Equitable Electrification: Solving the Affordability Catch-22 for LMI Households that Heat with Natural Gas

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ABSTRACT

Building electrification is essential to meeting climate goals. However, many customers who heat with natural gas face an "affordability catch-22": They are likely to experience energy cost increases from building electrification in the near term, but could be at risk of energy cost increases in the long term if high upfront costs prevent them from electrifying. Low- and moderate-income (LMI) households are particularly vulnerable to short-term cost increases because they already face high energy burdens and often live in housing that is challenging and expensive to electrify.

The affordability catch-22 demands that we find equitable solutions to help LMI households electrify their homes without increasing their energy burdens. This paper applies an affordability lens to survey electrification barriers and solutions, with a focus on LMI households that rely on natural gas. We first review the cost impacts of building electrification for households that use natural gas, and how those impacts pose a particular challenge to affordability for LMI households. We then offer emerging strategies to advance electrification while avoiding adverse consequences for LMI households, related to project design and planning, technology advancement, weatherization and utility programs, housing policy, bill assistance, and rate design. We conclude by suggesting a definition of *equitable beneficial electrification* that accounts for both short-term and long-term cost impacts.

Introduction

Building Electrification and the Clean Energy Transition

Building electrification is a central pathway in the clean energy transition. The building sector contributes close to 10% of annual greenhouse gas (GHG) emissions nationally (Billimoria et al. 2018). Since 70% of all buildings standing today will still exist in 2050 (Reeg 2021), investing in electrification of existing buildings, not just new construction, is critical.

In states with cleaner electric grids, the GHG advantage for heat pumps over natural gas appliances is already substantial, and a recent analysis by LBNL found that, based on today's U.S. electric grid composition, "the vast majority of states can be CO_2e neutral with typical modern heat pump equipment, compared with 95 and 65 AFUE gas appliances" (Walker, Less, and Casquero-Modrego 2022, 24).[1] Heat pumps will deliver even greater GHG reductions relative to gas appliances as the electric grid becomes cleaner over time. Currently, 30 states, 2 territories, and the District of Columbia have set clean-energy targets for their electric grids (NCSL 2021). Of those 30 states, 8 have established goals of 100% clean energy by mid-century (CESA 2021). In California, for example, "electrification is found to reduce total greenhouse gas

[1] Results could change if marginal rather than average emissions rates were used. Application of marginal vs. average emissions rate is a topic of much debate among analysts and stakeholders.

emissions in single family homes by ~30% – 60% in 2020, relative to a natural gas-fueled home. As the carbon intensity of the grid decreases over time, these savings are estimated to increase to ~80% – 90% by 2050, including the impacts of upstream methane leakage and refrigerant gas leakage from air conditioners and heat pumps" (E3 2019, iv). If adopted, federal legislation and executive action, such as Biden Administration actions to "tighten rules around toxic mercury, smog-forming compounds and other pollutants" (Grandoni 2022), will accelerate the transition to cleaner electricity even in states that have not set aggressive renewable energy targets.

Building Electrification and LMI Households

This paper explores barriers to building electrification for low- and moderate-income (LMI) households, and particularly residents of affordable housing. For this paper, the authors define *affordable housing* as rental housing units with rents below market rates. This includes housing subsidized by the government and "naturally occurring affordable housing" that rents at levels below the median market rent level without housing subsidies. In subsidized housing, the amount residents pay for rent and utilities is capped at 30% of either household income or Area Median Income thresholds. Many low-income households do not have access to housing that is considered affordable; of low-income households in need of rental assistance, only 24% live in subsidized housing (Fischer 2022).[2]

Low-income households occupy a range of housing types: 56% live in single-family homes, 11% in small multifamily homes, and 25% in larger multifamily buildings (5+ units) (LEAD 2022). Low-income households are more likely to rent their homes than higher-income households: 61% of Americans in the lowest income quartile rented their homes, compared to only 11% of people in the top income quartile (Pew 2022).

Although the environmental benefits are clear, building electrification can present challenges to affordability for low-income households, which already face disproportionate energy burdens (DOE 2018).[3] This paper applies an affordability lens to survey electrification barriers and solutions, with a focus on LMI households that rely on natural gas. The following sections describe the cost impacts of building electrification, summarize specific barriers faced by LMI households, and review emerging strategies to advance equitable electrification.

