER has exceeded its legislative goals for energy conservation statewide reporting a cumulative savings of 12 million MWh (that's enough electricity to power all of New York City for more than three years).[14]

Yet, while the initiative has surpassed expectations in terms of overall energy reduction, evaluations of EmPOWER reveal somewhat modest changes at the consumer level. One study of low-income housing found a somewhat modest average of 15-20% reduction in customer utility bills as a result of EmPOWER improvements.[15] Evaluations of a similar program in California have shown an especially disappointing <10% savings in electrical power usage.[16]

Achieving our 2030 national goal of 50% reduction in GHG emissions will require substantially higher levels of conservation, a process referred to as a "deep energy retrofit" (DER). The US Department of Energy defines DER as:

> A major building renovation project in which site energy use intensity (including plug loads) has been reduced by at least 50% from the pre-renovation baseline with a

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[12] Krigger, John (2014). *Residential Energy: Cost Savings and Comfort for Existing Homes.* Helena, MT: Saturn Resource Management.

[13] The "building envelope" refers to the physical barrier of a building that separates and protects interior from exterior elements. The envelope consists of the foundation, exterior walls, windows, exterior doors, and roof of a building.

[14] Public Service Commission of MD (2021). *The EmPOWER Maryland Energy Efficiency Act Report of 2021.* Baltimore, MD. Available at www.psc.state.md.us.

[15] Environmental Protection Agency (2017). Case Study: EmPOWER Maryland Leveraging Relationships and Experience. Washington, DC: EPA State and Local Climate and Energy Program.

[16] Less, Brennan, Walker, Iain, and Casquero-Modrego, Nuria, 2021. Emerging Pathways to Upgrade the US Housing Stock: A Review of the Home Energy Upgrade Literature. Berkeley, CA: US Department of Energy Lawrence Berkeley National Laboratory. Retrieved 2/7/2022 at https://www.researchgate.net/profile/Nuria_Casquero-Modrego2/publication/351075578_Emerging_Pathways_to_Upgrade_the_US_Housing_Stock_A_Review_of_the_Home_Energy_Upgrade_Literature/links/608345c5881fa114b423bdea/Emerging-Pathways-to-Upgrade-the-US-Housing-Stock-A-Review-of-the-Home-Energy-Upgrade-Literature.pdf.

corresponding improvement in indoor environmental quality and comfort. DERs demand a more thorough, whole-house approach than a typical retrofit or remodel. This approach must take into account all the energy uses in the home, as well as the activities of the occupants. [insert reference]

At its core, the process of a home retrofit for deep energy reductions targets building efficiency, occupant comfort and well-being through a series of home renovation projects that can be summarized into three categories: **(1) ENERGY REDUCTION: Equipment and Appliances** including heating and cooling units and hot water heaters; **(2) ENERGY CONSERVATION: Insulation and Air Sealing** of the foundation, walls, windows, roof and duct work; and **(3) ENERGY PRODUCTION: Renewable Energy Production** such as solar panels and geothermal systems. See Table 1. below for a summary of home improvements that may be addressed within each DER core component category.

Core Components of a Deep Energy Retrofit		
Energy Reduction: Equipment and Appliances	**Energy Conservation: Insulation and Air Sealing**	**Energy Production: Renewables**
- Install new HVAC equipment with heat pump technology - Replace outdated appliances with Energy Star certified appliances - Install mechanical ventilation (preferably ERV or HRV), filtration, and dehumidification - Replace domestic hot water heater with a high efficiency unit (tankless or electric heat pump) - Efficient lighting and plumbing fixtures - Prioritize electrification where feasible	- Optimize insulation properties of the home's exterior shell including foundation, walls, windows, exterior doors and roof structure - Identify and seal areas of thermal bridging - Seal all duct work	- Introduce new methods of onsite renewable energy production such as solar PV panels or shingles and geothermal systems - When onsite production is not feasible, explore community renewable energy opportunities - Install solar-powered backup battery storage

Table 1. Core Components of a Deep Energy Retrofit Home Improvement Project

A 2021 literature review by the US Department of Energy's Lawrence Berkeley National Laboratory identifies 13 DER programs, many of them state-sponsored initiatives, with a combined more than 25,000 projects completed across the U.S. (see Table 2).[17] Promising practices include:

- The ZEN pilot program of 24 single-family homes in Vermont, which has achieved an average 64% energy savings by combining modest envelope sealing with cold climate heat pumps and rooftop solar panels at an average cost of $54,500 per project.

