

Scaling Investment in Comprehensive Retrofits for Low-Income Housing

Yu Ann Tan, RMI

Lauren Reeg, RMI

Abstract

26 million low-income households in the US burn costly, health-damaging and climate-disrupting fossil fuels. These households are overburdened by air pollution, energy costs, and poor housing quality alongside disproportionate health, social, and economic burdens. Current retrofit programs are underfunded, inaccessible, and only reach ~.1% of eligible households with modest retrofits. Additionally, no single federal funding source can fund a sustained whole-building retrofit program.

In this paper, RMI outlines the One-Stop-Shop implementation model that consolidates funding and program services so home- and building-owners have a single-point of entry to access low-cost, whole-building retrofits. A comprehensive approach, where several interventions are packaged into a whole-home retrofit and delivered through a One-Stop-Shop implementation model, can maximize benefits to residents and expand resources for more equitable delivery. Such an approach can also consolidate the resources available among several areas of professional practice – climate action, housing policy, and public health. This model has been proved successful by various communities across the country. This paper also identifies available federal funding sources that can be stacked to ensure every retrofit service is funded and all eligible participants qualify.

RMI's research provides evidence that a whole-building approach (encompassing envelope, compartmentalization, equipment/appliance, ventilation, energy management, and energy assistance interventions) can reduce harmful exposures and mitigate vulnerabilities associated with environmental racism, persistent poverty, and other social determinants of health.

A One-Stop-Shop program that provides whole-home retrofits can support healthier homes and communities through:

- Improved indoor air and environmental quality
- Better neighborhood air quality
- Safer indoor temperatures during extreme heat and cold
- Increased safety from the removal of gas infrastructure
- Improved energy security

Introduction

Almost half of low-income households live in inadequate housing conditions due to decades of social and environmental injustice (JCHS 2020). Substandard housing conditions not only fail to provide quality shelter, but they also serve to further entrench communities in various climate, health, economic and social inequities. To equitably achieve 1.5C climate targets, current retrofit programs must dramatically accelerate the pace of building retrofits to reach 5% of all buildings each year—more than a 5X increase from today (Egerter et al. 2018). They must also significantly exceed the 15% energy reduction most building retrofits achieve now (Delmastro and Abergel 2021). Expanding retrofit services can eliminate climate-disrupting and health-damaging pollution in buildings. Comprehensive whole-home retrofits delivered through a ‘One-Stop-Shop’ point of entry can maximize benefits to residents and expand resources for more equitable delivery. A whole-home approach ensures sustainable, safe, and healthy physical structures that allow those facing disproportionate risks and burdens to better prepare, prevent, respond to, and recover from stressors. Whole-home retrofit interventions include four basic services: Health and Safety Upgrades, Weatherization and Energy Efficiency Measures, Appliance Electrification, and Energy Assistance. California’s Low-Income Weatherization Program and Philadelphia’s Built to Last Pilot are two examples of one-stop-shop whole-home retrofit programs currently comprehensively retrofitting low-income housing. Although some one-stop-shops exist, most current retrofit programs aren’t effective at delivering whole-home retrofits because they lack funding, aren’t comprehensive, and have obstacles to participation. These barriers make it difficult, if not impossible, for low to moderate income (LMI) residents to navigate the disjointed retrofit system and leverage the available resources to receive necessary retrofit services. However, recent efforts, such as the bipartisan Infrastructure Investment and Jobs Act (IIJA), present key opportunities for federal, state, and local officials, utilities, and community action agencies to funnel resources towards equitable housing investments and begin scaling whole-home retrofits. This report outlines the economic, social and health impacts that result from poor housing quality in LMI households, whole-home retrofit programs as a solution and some actionable items to funding and scaling such programs.

Low-income Housing Is Often Unsafe, Unhealthy, and Unaffordable

Housing quality is an important social and environmental justice issue because it disproportionately affects low-income, minority families as well as other vulnerable populations. Housing can play a transformative role in addressing long-standing inequities and improving the well-being of low-income communities, and thus should be prioritized as the residential sector ramps up for deep decarbonization (Tan and Jung 2021). Understanding how poor housing conditions cause and magnify disparate adverse outcomes for resource-constrained households provides us with compelling climate, health, and equity reasons to find more effective solutions (Taylor 2018).

The fossil fuels that 26 million low-income households burn exacerbates climate change while continuing to burden these populations with disproportionate economic, social and health burdens – which they face significant barriers to prevent, respond to, or mitigate. The residential sector has long been a significant contributor of greenhouse gas emissions, with residential

energy use currently accounting for 10% of all US direct GHG emissions (RMI 2021). As the residential sector decarbonizes and consumers move away from gas, the cost of the existing network will be shared amongst a shrinking pool of users. Utilities add pipelines but rarely remove them, even when the customer base from which to recover costs is shrinking (Davis and Hausman 2022). If low-income households are not prioritized in this clean energy transition, they face the reality of significantly higher bills, potentially further entrenching already overburdened families in more systems of extraction (Davis and Hausman 2022).

Housing quality is a social determinant of health and wellbeing. Residents of households in concentrated areas of poverty have been shown to face shorter life spans and higher rates of chronic health outcomes including asthma, diabetes, hypertension, obesity, and kidney disease (Richardson et al. 2020). Low-income households also tend to live in conditions that necessitates difficult trade-offs, many times jeopardizing health and wellbeing. Low-income households are more likely to experience higher energy use intensity and subsequently pay higher utility bills due to housing conditions that cause inefficiencies in space heating and cooling (Reames 2016). These households also face an energy burden three times higher than more affluent households, according to a study conducted by the Department of Energy (2018).¹ High energy burdens threaten a household's ability to pay for energy and other needs with one in five households reporting reducing or forgoing necessities such as food and medicine to pay an energy bill (EIA 2018).