Building Electrification: Practical Challenges

Cost Impacts for Natural Gas Customers

About half of U.S. homes use natural gas for space heating and water heating (EIA 2022), and natural gas heats 44% of all low-income housing (Census 2019). Utility natural gas service is more prevalent in single-family homes, but many residents of large multifamily buildings rely on natural gas as well. Of multifamily rental households with annual incomes below $30,000, 5.6 million use electricity to heat their home while 2.2 million use utility natural gas (Census 2019). Low-income households also tend to live in older buildings, which are more likely to use natural gas and can be challenging to electrify (Census 2019; LEAD 2022).

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[2] For this paper, we consider household income at or below 80% of Area Median Income to be low-income.
[3] Other housing types and configurations already make good sense to electrify from both a GHG and cost perspective, in nearly every region of the country. New construction and fuel switching from unregulated fuels (oil and propane) to heat pumps in existing homes are clear winners (E3 2019). Targeting these markets is the low-hanging fruit of beneficial electrification and should be pursued in tandem with the strategies outlined in this paper.

In most states, replacing natural gas equipment for space and water heating with high-efficiency air-source heat pumps and heat pump water heaters (HPWH) will reduce GHG emissions today. However, the picture is more complicated from a cost perspective. High upfront installation costs can prevent electrification, creating the risk that LMI households will face higher gas costs in the long term. In the short term, electrifying without safeguards can result in higher operating costs, particularly for customers that use natural gas.

Installation costs. Upfront equipment and labor costs are significantly higher for heat pumps than conventional gas equipment in most scenarios. In California, for example, HPWHs typically cost about $1,200 for the 50-gallon models and up to $2,000 for the 80-gallon models, versus $400 to $1,000 for natural gas and electric storage tank water heaters (VEIC and Energy Solutions 2020). The installation cost for HVAC heat pumps varies widely, depending on the type of heat pump and whether it is configured for heating, cooling, or both. The most cost-competitive approach is to install a heat pump to replace a pre-existing air conditioner and furnace at end of life, and to use the heat pump to provide both cooling and heating. In that case, which might not be possible in an emergency replacement scenario, installing an HVAC heat pump can be comparable in cost to installing central air conditioning and a gas furnace. For homes that do not have air conditioning, installing an HVAC heat pump costs about twice as much as installing a gas furnace. Many homes, particularly older ones and those without central air conditioning, also need electrical panel upgrades to accommodate the additional electric load of the heat pump, substantially increasing installation costs. Lack of contractor familiarity with heat pump technology adds to installation costs.

Short-term operating costs. Although installation costs for building electrification are likely to decline with economies of scale, operating costs represent a more persistent challenge. In many states, under current energy costs, customers who install heat pumps are likely to experience higher total energy bills than they would if they continued using natural gas. The operating costs of building electrification vary significantly by regional electric and gas rates and climate zones (because outdoor temperatures affect how well heat pumps perform).

Several studies have found very different impacts on customer operating costs for building electrification, depending on the assumptions used. Assumptions that can affect study results include: heat pump performance; electric and gas rates and trends; whether homes are assumed to have air conditioning; geographic analysis level; whether studies modeled multifamily buildings as well as single-family homes; and inclusion of installation costs. Despite methodological differences, most studies agree that many existing natural gas customers could face higher energy bills in the near term if they electrify end uses, particularly home heating. For example, the electrification advocacy group, Rewiring America, found that “37% of households using natural gas would... save on annual energy bills,” meaning that 63% would not (Rewiring America 2022). LBNL’s analysis found that in 21 U.S. states, homes that replace a 95 AFUE natural gas furnace with a heat pump at COP of 3 would experience energy cost increases (Walker, Less, and Casquero-Modrego 2022). This applies to 10 states where natural gas heating is most prevalent: California,[4] Colorado, Illinois, Indiana, Massachusetts, Michigan, Minnesota, New Jersey, New York, and Wisconsin.