- Energiesprong, an initiative launched in the Netherlands in 2013, which has developed a tech-driven process for scaling home retrofit production combining pre-fabricated exterior insulation panels, updated mechanicals, and solar panels to achieve a Net Zero performance standard. To date, Energiesprong has retrofitted more than 5,000 homes in the Netherlands and is expanding throughout Europe.

- Sealed.com, a New York-based energy technology and financing firm, which performs remote energy audits, offers no-money-down financing for some upgrades, and connects homeowners to qualified contractors. Similar to Energiesprong, Sealed.com Co-Founder Andy Frank champions performance guarantees to customers, saying "finance innovation is key, and we are a catalyst to unlock the money that homeowners are wasting on energy and transition to performance."[18] The company uses data analytics to identify homes that would most benefit from their upgrades in communities in the Northeast US, attracting customers by appealing to homeowners' interests in enhancing the comfort, health and safety of their homes.

The Berkeley literature review highlights several best practices emerging from the research such as the importance of a whole-home comprehensive approach to maximize energy conservation, comfort and health benefits of a DER project. Researchers caution that while it's common to "phase in" home improvements over time to minimize upfront costs and household disruptions, phasing without a holistic plan can have negative consequences, as well. For example, focusing solely on sealing the building envelope can create problems with indoor air quality if not mitigated with proper mechanical ventilation. Phasing can make it more difficult to properly size HVAC equipment (e.g. are you modeling mechanical loads based on the home as-is, or with a fully insulated package?). Researchers also found

[17] Less, Brennan, Walker, Iain, and Casquero-Modrego, Nuria, 2021. Emerging Pathways to Upgrade the US Housing Stock: A Review of the Home Energy Upgrade Literature. Berkeley, CA: US Department of Energy Lawrence Berkeley National Laboratory. Retrieved 2/7/2022 at https://www.researchgate.net/profile/Nuria_Casquero-Modrego2/publication/351075578_Emerging_Pathways_to_Upgrade_the_US_Housing_Stock_A_Review_of_the_Home_Energy_Upgrade_Literature/links/608345c5881fa114b423bdea/Emerging-Pathways-to-Upgrade-the-US-Housing-Stock-A-Review-of-the-Home-Energy-Upgrade-Literature.pdf.
[18] Andy Frank Habitat X webinar (2019) "A Bullish Approach to Home Performance" https://vimeo.com/348905443

that strategies narrowly targeting electrification can have the unintended consequence of increasing overall energy usage either by switching appliances from gas to electric, or by introducing new electrical equipment such as ventilation and whole house dehumidification.[19]

Program Name	Number of Homes	Average Cost ($)	Average Site Energy Savings
Energy Upgrade California - CA	20,000	$6,300	274 kWh, 16 Therms
Zero Energy Now - VT	24	$54,500	39% delivered site energy savings; 64% fossil fuel and grid energy savings; 60% energy cost savings
Home MVP – MA: Deep	66	$49,126	48%
Home MVP – MA: All	341	$21,675	33%
Extreme Energy Makeovers - TN	3,420	$9,000	35% (4,900 kWh)
National Grid Deep Energy Retrofit Pilot Community - MA and RI	60	$34.59 /ft²	55%; 43% source energy savings
FSEC DERs - FL	10	$14,323	38%
FSEC DERs - FL	70	$16,424	30%
EnergyFIT Philly - PA	67	$14,257	36% gas, 22% electric
EnergySmart Ohio - OH	11	$30,173	
Home Intel by Home Energy Analytics - CA	1,400	Effectively zero	10%
Home Intel by Home Energy Analytics - CA	16	Effectively zero	42% electric, 17% gas
Sealed - NY	338	$10,000	20% heating, 5% electricity