Improving housing quality is also an opportunity to readdress historic and existing inequities. Problems with substandard housing conditions and disrepair continue to persist in many neighborhoods with high shares of LMI households, many of which are communities of color. Federal analysis by the United States Government Accountability Office (2020) shows that lower-income households typically dwell in units facing substantial quality issues and nearly 80 percent of units lack essential components (such as heating equipment or hot and cold running water). Extremely low income or rent-burdened households are more often affected by more serious deficiencies (typically a combination of issues such as cracked walls, multiple heating problems and the presence of rodents). Decades of disinvestment and discriminatory housing policy also expose communities whose residents are disproportionately African American, Indigenous, or other people of color to more location-based risks and vulnerabilities. Across the US, affordable housing is far more likely to experience coastal flooding from sea-level rise relative to other types of housing (Buchanan et. Al 2020). Neighborhoods that have been subject to public policy decisions that withhold or fail to upgrade essential infrastructure needed, a practice also known as “redlining”, experience summer temperature differences up to 20°F higher relative to non-redlined neighborhoods (Hoffman, Shandas, and Pendleton 2020). These conditions both overload physical home infrastructure, and strain residents socially and economically, further entrenching them in disparate adverse outcomes. LMI communities are often the least able to rebound, not just on an individual household level but also at the community scale. Improving housing quality will ease the climate, health and equity burden on resource constrained households and communities.

¹ Energy burden is defined here as the percentage of gross household income spent on energy costs.

The Current Retrofit System does not Effectively Administer LMI Retrofits

Current retrofit programs are not meeting the most pressing needs of LMI residents. Communities often face unmanageable barriers when accessing these programs that make affordable retrofits difficult, if not impossible. Federal, state, and utility retrofit programs are generally administered separately making it difficult for residents to navigate the system and maximize financial incentives. Federally funded retrofit programs are administered through local Community Action Agencies which delivers resources like the Department of Energy's Weatherization Assistance Program and the Department of Health and Human Service's Low-Income Home Energy Assistance Program to income-qualified residents. State programs either supplement these federal programs or develop entirely separate programs that are often duplicative of federal programs. Finally, many utilities provide incentives for efficient appliances and weatherization to their customer base. This disjointed system of federal, state, and local retrofit services creates market confusion. This means residents are often unable to maximize their energy assistance funding and do not receive the retrofit services that are necessary for affordable, safe, and healthy housing. Given the current retrofit system, the three largest barriers to current retrofit programs identified are limited retrofit measures, high deferral rates and inadequate funding.

- **Limited Retrofit Measures:** Retrofit programs are generally focused on weatherization and efficiency measures (EERE 2022). Although these services are necessary, health and safety measures, appliance electrification and energy assistance services are crucial to improving housing quality through affordable and climate-aligned retrofits (Wilson 2011). Weatherization and efficiency don't cover critical interventions such as lead, mold, and asbestos removal or building structural repairs. These programs also often leave homes with polluting gas appliances that can damage occupant health and continue to compound climate impacts.
- **High Deferral Rates:** Some LMI retrofit programs have deferral² rates as high as 50% due to a combination of inadequate funding, restrictive eligibility, and health and safety requirements (PEA 2020). These deferrals leave households with serious health and safety concerns and no assistance in helping them make these upgrades.
- **Inadequate Funding:** Even with a primary focus on weatherization and efficiency measures, retrofit programs do not have enough funding. Low-income retrofit programs need funding to increase by 100-fold to effectively retrofit all low-income housing (Norton, et al. 2021). Inadequate funding from traditional existing sources leaves programs with long waiting lists and communities without timely access to retrofit funding.

Although some retrofit programs are working to address these issues, they are not sufficiently comprehensive or scaling to reach enough households. Decarbonizing buildings must

² Program deferrals occur when applicants don't meet the program requirements. A common reason applicants are deferred from weatherization programs is inadequate housing quality. Households can be deferred until they address the health and safety concerns in their house, such as mold, asbestos, and lead paint.

start by ensuring that every LMI household has easy access to an affordable whole-home retrofit that can comprehensively improve housing quality.

Whole-home Retrofits Comprehensively Improve Housing Conditions

The current state of public policy promotes the application of a variety of disparate housing performance interventions to a diverse building stock. Integrative methods, like a whole-home approach, can capture the complex relationships between building systems, housing quality and the impacts on residents. This process brings together different kinds of knowledge and resources, streamlines decision-making and ultimately maximizes benefits to low-income households.

Four categories of retrofit services are identified that encompass a whole-home retrofit and align with common funding parameters. Figure 1 provides a possible example.

1. **Health and Safety** services include building structural repairs, adequate and safe electrical wiring, toxic chemical abatement, roof repair, indoor ventilation, etc. (DHHS 2011). These basic interventions are required for habitable, safe households.
2. **Weatherization and energy efficiency** services are necessary to ensure households are energy efficient, minimize utility bills, and reduce grid impacts (EERE 2015). These measures include building envelope improvements, air tightness, and air sealing.
3. **Appliance Electrification** mitigates indoor and outdoor air pollution as well as onsite climate emissions (Gerdes, 2020). This service replaces fossil fuel appliances, like gas stoves and furnaces, with smart, efficient, electric alternatives, like induction stoves or air source heat pumps.
4. **Renewable Energy Assistance** ensures households have access to affordable, renewable electricity. Energy assistance includes energy burden limits, on-bill financing, rooftop solar, and/or community solar.