[4] Using a lifecycle analysis with varying cost escalation rates for electricity versus natural gas, E3 reached a different conclusion about the operating cost impact of switching from natural gas to HVAC heat pumps in

Long-term operating costs. Failure to electrify because of upfront costs can increase long-term costs. Natural gas might have a short-term operating cost advantage, but gas prices can fluctuate substantially, as seen in recent price spikes caused by extreme weather events and rising overseas demand driven by Russia's invasion of Ukraine (Reuters 2022). Over the long term, customers who continue using natural gas are likely to experience rate increases from declining throughput, when other customers electrify and exit the gas system. There is a significant risk that LMI customers that remain on the natural gas system could bear the brunt of gas rate increases, leading to higher monthly bills (Gridworks 2019). While electricity costs may also increase due to investments in grid infrastructure to accommodate increased electricity demand, those rate impacts are expected to be more modest than gas rate impacts for those who remain on the system (CPUC 2021). In Maryland, an E3 study found that gas delivery rates could increase more than 20 times for consumers left on the gas system in a "high electrification" scenario where almost all buildings switch to heat pumps and are retrofitted to high efficiency through deep building retrofits (MCCC 2021). A nationwide statistical analysis found that a 15% reduction in residential gas customers would result in bill increases of roughly $30 per year for customers that remain on the gas system, while a 90% reduction in gas customers would result in bill increases of $1,500 per year (Davis and Hausman 2021).

In short, many natural gas customers could experience energy cost increases from building electrification in the near term, yet are at a high risk of energy cost increases in the long term if they do not electrify. This "affordability catch-22" demands that we find equitable solutions to help these customers electrify their homes without increasing their energy burdens.

Challenges of Electrifying Housing Occupied by LMI Households

LMI households face specific barriers to electrification that often lead to higher installation and operating costs. These include baseline housing conditions that make comprehensive retrofits more expensive, the lack of proven and commercially available solutions for mobile homes and multifamily buildings where higher shares of LMI households live, the impact of higher operating costs on the ability of subsidized housing developers to leverage debt, and owner-resident dynamics in rental housing.

Bundling electrification with weatherization and other efficiency measures is a core strategy to drive down post-retrofit operating costs, as this paper will discuss. However, addressing pre-existing health and safety hazards or repair requirements such as mold and moisture issues and roof repairs can increase the costs of weatherization projects in LMI-occupied housing. This is a longstanding barrier to participation in income-qualified energy efficiency programs. To provide a sense of scale, a national occupant survey of the Weatherization Assistance Program (WAP) indicated that approximately 30% of audited households are at least initially deferred (Rose et al. 2015).

In addition, older housing, which is more likely to be occupied by LMI households, can be more complicated and expensive to electrify. In addition to necessary health and safety upgrades, electrification retrofits may require "make ready" measures to accommodate greater electrical loads. These commonly include additional wiring or circuit panel upgrades and, in some cases, affect elements of the distribution system such as service lines or electrical transformers. Recent pilots in California's San Joaquin Valley, New York, and Washington, D.C.

California, finding that "HVAC heat pumps deliver bill savings for all homes for both retrofit and new construction of up to $600 per year (E3 2019)."

have demonstrated the need for upgrades in LMI-occupied buildings before electrification projects can be completed (Gridworks 2021; P. Boyd, director, DCSEU, pers. comm., March 21, 2022). Additional considerations include space constraints when switching to heat pump water heating, which often requires larger tanks, and can increase retrofit costs. Additionally, heat pump HVAC systems are most cost effective when replacing both heating and cooling systems, and LMI-occupied housing is more likely to lack air conditioning and associated duct work. While improved access to cooling is a clear health and comfort benefit of switching to heat pumps, it affects the upfront costs for properties without air conditioning as a baseline system.

In multifamily buildings, in which higher shares of LMI households live, electrification can require expensive custom engineering, guided by architects and engineers with specialized experience that is not yet widely available. Technological barriers common to multifamily buildings include the electrification "make ready" measures described above, reliance on window air conditioners, and the need for central heating and hot water solutions to replace central boilers and water heaters. Housing developers may also avoid retrofitting buildings to all-electric out of concern about high operating costs (Harris 2021). Higher operating expenses reduce net operating income and limit the amount of debt that the property can leverage, making it hard for project financing to pencil out.