Table 2. Summary of Deep Energy Retrofit Programs with Performance Data (Source: Less et al, 2021). [request permission to reprint]

The Berkeley reviewers also explain how DER designers have been working to simplify and economize retrofit solutions over the past decade. For example, promising practices appear to be moving away

[19] Brennan Less & Iain Walker 2015. Deep Energy Retrofit Guidance for the Building America Solutions Center. US DOE Environmental Energy Technologies Division, Berkeley National Laboratory. Accessed https://eta.lbl.gov/publications/deep-energy-retrofit-guidance on Jan 21, 2022.

from super tight Passive House standards[20] for envelope sealing in favor of a more balanced approach of energy-efficient upgrades and renewables that are less costly, less labor intensive, and less intrusive for homeowners. The Vermont ZEN program provides an example of such a balanced approach.

While the research offers some high-level outcome data regarding energy reduction (see Table 2), more detailed and descriptive results of the retrofit demonstrations seem to be missing, particularly in terms of homeowner/occupant feedback. Studies capture customer motivation (e.g, data point to homeowners seeking both increased comfort and energy savings) and challenges (e.g., studies show homeowners are often deterred by the high cost of retrofit projects, the inability to find qualified contractors, and the lack of knowledge or understanding of energy audits and improvement strategies). One meta-analysis of health-related outcomes associated with retrofit projects identified multiple positive benefits including reductions in asthmatic conditions and other upper respiratory problems including fewer hospitalizations.[21] Yet, overall, the research appears to be lacking in personal testimonials and case studies highlighting the homeowners' perspectives on the impact of various retrofit upgrades.

In the conclusion of the 2021 review, the Berkeley Lab authors declare DERs have moved beyond the "demonstration phase" in the U.S., an assertion that remains debatable. Chat rooms on Green Building Advisor, for example, belie the impression that construction professionals have reached consensus on even the most basic technical aspects of the retrofit process such as the optimal application of heat pump hot water heaters and the benefits of absorbing attics into the conditioned space of a home. These debates are complicated by the fact that existing conditions of our current housing stock vary significantly by the home's age, size, design, materials, maintenance, climate zone, etc. Thus, there is no one-size-fits-all approach for deep energy retrofits, but rather a complex web of solutions that must be carefully calibrated based on the unique profiles of homes and geography across the country.

Yet, assuming that a standardized approach (aka "Energiesprong type" solution) appropriate for a large swath of retrofit projects is on the horizon in the U.S., the Berkeley review points to additional obstacles to scaling DERs such as low customer demand, high cost of implementation competing with relatively inexpensive utility rates, and a lack of skilled workforce for project implementation. In other words, the retrofit industry must cross the "great chasm" common among new technology adoption life cycles, as defined by marketing expert Geoffrey Moore (see Figure 2).[22] Moore's theory, which segments a potential market into distinct psychological and social profiles, provides a useful framework for understanding the customer acquisition challenges that confront this next phase of DER development, as retrofit providers will need to move beyond a small pool of early eager adopters into the more skeptical majority mainstream (see Table 3).

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[20] The Passive House Institute of the US recommends a maximum 0.06 cfm50/ft2 airtightness for most buildings. For more information, visit www.PHIUS.org.

[21] E4 the Future, 2016. "Occupant Health Benefits and Residential Energy Efficiency." An E4The Future, Inc. White Paper available at https://e4thefuture.org/wp-content/uploads/2016/11/Occupant-Health-Benefits-Residential-EE.pdf.

[22] Moore, Geoffrey A. (2014). Crossing the Chasm, 3rd Edition (Collins Business Essentials).