Comprehensive Action will Yield Important Benefits for LMI Communities

A whole-home approach which utilizes smart, efficient investments for holistic, comprehensive retrofits will deliver both energy and non-energy benefits at the individual level and community level. A whole-home comprehensive approach can improve health equity by creating more healthy living environments, thereby addressing disparate health impacts.

Comprehensive interventions can yield important benefits to low-income residents when buildings are approached as more than the sum of its parts (Tan and Jung 2021). Comprehensive approaches to improving housing quality and performance can provide benefits at the household and community level, specifically:

1. Improve indoor air and environmental quality (Lin, Brunekreef, and Gehring 2013; Seals and Krasner 2020; Jacobs and Baeder 2009),
2. improve neighborhood air quality (Buonocore et al 2021; Zhu et al 2020),
3. ensure safer indoor temperatures during extreme heat and cold (Tan and Fathollahzadeh 2021; Ayyagari, Gartman, and Corvidae 2020),

4. increase safety from the removal of gas infrastructure (Ahrens and Evarts 2018),
5. improve energy security (Hernandez 2015; Jessel, Sawyer, and Hernandez 2019).

Improved Indoor Air and Environmental Quality

Comprehensive interventions that are a combination of source control and ventilation have been shown to be the most effective at improving indoor air and environmental quality and confer the most health benefits. Gas stoves are a main contributor to poor indoor air quality and pollution levels from everyday use of gas stoves often exceed the limits of outdoor air quality standards, often much higher than guidelines set by the World Health Organization (Seals and Krasner 2020). Gas stoves emit several pollutants – PM_{2.5}, NO_x as well as carbon monoxide (CO), and formaldehyde (Logue et al 2014). Removal of combusting sources will yield immediate improvements to indoor air and environmental quality, which can have significant health benefits. Children living in a home with a gas stove have a 42% increased risk of having asthma symptoms and a 24% increased risk of being diagnosed with asthma by a doctor, according to the most recent peer-reviewed meta-analysis (Lin, Brunekreef and Gehring 2013). Indoor air and environmental quality improvements can also improve the overall health and well-being of lower-income populations who face higher rates of heart disease, respiratory symptoms, obesity, and shorter lifespans (Tan and Jung 2021). The removal of combusting sources directly alleviates the greater burden of asthma that low-income families across the US face. This is especially important in households with children since asthma is more prevalent in children living in low-income families (with an incidence of 10.5%) than among those of families with income above the federal poverty level (approximately 6%-9%) (Zahran et al 2018). The combination of electrification of cooking together with the provision of mechanical ventilation is the most effective intervention to improve indoor air and environmental quality; evidence shows that just opening windows or mechanical ventilation is inadequate to meaningfully decreasing the levels of health harming air pollution creating during gas stove use (National Center for Healthy Housing 2022).

Improve Neighborhood Air Quality

Removing in-home combustion will have significant positive impacts on neighborhood air quality. Air pollution source modeling has shown that buildings are a significant source of neighborhood air pollution. The commercial and residential buildings sector was found to be the most important sector contributing to estimated early deaths in a study on premature deaths from air pollution (Dedoussi et al 2020). Further, Buonocore et al (2021) found that between 15,000 and 20,000 premature deaths resulted from just outdoor PM_{2.5} air pollution from burning fuels in residential buildings in 2017, the most recent available data. Additionally, the associated reductions in outdoor NO_x and PM_{2.5} from an immediate replacement of all Californian residential gas appliances to clean electric alternatives would yield \$3.5 billion in monetized health benefits and 350 lives saved in a year (Zhu et al 2020). Low-income populations continue to experience heightened exposure to pollutants as well as live in closer proximity to mobile and stationary polluting sources such as highways, power plants, toxic waste sites and landfills (Tessum et al 2021; Bell and Ebisu 2012). Residential electrification through whole-home

approaches will directly address poor neighborhood air quality and improve the inequities associated with disparate exposure to unhealthy living conditions.

Ensure Safer Indoor Temperatures During Extreme Heat and Cold

High-performing buildings equipped with cooling technology have been shown to effectively mitigate the effects of heat buildup, especially during heat waves (Tan and Fathollahzadeh 2021). In parallel, high-performance envelopes have also demonstrated the ability to provide increased “hours of safety” maintaining safe indoor temperatures during both hot and cold weather (Ayyagari, Gartman, and Corvidae 2020). Urban and social policies that have increased exposure of low-income populations to pollutants and toxins also have the same effect for climate risk (Hoffman, Shandas, and Pendleton 2020). Neighborhoods with lower-income and higher shares of non-white residents experience significantly more extreme surface urban heat than their wealthier, whiter counterparts (Benz and Burney 2021). This is a significant reality given residents of low-income census tracts are among those most vulnerable to the health impacts of extreme heat, with conditions ranging from heat rash to death (Basu and Samet 2002). Whole-home approaches can provide safe shelter, while decreasing the disparate health impacts of historically discriminatory housing policy.