In rental housing, owner-resident dynamics can complicate decision-making around electrification opportunities. Split incentives can decrease owners' willingness to pay higher upfront costs for measures that deliver bill savings to residents (Reina and Kontokosta 2016). At the same time, it increases owners' willingness to undertake upgrades that may raise utility costs for residents. Similarly, in multifamily properties where natural gas is not metered to residents or the property is served by central systems, a switch to electric or in-unit systems may change who pays for certain end uses. This risk can be mitigated in subsidized housing with well-designed utility allowances, but additional consumer protections are needed for unsubsidized housing.

In federal housing subsidy programs, utility allowances (UAs) can also affect electrification decisions.[5] When residents pay for their own utilities, they receive a UA that reduces their rent by the typical monthly utility cost for that region and unit type.[6] Although UAs are often an effective protection against increases in resident utility costs, in certain scenarios they can be a disincentive for owners to invest in higher-cost but more efficient electrification upgrades even when cost-effective (Venkatraman and Sampath Kumar 2022). In other cases, UAs may lag actual building upgrades in reflecting property-specific operating conditions.

Customers receiving non-electric fuel assistance through the Low-Income Home Energy Assistance Program (LIHEAP) may also be vulnerable to increased energy bills if the assistance does not keep pace as their fuel bills fall and electricity bills rise. Under current program rules, households' electric assistance does not automatically increase even if gas assistance decreases, and they must reapply for assistance when changing their primary heating fuel.

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[5] Federal housing subsidy programs include HUD Project-Based Section 8 Rental Assistance, USDA Rural Development Rental Assistance, Public Housing, Section 8 Vouchers, Project-Based Vouchers (PBV), the Low-Income Housing Tax Credit Program, and the HOME Investment Partnerships Program.

[6] UA schedules are set by the local Public Housing Authority (PHA) or state Housing Finance Agency (HFA). Based on local data, the schedule provides a rough estimate of reasonable energy consumption by an energy-conservative household of modest circumstances. Although the schedules may be less accurate than property-specific UAs, they have the advantage of being simple to administer for both the property owner and the oversight agency. When establishing UAs for electric space or water heating, PHAs/HFAs may base their estimate of energy costs on electric resistance technologies, resulting in higher UAs than if heat pumps were assumed to be used.

Recommendations to Advance Equitable Electrification

Given the groundwork laid by our examination of the practical challenges, we offer strategies for advancing electrification for LMI households and affordable housing by reducing cost barriers to fuel switching while minimizing negative impacts on energy affordability. They encompass project design and planning, technology advancement, weatherization and utility programs, housing policy, and bill assistance and rate design. The recommendations highlight real-world examples and emerging strategies to reduce both operating costs and installation costs and enable comprehensive retrofits that deliver energy bill savings to residents. Crucially, **all of these strategies should be paired with inclusive processes to understand barriers to electrification and center communities in planning and decision-making** (Greenlining 2019).

Project Design and Planning

Project developers can take a number of steps to screen electrification projects for customer cost impacts and improve project economics through design and planning.

Screen projects for cost impacts. Proposed LMI electrification projects should be screened for short- and long-term customer cost impact at the project level, in order to identify projects that will require addition steps to ensure that customer bills do not increase. Notably, screening for customer economics may differ from the cost-effectiveness screening performed within energy efficiency or weatherization programs; societal cost-effectiveness tests commonly incorporate non-energy, societal benefits such as carbon value and health benefits from cleaner indoor air. Screening projects for customer cost impacts necessitates using credible estimates or ranges for future electric and gas rates over time, so that cost impacts can be assessed in both the short-term and over the project's lifetime. We suggest that State energy offices and regulators should play a role in developing these credible projections of future rates and requiring their consistent use in projects receiving state or utility incentives. Screening tools may also need to be updated to better address multifamily housing electrification scenarios.

Design comprehensive projects to include energy efficiency and solar. Bundling electrification with energy efficiency and solar photovoltaics (PV) can significantly improve customer economics (BDC 2021). Particularly in cold climates, weatherizing homes prior to electrification helps to control costs by reducing heat loads, which in well-sealed homes can allow cold-climate air-source heat pumps to fully meet a home's heating requirements.[7] Combining solar PV with electrification also improves project economics in many scenarios, because lower-cost electricity from onsite or community solar can reduce the near-term cost impacts of electrification. For example, RMI modeled the addition of rooftop solar to retrofits in Oakland, California and found that "solar plus electrification lowers net present cost below that of either a natural gas retrofit or electrification alone, though it increases initial capital cost" (Billimoria et al. 2018). The Washington, DC Low-Income Decarbonization Pilot took this approach, combining comprehensive energy efficiency and electrification upgrades with solar installations to provide the best results for participating low-income households (P. Boyd, director, DCSEU, pers. comm., March 21, 2022). In a very different geography, a recent