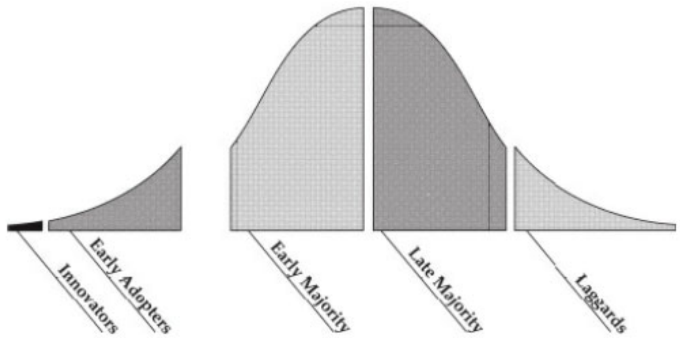

Figure 2. Market Chasms of the Technology Adoption Lifecycle. Source: Moore, 2014.

TALC MARKET SEGMENT	MOORE'S DESCRIPTION	DEEP ENERGY RETROFIT MARKET
The Innovators	This first group of eager product adopters, AKA “techies” or “enthusiasts,” are also the most willing guinea pigs for innovation-- provided they get “test case” reduced pricing and direct access to developers. In exchange, the Innovators become a valuable sounding board for product research and development.	To date, much of the work in the DER industry has been concentrated among this niche group of highly motivated pioneers committed to energy conservation. Yet, the research appears to lack first-hand accounts of their experiences and feedback.
The Early Adopters	Similar to Innovators, the Early Adopters are also willing to jump in at the emerging technology phase, but have a high bar for impact, as this group of “visionaries” are seeking a “fundamental breakthrough,” a product that will reap significant benefits for the extra effort of engaging in the demonstration phase. Early Adopters often seek influence over product development and make demands to tailor products to their needs, but in exchange, this group can provide a critical litmus test of product viability.	Federal, state and local policymakers are among the Early Adopter clients of DER technologies as public resources have supported the vast majority of retrofit initiatives. Many energy experts argue that these heavily subsidized programs need to continue in order to meet GHG reductions targets, particularly for retrofitting low-income housing.
The Early Majority	This group provides entry point into the mainstream market, and therefore represents the bulk of potential customers and largest share of potential revenues. The leap from Early Adopters to Early Majority presents the most challenging chasm of the technology adoption life cycle. Unlike the first two groups, the pragmatic Early Majority is not interested in being pioneers, nor are they motivated by innovation. The Early Majority wants tried and true strategies that promise incremental improvements verified by other familiar Early Majority members. In other words, word-of-mouth marketing from their community is absolutely key to gaining inroads with this mainstream group.	A large portion of potential Early Majority customers for retrofit projects are single-family homeowners seeking to make improvements to their homes. Capturing the attention of this market segment remains one of the most immediate and significant challenges for the DER industry.

Table 3. Analysis of Market Segments in Technology Adoption Lifecycle (Moore, 2014) & Applicability to the Deep Energy Retrofit Industry

IV. The Retrofit Lab Strategy

Retrofit Lab seeks to build community-based networks of green building professionals, homeowners, nonprofit organizations, realtors, and financing companies in neighborhoods with the potential to replicate a deep energy retrofit (DER) solution. In partnership with local builders, Retrofit Lab identifies homes in need of retrofit improvements which become living, breathing classrooms for stakeholders to observe and learn the DER process. Through virtual and in-person workshops, home tours and an online directory of resources, Retrofit Lab creates the conduit by which contractors receive training in DER methods, homeowners become familiar with the value proposition, and communities unite around home improvements as a critical climate solution.

The Retrofit Lab strategy addresses several immediate needs in the development of the DER market, including:

- **Designing “packaged” retrofit solutions -** This neighborhood-based approach creates the opportunity to design a DER prototype that can be replicated across multiple similar homes in a concentrated geographic area. Many communities have tracts of homes of similar age, design, materials, etc. Both Energiesprong and Sealed.com capitalize on these common characteristics to recruit customers and promote uniform solutions. The Retrofit Lab will be unique in its marketing potential, as the Lab becomes a visible and easily accessible storefront in the neighborhood.

- **Support for contractor networks -** Each Retrofit Lab will work to build communities of practice among local construction professionals including green raters, architects, the trades (mechanical, electric, plumbing), carpenters, drywallers, insulation installers, etc. Contractors will be offered training and technical support on site, as well as connections to certification programs, such as those offered by the Building Performance Institute. In addition, contractors will benefit from an expanded local customer base, standardized and predictable scopes of work, and transparent budget estimates which will increase their efficiency and profit margins.