Increase Safety from Removal of Gas Infrastructure

Gas distribution infrastructure is often disproportionately located in areas of high social vulnerability, leaving these populations grappling with an increased risk of fires, explosions and consequential damage to property and threat to safety (Emanuel et al 2021). At both the household and neighborhood level, decommissioning gas infrastructure through electrification would reduce the risks posed by gas distribution systems. Electrification can facilitate improved neighborhood air pollution, reduced safety threats from fires or explosions, or the exacerbation of climate change through GHG emissions (Buonocore et al 2021; Ahrens and Evarts 2018)

Improve Energy Security

There is the risk of increasing energy burdens for families, especially in regions with higher electricity to gas prices, if interventions like electrification are implemented in isolation. Flexible, comprehensive strategies are key; ensuring that housing is free from health-harming combustion sources via electrification while also being paired with high efficiency upgrades like high-performance envelopes, weatherization and insulation will support energy affordability, reliability and accessibility. These factors are particularly important for low-income households as they face higher energy and housing-related cost burdens. Such an approach can improve energy insecurity – the inability to adequately meet basic household energy needs, by better managing the amount and timing of clean, health-protective electric energy consumption (Hernandez 2016; Tan and Jung 2021). More energy security will allow low-income households to avoid the wide range of health issues that stem from energy insecurity, from stress and impacts on mental health, to poor sleep and cardiovascular and respiratory health (Hernandez et al 2016). Households will be more equipped to thrive, being less likely to have to make critical tradeoffs, such as between heating and eating (Jessel, Sawyer, and Hernandez 2019).

A One-Stop-Shop Model Improves Access to Whole-home Retrofits

Given these equity concerns, the One-Stop-Shop model for administering retrofits addresses these equity concerns by providing accessible, affordable comprehensive retrofits. Federal, state, and local officials, utilities, and community action agencies who administer energy efficiency and assistance programs must work together to consolidate funding and access to simplify the building retrofit process for residents. Programs must coordinate to align funding and retrofit program delivery into a “One-Stop-Shop” point of entry for families and building owners. A One-Stop-Shop Retrofit Program for whole-home retrofits is akin to walking into a car dealership and picking your make and model, product and aesthetic specifications, and financing and maintenance plan all at once. The One-Stop-Shop Retrofit Program would have a similar framework but allow for residents and building owners to determine their retrofit needs, access contractors, and leverage multiple funding sources.

Existing One-Stop-Shop models walk participants through four stages to receive retrofit services, as outlined in Figure 2.

- **Step 1:** The program administrator engages with the community to recruit eligible program applicants. The program administrator should collaborate with community-based organizations and local partners to expand their engagement and reach those most in need as done in other successful programs (SOMAH 2022).
- **Step 2:** Once the administrator receives and approves an application, a case manager is assigned to the participant where they help families and building owners navigate the retrofit program. Participants are matched with technical assistance staff who complete eligibility verification and a home or building audit. This step is used to ensure an applicant is eligible for the program and determine what retrofit measures are needed.
- **Step 3:** Once completed, participants may choose from a list of eligible contractors to complete the retrofit.
- **Step 4:** Upon completion of the retrofit, the administrator is then responsible for completing verification and monitoring services to ensure the retrofit was done correctly as well as assist in claiming financial incentives.



Figure 2: A visualization of the four-step process for participants to receive a retrofit in the One-Stop-Shop model.

This approach improves upon the current disjointed retrofit system by consolidating funding and services into an accessible program. A One-Stop-Shop retrofit program consolidates funding to ensure that all necessary services are available and all LMI residents are eligible for the program. During Step 3, the administrator taps all eligible stacked funding to help households

pay for the retrofit contracting services. The single program interface ensures residents can easily access all services ensuring that federal, state, and local funding is efficiently delivered.

One-Stop-Shop Programs Can Stack Funding to Maximize Program Effectiveness

One-Stop-Shop programs require funding for the four services of a whole-home retrofit and program staffing. Staffing needs include the administrator staff, program management staff, technical advisors, and contractors. The current pool of existing funding used for retrofits (like Weatherization Assistance Program and Low-Income Home Energy Assistance Program funding) is inefficiently used and not enough to cover the measures and participants needed for a comprehensive retrofit program. To deliver affordable whole-home measures, existing funding must be stacked, and non-traditional retrofit funding sources leveraged to supplement existing retrofit funds. Alongside stacking traditional and non-traditional funding sources, additional funding for all retrofit programs must be approved. Currently, there is no single federal funding source that can fund a sustained whole-home retrofit program, however, the Infrastructure Investment and Jobs Act (IIJA), passed in 2021, allocates \$6.5 billion in additional funding for weatherization and energy efficiency programs (H.R.3684 2021). To fund retrofit programs, federal, state, and local officials, utilities, and community action agencies (CAA) who administer energy assistance programs must stack existing funding with the expanded funding from IIJA to provide no- or low-cost retrofits. Program administrators can vary by program, but include CAAs, state energy offices, and energy efficiency program administrators, and should collaborate with the necessary parties to apply and funnel money to these programs. Figure 3 details five common funding sources that can be stacked for a retrofit program.