[7] Northeast Energy Efficiency Partnerships (NEEP) hosts the Cold Climate Air Source Heat Pump Product List and Specifications: https://neep.org/heating-electrification/ccashp-specification-product-list

Midwest study found that "residents of both northern Michigan and Southern Ontario can profitably install residential solar to provide for all of their electric needs," with combined solar plus heat pump systems providing a positive internal rate of return while reducing the risk of natural gas price escalations in the future (Pearce and Sommerfeldt 2021).

Develop electrification roadmaps. Planning ahead by developing electrification roadmaps or readiness plans is an important way to control costs by syncing the timing of electrification investments with end-of-life equipment replacement, major renovations, or refinancing opportunities. As an example of this strategy, a TECH Clean California regional pilot is working with owners of subsidized multifamily affordable housing to develop electrification readiness plans to install electric equipment at time of unit turnover and plan for electrification as part of major renovations completed during refinancing (TECH 2021).

Technology Advancement

Expanding the suite of commercially available electrification solutions and driving down their cost is an important element of broader market transformation. Technology advancement has the potential to have an outsized impact on LMI-occupied housing given the prevalence of preexisting health and safety hazards or repair requirements (e.g., mold and moisture issues, inadequate amperage to accommodate electrification), combined with the challenges of electrifying certain multifamily properties with current technologies. New technology options may be able to avoid the need for electrical infrastructure upgrades. For example, "retrofit-ready" HPWHs are 120v equipment which do not require upgrades to wiring and or electric panels.[8] Additionally, lower-cost options for deep weatherization solutions, such as exterior cladding, can deliver important health, comfort, and resilience benefits to LMI households while driving down the upfront and operating costs of comprehensive electrification retrofits. Multifamily building owners in particular need additional technical solutions for central hot water heating replacement, as units designed specifically for multifamily housing have only recently entered the U.S. market. Electrifying high rise multifamily is also complicated by the challenges of running long refrigerant lines, making through-the-wall heat pump HVAC units an important area for technology development. In New York, the housing authority is taking on this challenge with support from the New York Power Authority and NYSERDA through the Clean Heat for All Challenge (Walton 2021).

Weatherization and Utility Programs

As weatherization and utility energy efficiency programs evolve to incorporate electrification, program administrators can design programs and braid funding to support equitable outcomes.

Design LMI electrification programs to support and incentivize comprehensiveness. Because of the risk of increased operating costs, program administrators should generally avoid promoting equipment-only electrification to LMI customers. While mass-market programs often encourage heat pump adoption through equipment rebates and discounts, programs specifically

[8] See the Advanced Water Heating Initiative: https://www.advancedwaterheatinginitiative.org/120v-field-study.

targeted to LMI customers should focus on comprehensive retrofits because these projects are much more likely to reduce energy bills in both the short and long term.

Designing comprehensive programs that support both electrification and efficiency involves several complementary strategies. Many utility and weatherization programs, including the federally funded Weatherization Assistance Program, need updates to enable electrification. This can include updating program rules and guidelines, clarifying that fuel switching is allowable, revising measure characterizations, updating cost-benefit tests to more accurately value the GHG and non-energy benefits of electrification projects, and modifying goal frameworks to be fuel-neutral, rather than single-fuel (Levin 2018).

Facilitating electrification as part of comprehensive retrofits delivers both near- and long-term bill savings, but comprehensive projects are expensive. Many programs serving LMI customers may need to expand budgets, increase cost caps, or revise cost-effectiveness screening practices to raise incentives and subsidies to the level needed. California's Low Income Weatherization Program (LIWP) provides a model for incentivizing electrification in a manner that addresses many of the barriers to electrification of LMI-occupied housing. LIWP is funded by revenue from the state's cap and trade program and has goals to reduce GHG emissions and deliver co-benefits to disadvantaged communities (CSD 2019). Its emphasis on GHG reduction is favorable to fuel switching, and a tiered incentive structure encourages retrofit projects with deeper energy savings. The multifamily program incentive structure addresses the split incentive by offering higher incentives for savings tied to tenant-paid meters. LIWP is a comprehensive, whole-building, audit-driven retrofit program with robust technical assistance, factors which both deliver impact and enable electrification. In cases where fuel switching could result in higher operating costs, LIWP's comprehensive offerings for both efficiency and solar PV enable projects to achieve overall energy cost savings. Technical assistance from the LIWP program implementers supports homeowners and affordable housing providers in identifying measures that meet their needs and are configured to their buildings' baseline conditions and to understand the expected energy and cost impacts.