- **Mainstreaming the process -** As outlined in Moore's work on the technology adoption lifecycle, we know that aligning with customer motivations is necessary, but not sufficient to ensure widespread market penetration. To capture the mainstream, homeowners need to be familiar with the technology and confident of the benefits associated with energy-saving modifications to their home. In other words, a DER solution must be low risk and high reward, thus the localized demonstration project is key to building trust and familiarity with the retrofit process, as well as showcasing the benefits of DER.

- **Expanding customer base through word-of-mouth recruitment -** According to Moore's theory, word-of-mouth recruitment among peers within a mainstream market segment is absolutely critical for gaining traction with the Early Majority. During the initial pilot phase, Retrofit Lab will target communities with fertile soil for successfully launching and showcasing the initiative (see neighborhood characteristics below). However, once the brand is established, Retrofit Lab will expand services via grassroots engagement. A request for proposals process will help identify expansion opportunities that build upon the work of established local nonprofits, government initiatives, and community groups. Thus, the Retrofit Lab's ground-up neighborhood strategy seeks to support a YIMBY (Yes In My Backyard) culture for deep energy retrofit solutions.

These key aspects of the Retrofit Lab strategy align with recommendations from DER research and policy work. The Berkeley review highlighted both "neighborhood-level recruitment" and "working with community organizations" as innovative approaches. Recommendations of the large-scale Energy Upgrade California study include: "Foster peer-to-peer marketing on social media; offer events and workshops; build the future target market based on characteristics of past participants; support contractor marketing; and focus training and mentoring on top-performing contractors to make them more successful."[23] The Rocky Mountain Institute cited the imperative for "growing and fostering smart contractor networks" with access to "aggregations of households" that are educated and motivated to pursue energy-conservation options.[24]

Retrofit Lab also builds on lessons learned from the exemplar "Coolest Block" program in Philadelphia, an initiative of the nonprofit Energy Coordinating Agency (ECA) to retrofit dilapidated homes in low-income Philly neighborhoods. From 2014-2017, ECA mobilized residents on select streets to participate in extensive energy upgrades including cool roof replacements, structural repairs, air sealing and insulation, new HVAC equipment, and programmable thermostats. The program was successful in transforming energy conservation of entire city blocks, retrofitting a total of 67 homes with an average energy savings of 36% gas and 22% electric per household. In addition to energy savings, the program also demonstrated improvements to indoor air quality such as reductions in airborne allergens and optimization of indoor humidity levels.[25]

Yet, despite their successes, the Coolest Block ended after three years. Research on the program cites ECA's struggles to gain trust with residents in some neighborhoods and their inability to connect with landlords as reasons for the program's demise. [26] It is also important to note that the initiative was entirely dependent on public resources and private foundation grants to fund all operations and home improvements, and that the deteriorated condition of many homes likely added significant costs to each project. Thus, the advantages of co-location and uniformity in design may have been eclipsed by other challenges such as major structural repairs and disengaged homeowners.

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[23] Less et al, 2021, p. 21.
[24] Schwisberg et al, 2021, p. 31.
[25] Denson, R., and S. Hayes. 2018. The Next Nexus: Exemplary Programs That Save Energy and Improve Health. Washington, DC: ACEEE. www.aceee.org/sites/default/files/publications/researchreports/h1802.pdf.
[26] Dewey, A., J. M. ah, and B. Howard. 2021. Ready to Go: State and Local Efforts Advancing Energy Efficiency. Washington, DC: American Council for an Energy-Efficient Economy. Retrieved 3/20/22 at https://www.aceee.org/toolkit/2021/11/ready-go-state-and-local-efforts-advancing-energy-efficiency.