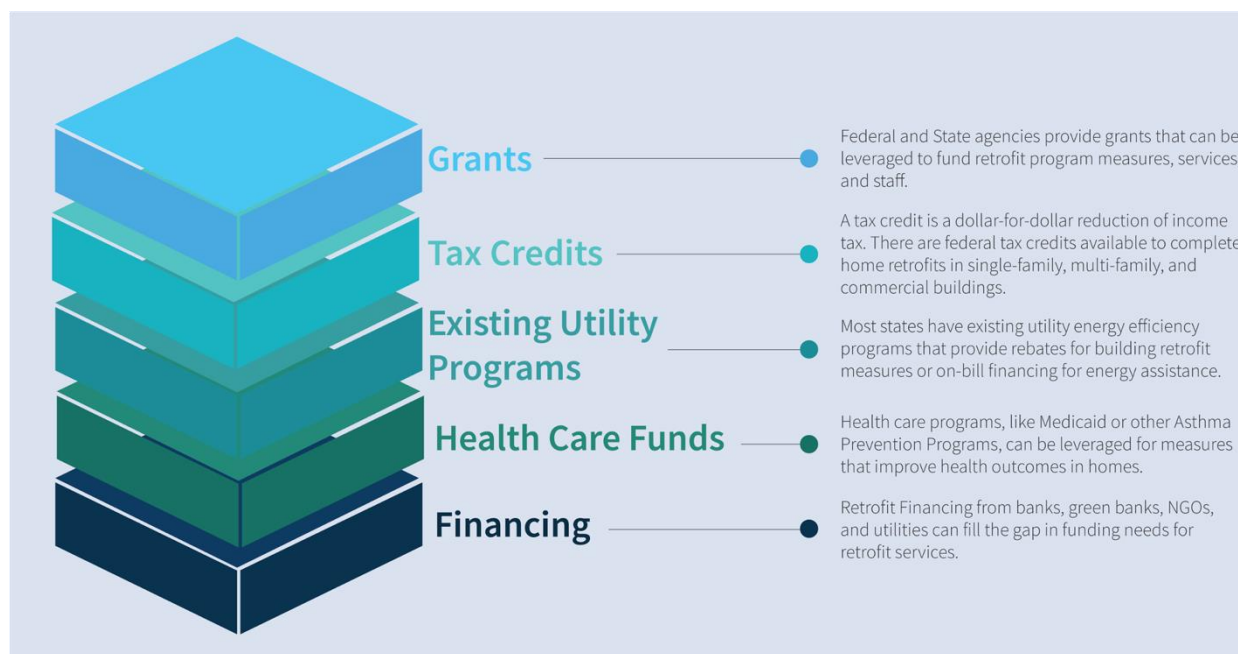


Figure 3: Stacking funding to pay for whole-home retrofits requires access to multiple funding sources including grants, tax credits, existing utility programs, health care funds, and financing.

- **Grants:** Generally, grants have a specific purview for eligible services or applicants, so program staff must thoroughly understand grant limitations when stacking funding. IJIA expanded key grants, like the Energy Efficiency and Conservation Block Grant Program and the Weatherization Assistance Program, which retrofit administrators can tap for additional funding.
- **Tax Credits:** Program staff can identify qualifying activities and help participants claim eligible tax credits. Eligible tax credits include, but not limited to, 179D and 25C which address commercial and residential buildings, respectively.
- **Existing Utility Programs:** One-Stop-Shop programs can collaborate with utility programs to ensure participants are informed of and can access incentives from their local utility. Successful existing utility programs include, but are not limited to, Efficiency Maine, MassSaves, and Focus on Energy (ACEEE 2016).
- **Health Care Funds:** Program staff can collaborate with state health care administrators to identify eligible services and participants (MACPAC 2018) (HUD 2018). Any use of Medicaid or other health care funds must directly address resident health outcomes.
- **Financing:** Retrofit Financing must include consumer protections (Wolfe 2021). Consumer protections include ensuring any household eligible for grant funding receives that and not financing, and no participating household can be evicted or have their utilities shut off because of participating in a retrofit financing program. Examples include loans from green banks or clean energy financing like Property Assessed Clean Energy (PACE).

Programs will need to leverage multiple streams of funding from these various sources to fund a comprehensive whole-home retrofit program. First, programs must determine what services they will provide and who is eligible for the program. Once these guidelines are determined, the program staff must work backwards to fill in the funding needs ensuring every measure and service is funded and the eligible participants qualify. Funding sources have widely varying requirements for participants and measure eligibility meaning program administrators must thoughtfully consider funding sources. Financing options are available to fill in the funding gaps for low-cost whole-home retrofits. With thoughtful planning, a program can stack funds to cover affordable whole-home retrofits.

Scaling One-Stop-Shop Retrofit Programs

The One-Stop-Shop model is an emerging implementation tactic designed to increase retrofit program accessibility and effectiveness. Scaling these programs from one-off programs to programs available in every community across the country will require national information sharing, restructuring of funding sources, and a commitment to accessible whole-home retrofits. These efforts begin with sharing best practices from early adopters and implementers. The One-Stop-Shop program model has allowed implementers to do more comprehensive retrofitting, however, program implementers still face numerous barriers, specifically around identifying available funding. Low-income funding often has varying definitions for eligibility that can make it difficult to ensure a participant qualifies for each program and covers every measure. One-Stop-Shop programs must ease and unify those eligibility requirements. One-Stop-Shop

programs have identified two program-level solutions to address problems related to stacking funds.

At a program-level, One-Stop-Shop programs must ensure they have funding that their qualified participants are eligible for and that fund all the components of whole-home retrofits by stacking funding as outlined in the section above. This method has proven successful in programs like Philadelphia's Built to Last's pilot which is stacking over 20 funds to implement their One-Stop-Shop program (PEA 2020). In addition to program eligibility, funding sources often have varying participant and service eligibility that necessitates fund stacking. Federal and state agencies can ease eligibility and facilitate unification of qualifications to ensure that stacking funding is easier. California addressed funding eligibility at a state-level by creating a state-sponsored fund with broad eligibility. This has allowed California's Low-Income Weatherization Program to deliver retrofits more effectively and efficiently than federal programs administered in the state (CSD 2020).

To address these program barriers at a foundational level, federal intervention is required. Federal agencies may increase accessibility for stacking funding by easing eligibility and unifying qualification requirements across programs. For example, many low-income federally funded retrofit programs have different income qualifications, some use 80% Area Mean Income while others use the Federal Poverty Line. Depending on the department the funding is housed in, developing a universal definition for income qualified individuals would make program implementation more feasible. Additionally, federal and state funds often have strict cost-effectiveness tests that make comprehensive retrofits difficult when they are addressing health and safety problems. Although existing programs have navigated these issues at a program level, federal intervention would make administering low-income whole-home retrofit programs easier.

Case Studies

Both Philadelphia and California established One-Stop-Shop retrofit programs administered at different scales and with different funding methods. These two programs each showcase best practices and can be useful for organizations looking to replicate these programs.

California's Low-Income Weatherization Program (LIWP):

The California Low-Income Weatherization Program (LIWP) for Multifamily Housing provides whole-home retrofits to multifamily buildings with at least 66% of units occupied by households with a median income at or below 80% of Area Median Income (CSD 2020).³ Funded by California Climate Investments, the state's cap and trade program, LIWP was allocated \$212,000,000 over five years by the state legislature (CSD 2020). This funding covers 30-100% of the cost of energy efficiency (EE) upgrades and solar installations alongside free property assessments, design assistance, and contractor coordination. Eligible upgrades include health and safety measures, weatherization, electrification, and energy assistance through solar PV installations. LIWP isn't braided with federal programs to ensure eligibility and the

³ The Area Median Income (AMI) is the midpoint of a region's income distribution – half of families in a region earn more than the median and half earn less than the median.

application process is uniform and accessible. Applying to LIWP is easier than federal programs like WAP or LIHEAP. Once building owners complete the interest form, building owners receive a free technical support session and are connected to eligible contractors who install the upgrades. The program administration simultaneously works with the building owner to claim LIWP's financial incentives.

LIWP has proven to be wildly successful. Within the first 5 years, 8,400 households in multi-family buildings have benefitted from energy efficiency and solar PV upgrades through California's LIWP. With an average property energy savings of 40%, multi-family buildings saved over 167,000 MtCO₂e in lifetime emissions (CSD 2020). This is equivalent to removing 36,400 cars from the road or planting 7.6 million trees. The single-family (SF) LIWP provided energy efficiency upgrades to 16,107 SF homes alongside 4,882 SF solar PV upgrades. Single-family households are expected to earn \$2,498 in lifetime savings for EE retrofits and \$9,200 for solar upgrades (CSD 2020). Health and safety measures alongside electrification retrofits also reportedly reduced allergy, asthma, and other building-related illnesses (CSD, 2020).

Philadelphia's Built to Last Pilot Program:

Overseen by the Philadelphia Energy Authority (PEA), Built to Last is a one-stop-shop low-income retrofit pilot with the objective of providing whole-home retrofits to 40-50 single-family homes starting in 2021 (PEA 2020). Built to Last serves Philadelphia residents who own their home and make less than 150% Federal Poverty Level with a particular focus on rowhomes. Built to Last is funded by braiding over 20 funding sources including utility programs, legal services, repair programs, and health and housing counseling. By braiding these funding sources into one accessible program, PEA can provide comprehensive retrofits including health and safety measures, pest management, basic home repairs, site or structural work, exterior lighting and security, energy efficiency, electrification, and solar PV.

With 60,000 Philadelphia homeowners living in poverty and federal retrofit programs experiencing deferral rates as high as 50%, the PEA and Built to Last Coalition identified the need for a one-stop-shop retrofit service that braided funding from across the city to provide accessible whole-home retrofits to LMI residents (PEA 2020). The Coalition first scoped the program's objectives and then recruited organizations with the funding and skills needed to administer the program. In 2020, Built to Last launched a small pilot to test this program's ability to address low-income housing needs. PEA, the Built to Last administrator, is currently recruiting and processing participant applications. They will then match homeowners with technical assistance staff to complete home audits and contractors to complete the upgrade. PEA staff will work with participants to claim financial incentives. The PEA and collaborators will consider this initial pilot successful if it provides whole-home retrofits to at least 40 low-income homeowners.

Conclusion

Housing represents an important venue for advancing climate, health, and social justice. Improving housing quality through a whole-home approach ensures that disproportionately affected populations can thrive. Decades of environmental injustice and racist housing practices

have led to extreme underinvestment in low-income housing across the US. As the nation transitions toward a climate-aligned economy, we must ensure that the country's most vulnerable populations are not burdened with unsafe housing conditions, poor air quality, volatile utility bills and left to bear the rising costs of stranded gas infrastructure. Accessible whole-home retrofits that comprehensively repair and future-proof homes will provide low-income residents with affordable, climate-aligned housing. This requires health and safety measures, efficient and weatherized building envelopes, efficient electric appliances, and affordable renewable electricity. To ensure that these retrofits are accessible, state and federal agencies, community action agencies, and utilities must collaborate to deliver a "One-Stop-Shop" program interface. These programs and their funding sources must ease and unify eligibility requirements to ensure all LMI households have access to affordable retrofits. Multiple programs across the US have already begun implementing and scaling whole-home One-Stop-Shop retrofit programs by leveraging and stacking existing federal and state funding. Continued development of well-designed retrofit programs will increase national retrofit demand, improve public support, and lay the foundation for avenues of increased funding opportunities. Scaling whole-home one-stop-shop retrofit programs is crucial to ensure the US can equitably decarbonize the housing sector while ensuring everyone has a safe and healthy home.