In our Phase 1 launch of Retrofit Lab, we will target neighborhoods with significant capacity-building potential as a means of establishing trust in the brand, diversifying funding opportunities, and creating the infrastructure necessary to scale. Key neighborhood characteristics include:

- An abundance of older (30+ years) uniform tract homes;
- Predominantly owner occupied;
- High concentrations of remodeling activity;
- Active civic groups demonstrating commitment to climate causes;
- Above average energy use per occupant as a function of climate and/or home design;
- Availability of public incentives (e.g. tax rebates) to support energy-efficient upgrades.

In addition to the above characteristics, Retrofit Lab will launch in a neighborhood upon identification of a prototype property that fits the criteria of a DER demonstration project. Prototype properties may be secured through multiple avenues, such as:

- Purchase of a fixer upper by one of Retrofit Lab's builder/developer partners;
- Collaborate with a homeowner planning a conventional remodeling project;
- Collaborate with a homeowner based on need (e.g. an elderly owner, single parent, or dilapidated rental).

In Phase 1 (years 1-5), Retrofit Lab will work to establish a sustainable funding mix of public and private grants with fee-for-service products such as home energy audits and professional training modules. As the Lab reaches self-sufficiency, we will launch Phase 2 expansion into underserved areas. The goal is to have well-established standard operating procedures, sustainable revenue streams, strong networks of manufacturers and contractors, and a well-known and trusted brand prior to Phase 2 implementation.

Retrofit Lab PHASE 1 – Launch and Capacity Building **Years 1-5**	**Retrofit Lab PHASE 2 – Equity Expansion** **Years 6+**
- Select 2-5 pilot sites for the first years of organizational development - Establish brand, online resources, startup funding - Transition to invitation-only neighborhood development via request for proposals by Year 3 - Create fee-for-service revenue streams to support philanthropic activity (curriculum, training, digital resources)	- Expand to low-income and underserved communities

V. Retrofit Lab: Mission, Vision, Goals

MISSION
To improve the energy efficiency and sustainability of American homes by developing a community of stakeholders with the tools, knowledge and resources necessary to transform the current stock of housing.

VISION
We envision a vibrant and productive green building industry with the capacity and market demand to meet or exceed our goals of 50% reduction in greenhouse gas emissions in the built environment by 2030, thereby curbing the current trend toward climate catastrophe.

GOALS
1) Conduct empirical research and community-based demonstration projects that will identify cost-effective pathways towards deep energy retrofits, building a compendium of best practices across a diverse range of housing types and climate zones.

2) Train contractors and green building consultants on best practices for analyzing building performance and implementing deep energy retrofit solutions.

3) Educate homeowners on the opportunities, costs, and benefits associated with energy-efficiency upgrades.

4) Build an online community of practice for green building professionals and interested homeowners that provides critical information, education, and resources to meet the demands for energy-efficient retrofits.

VI. Sample Course Topics

General Contractors

- Intro to the Building Performance Institute (BPI) Courses
- Components of an Energy Audit
- Becoming a Resilient Remodeler

Homeowners

- Overview of the Inflation Reduction Act Programs and Incentives
- Heat Pumps 101
- Solar Payback Periods
- Insulation & Air Sealing Options (site tour)

Architects

- Designing for whole house deep energy retrofits
- Efficient Windows
- High performance wall systems

Vocational Students

- Retrofit Careers
- Building Science 101

HVAC Contractors

- Intro to Accreditation (ACCA, Advanced Energy, Energy Star)
- Manufacturer-sponsored heat pump continuing education / advanced coursework (e.g. Mitsubishi Electric Trane Electric HVAC US)