References

- ACEEE. 2016. "Customer Energy Efficiency Programs".
www.database.aceee.org/state/customer-energy-efficiency-programs
- Ahrens, M., Evarts, B. 2018. *Natural Gas and Propane Fires, Explosions and Leaks Estimates and Incident Descriptions*. National Fire Protection Association. www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/Hazardous-materials/osNaturalGasPropaneFires.ashx.
- Ayyagari, S., Gartman, M., Corvidae, J. 2020. *Hours of Safety in Cold Weather*. RMI.
www.rmi.org/insight/hours-of-safety-in-cold-weather.
- Basu, R., Samet, J. M. 2002. "Relation Between Elevated Ambient Temperature and Mortality: A Review of the Epidemiologic Evidence." *Epidemiologic Reviews* 24(2): 190-202.
- Bell, M. L., Ebisu, K. 2012. "Environmental Inequality in Exposures to Airborne Particulate Matter Components in The United States" *Environmental Health Perspectives* 120 (12): 1627-a475.
- Benz, S. A., Burney, J. A. 2021. "Widespread Race and Class Disparities in Surface Urban Heat Extremes Across the United States." *Earth's Future* 9(7).
- Buchanan, M. K., Kulp, S., Cushing, L., Morello-Frosch, R., Nedwick, T., Strauss, B. 2020. "Sea Level Rise and Coastal Flooding Threaten Affordable Housing." *Environmental Research Letters* 15 (2).
- Buonocore, J. J., Salimifard, P., Michanowicz, D. R., Allen, J. G. 2021. "A Decade of The U.S. Energy Mix Transitioning Away from Coal: Historical Reconstruction of The Reductions in the Public Health Burden of Energy." *Environmental Research Letters* 16 (5).

- CSD (California Department of Community Services & Development). 2020. *Low-Income Weatherization Program (LIWP) Impact Report*. Sacramento, CA: CSD.
www.csd.ca.gov/Shared%20Documents/LIWP-Impact-Report-November-2020.pdf
- Davis, L., Hausman, C. 2022. “Who Will Pay for Legacy Utility Costs.” *Energy Institute at HAAS*. <https://haas.berkeley.edu/wp-content/uploads/WP317.pdf>
- Dedoussi, I. C., Eastham, S. D., Monier, E., Barrett, S. R. H. 2020. “Premature Mortality Related to United States Cross-State Air Pollution.” *Nature* 578: 261-265.
- Delmastro, C., Abergel, R. 2021. *Building Envelopes*. IEA. Paris: IEA.
www.iea.org/reports/building-envelopes
- EIA (Energy Information Administration). 2018. *One in three U.S. households face a challenge in meeting energy needs*. Washington, DC: EIA.
www.eia.gov/todayinenergy/detail.php?id=37072
- Egerter, A., Hopkins, G., Mandel, J., Verhaar, H. 2018. *Energy Efficiency and Electric Vehicles: How Buildings Can Pave the Way for the Global EV Revolution*. RMI.
<https://rmi.org/insight/energy-efficiency-and-electric-vehicles/>.
- Emanuel, R. E., Caretta, M. A., Rivers III, L., Vasudevan, P. 2021. “Natural Gas Gathering and Transmission Pipelines and Social Vulnerability in the United States.” *GeoHealth* 5(6).
- ERRE (Office of Energy Efficiency and Renewable Energy). 2015. “Getting It Right: Weatherization and Energy Efficiency Are Good Investments”.
www.energy.gov/eere/articles/getting-it-right-weatherization-and-energy-efficiency-are-good-investments.
- ERRE (Office of Energy Efficiency and Renewable Energy). 2022. “About the Weatherization Assistance Programs”. www.energy.gov/eere/wap/about-weatherization-assistance-program
- Gerdes, J. 2020. “So, What Exactly Is Building Electrification?”.
www.greentechmedia.com/articles/read/so-what-exactly-is-building-electrification.
- Hernandez, D. 2015. “Understanding ‘Energy Insecurity’ And Why It Matters to Health.” *Social Science & Medicine* 167: 1-10.
- Hernandez, D., Jiang, Y., Carrion, D., Philips, D., Aratani, Y. 2016. “Housing Hardship and Energy Insecurity Among Native-Born and Immigrant Low-Income Families with Children In The United States.” *Journal of Children and Poverty* 22(2): 77-92.
- Hoffman, J. S., Shandas, V., Pendleton, N. 2020. “The Effects of Historical Housing Policies On Resident Exposure To Intra-Urban Heat: A Study Of 108 Urban Areas” *Climate* 8 (2).
- HUD (U.S. Department of Housing and Urban Development). 2011. *Housing-Related Health and Safety Hazard Assessment*.
https://www.hud.gov/sites/documents/HHPGM_FINAL_CH4.PDF