Appendix A. Deep Energy Retrofit Resources

Organization	Description
National & International Organizations	
Advanced Building Construction Collaborative	Membership organization of high performance housing groups.
American Council for an Energy-Efficient Economy	The American Council for an Energy-Efficient Economy (ACEEE), a nonprofit research organization, develops transformative policies to reduce energy waste and combat climate change. With our independent analysis, we aim to build a vibrant and equitable economy – one that uses energy more productively, reduces costs, protects the environment, and promotes the health, safety, and well-being of everyone.
Bloc Power	Multi-family retrofits (mostly hvac, some solar) with no money down. Has it's own proprietary software for analysis, leasing, project mgmt, and monitoring. Projects realize 20-40% reduction in energy bills.
Building Performance Association	The Building Performance Association (BPA) is a 501(c)6 industry association committed to redefining the industry by supporting policies that will improve and increase the expansion of home and building performance, energy efficiency businesses, and industries. BPA is made up of more than 10,000 members who are working professionals in contracting services, weatherization, product manufacturing and distribution, program administration, building science, and nonprofits. The association is devoted to enhancing the workforce development of its members by creating educational opportunities that establish a culture of ongoing learning. The BPA mission is to advance a thriving industry that delivers improved energy efficiency, health, and environmental performance of buildings.
Eco Achievers	Green consulting and certification (mostly multi-families) based in Chicago and Detroit
E4The Future	national nonprofit
Habitat X	"Habitat X produces dynamic conferences and strategic planning events for the Building Performance Industry."
Home Innovation Research Labs	Green build arm of the National Association of Home Builders. Manages the NGBS certification program.
Homes Renewed Coalition	Age in place advocacy, lobbying, and education.
International Energy Agency (IEA) Energy in Buildings and Communities (EBC) Programme	International research NGO
National Renewable Energy Laboratory	Part of US DOE
Oak Ridge National Laboratory	Oak Ridge National Laboratory delivers scientific discoveries and technical breakthroughs needed to realize solutions in energy and national security and provide economic benefit to the nation.
Pearl Certification	Efficiency certification for new and existing homes. Has a "Green Door" app where homeowners can track energy efficient upgrades. NOTE: score is based solely on energy efficiency and does not include other aspects of sustainability such as IAQ, renewables, etc.
Rocky Mountain Institute	Check out their REALIZE initiative -- streamlining the retrofit process. (https://rmi.org/our-work/buildings/realize/)

Organization	Description
Sealed.com	NY-based retrofit finance company
The Residential Building Systems group at the Lawrence Berkeley National Laboratory (program of US Dept of Energy)	Research and Energy modeling tool: LBNL Home Energy Saver
US Dept of Energy BA-PIRC	The U.S. Department of Energy's Building America Program is an industry-driven, cost-shared research program to accelerate the development and adoption of advanced building energy technologies and practices in new and existing homes. As one of several competitively selected research teams, our Building America Partnership for Improved Residential Construction (BA-PIRC) works closely with industry and utility partners to develop innovative, real-world solutions that achieve significant energy and cost savings for homeowners, builders, and remodelers.
Zero Energy Project	The Zero Energy Project is a non-profit educational organization whose goal is to help home buyers, builders, designers, and real estate professionals take meaningful steps towards radically reducing carbon emissions and energy bills by building zero net energy homes and near zero energy homes.
Local Organizations	
EcoMize	maryland-based energy auditor (Pepco certified)
Housing Initiative Partnership, Inc.	green nonprofit housing developer and counseling agency based in Prince George's County, Maryland dedicated to revitalizing neighborhoods.
Maryland Clean Energy	Government-appointed agency that monitors and promotes clean energy and energy-efficient upgrades across State of MD
Building Innovation Hub	DC-Based nonprofit focused on high performance buildings (commercial and multi-family).
Publications & Tools	
University of Minnesota, Center for Sustainable Building Research Handbook on Residential Foundations	The purpose of this handbook is to provide information that will enable designers, builders, and homeowners to understand foundation design problems and solutions.
US DOE EERE Residential Program Guide	The Better Buildings Residential Program Guide is a repository for lessons learned, resources, and knowledge from program administrators and industry experts across the country. Click on the links below for more information to help plan, operate, and evaluate residential energy efficiency programs.
Ekotrope	energy modeling software
NREL BEopt	energy modeling
RESNET	HERS rating system
US DOE Home Energy Score	Energy modeling
Clean Energy Connection of CA	Portal that connects homeowners with clean energy contractors
Low Energy Building Database	UK Database of retrofits
DOE Office of Scientific and Technical Information	Compendium of research articles on deep energy retrofits
Education & Training	
Building Performance Institute	Provides training and certification in building science related skills for construction professionals.
Building Science Fight Club	Building science education for architects and builders.