- HUD (U.S. Department of Housing and Urban Development). 2018. *Guide to Sustaining Effective Asthma Home Intervention Programs*. Washington D.C.: HUD. www.hud.gov/sites/dfiles/HH/documents/HUD%20Asthma%20Guide%20Document_Final_7_18.pdf
- Infrastructure Investment and Jobs Act of 2021. H.R.3684.
- Jacobs, D. E., Baeder, A. 2009. *Housing Interventions and Health: A Review of the Evidence*. National Center for Healthy Housing (NCHH). www.nchharchive.org/LinkClick.aspx?fileticket=2lvaEDNBIdU=&tabid=229.
- JCHS (Joint Center for Housing Studies of Harvard University). 2020. *The State of the Nation's Housing 2020*. Cambridge, MA: JCHS. www.jchs.harvard.edu/sites/default/files/reports/files/Harvard_JCHS_The_State_of_the_Nations_Housing_2020_Report_Revised_120720.pdf
- Jessel, S., Sawyer, S., Hernandez, D. 2019. "Energy, Poverty, and Health in Climate Change: A Comprehensive Review of an Emerging Literature." *Frontiers in Public Health* 7.
- Lin, W., Brunekreef, B., Gehring, U. 2013. "Meta-analysis of the effects of indoor nitrogen dioxide and gas cooking on asthma and wheeze in children." *International Journal of Epidemiology* 42 (6): 1724-1737.
- Logue, J. M., Klepeis, N. E., Lobschied, A. B., Singer, B. C. 2014. "Pollutant Exposures from Natural Gas Cooking Burners: A Simulation-Based Assessment for Southern California." *Environmental Health Perspectives* 122(1), 43-50.
- MACPAC. 2018. "Medicaid's Role in Housing". www.macpac.gov/wp-content/uploads/2018/10/Medicaid%E2%80%99s-Role-in-Housing.pdf
- Norton, R, Lewis, J., Klinger, C. and Goldman, N. 2021. *Leading with Equity and Justice in the Clean Energy Transition: Getting to the Starting Line for Residential Building Electrification*. Baltimore, MD: GHHI. www.greenandhealthyhomes.org/wp-content/uploads/2021-GHHI-Leading-with-equity_wp_Final.pdf.
- PEA (Philadelphia Energy Authority). 2020. "Built to Last An Initiative to Restore Safe, Healthy, and Affordable Homes." Philadelphia, PA: PEA. Philaenergy.org/wp-content/uploads/2020/08/8-2020-PEA-Built-to-Last-Overview.pdf
- Reames, T. G. 2016. "Targeting Energy Justice: Exploring Spatial, Racial/ Ethnic and Socioeconomic Disparities in Urban Residential Heating Energy Efficiency." *Energy Policy* 97: 549-558.
- Richardson, J., Mitchell, B. C., Meier, H., Lynch, E., Edlebi, J. 2020. *Redlining and Neighborhood Health*. National Community Reinvestment Coalition (NCRC). www.ncrc.org/holc-health/
- RMI. 2019. *The Impact of Fossil Fuels in Buildings*. www.rmi.org/insight/the-impact-of-fossil-fuels-in-buildings/
- Seals, B., Krasner, A. 2020. *Gas Stoves: Health and Air Quality Impacts and Solutions*. RMI. www.rmi.org/insight/gas-stoves-pollution-health.

- Solar on Multifamily Housing (SOMAH). 2022. “About the Program” calsomah.org/about
- Tan, L., Fathollahzadeh, M. H. 2021. *Why Heat Pumps Are the Answer to Heat Waves*. RMI. www.rmi.org/why-heat-pumps-are-the-answer-to-heat-waves/.
- Tan, Y., Jung, B. 2021. *Decarbonizing Homes: Improving Health in Low-Income Communities through Beneficial Electrification*. RMI. www.rmi.org/insight/decarbonizing-homes.
- Tessum, C. W., Paoletta, D. A., Chambliss, S. E., Apte, J. S., Hill, J. D., Marshall, J. D. 2021. “PM_{2.5} Polluters disproportionately and systematically affected people of color in the United States” *Science Advances*
- Taylor, L. 2018. “Housing and Health: An Overview of the Literature.” *Health Affairs*. <https://www.healthaffairs.org/doi/10.1377/hpb20180313.396577/full/>
- U.S. Department of Energy. 2018. *Low-Income Household Energy Burden Varies Among States – Efficiency Can Help Them All*. Washington, DC: DOE. www.energy.gov/sites/prod/files/2019/01/f58/WIP-Energy-Burden_final.pdf
- United States Government Accountability Office. 2020. *Rental Housing: As More Households Rent, The Poorest Face Affordability and Housing Quality Challenges*. Washington, DC: GAO. www.gao.gov/assets/gao-20-427.pdf
- Wilson, J., Tohn, E. 2011. *Healthy Housing Opportunities During Weatherization Work*. Golden, CO: NREL. www.nrel.gov/docs/fy11osti/49947.pdf.
- Wolfe, M. 2021. “We need a national green bank to build the green economy”. www.thehill.com/opinion/energy-environment/567718-we-need-a-national-green-bank-to-build-the-green-economy.
- World Health Organization. 2021. *WHO Global Air Quality Guidelines: Particulate Matter (PM_{2.5} and PM₁₀), Ozone, Nitrogen Dioxide, Sulfur Dioxide and Carbon Monoxide: Executive Summary*. <https://apps.who.int/iris/handle/10665/345334>
- Zahran, H. S., Bailey, C. M., Damon, S. A., Garbe, P. L., Breysse, P. N. 2018. “Vital Signs: Asthma in Children – United States, 2001 – 2016.” *Centers for Disease Control and Prevention: Morbidity and Mortality Weekly Report (MMWR)* 67 (5): 149-155.
- Zhu, Y., Connolly, R., Lin, Y., Matthews, T., Wang, Z. 2020. *Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California*. UCLA Fielding School of public Health. www.ucla.app.box.com/s/xyzt8jc1ixnetiv0269qe704wu0ihif7