Leverage funding from multiple sources. On top of the expense of comprehensive projects that pair electrification with weatherization and solar, many electrification projects in LMI homes face health and safety or structural barriers that add to the cost. One solution is to braid utility and weatherization funding with other sources that can pay for health and safety measures.. States are "allowed to allocate up to 15% of their LIHEAP grant to deliver weatherization services… [and] generally have more flexibility using LIHEAP funds to install weatherization measures and address weatherization barriers than WAP funds" (Bourguet and Faesy 2020, 6). After working with stakeholders, the Connecticut LIHEAP board recently voted to allow $2 million in funding to address health and safety barriers (McLean and Boyd 2021). In Massachusetts, utility program administrators, through the statewide Mass Save program, provide about $1 million annually to the Low-Income Energy Affordability Network (LEAN) agencies that deliver the WAP program, specifically to tackle structural and health and safety barriers that prevent weatherization projects from moving forward (Bourguet and Faesy 2020, 7).

Electrification readiness also adds to project costs. Just as electric utilities are starting to invest in "make-ready" programs that provide the necessary electrical infrastructure for electric vehicle (EV) charging – and receiving regulatory approval to recover the cost through the rate base or other cost recovery mechanisms – electric utilities may prove to be the logical choice to pay to make buildings ready for heat pumps. For example, in Washington, DC, a recent DC Sustainable Energy Utility (DCSEU) pilot found that nearly 20% of the cost for a typical comprehensive electrification retrofit for an LMI household was associated with upgrading the home's electric system, such as increasing the amperage (P. Boyd, director, DCSEU, pers. comm., March 21, 2022). One potential solution is for the electric utility, Pepco, to pay for these updates; Pepco's Climate Action Plan proposes to offer rebates for a Behind-the-Meter Heavy Up Program to address this need (Pepco 2021).

States are also expanding funding for LMI solar programs. Since many efficiency and weatherization programs do not incentivize solar PV or have strict cost caps limiting the amount that can be spent on PV, this funding is critical to enable comprehensive electrification projects to move forward. Washington, DC is looking to the Solar for All community solar program to mitigate potential cost increases associated with multifamily electrification projects that shift costs from master-metered gas bills to individually metered electric bills (P. Boyd, director, DCSEU, pers. comm., March 21, 2022). Solar for All's Community Renewable Energy Facility (CREF) allows a household to receive a monthly credit on their electricity bill from an offsite solar project, covering about 50% of the typical monthly electricity use (DOEE 2022).

Plan thoughtfully to phase out efficiency incentives for long-lived gas equipment. Some jurisdictions are considering phasing out efficiency program incentives for natural gas equipment. For example, the DC Department of Energy and Environment (DOEE) decided to phase out DCSEU incentives for natural gas equipment starting in FY2022, given that the District plans to achieve 100 percent renewable energy by 2032 – well within the 15-20 year lifespan of heating equipment installed in 2022 (DCSEU 2022). Regulators and program administrators should consider the cost impacts of gas incentive phase-out on LMI customers and consider a phased approach to ensure that market solutions are available. In Maryland, when the Montgomery County Council sought to prohibit use of county funding to the Montgomery County Green Bank (MCGB) to upgrade the efficiency of existing fossil fuel equipment, MCGB expressed concern that implementing an immediate ban would be problematic given the challenge of electrifying older multifamily buildings. The Council delayed the ban for a year and authorized the county Department of Environmental Protection to complete a study estimating the costs of converting fossil fuel mechanical energy equipment to electric prior to the ban's implementation. The transition period and study provide flexibility to the MCCB as the electrification market matures and provide information to the Council as it considers when to implement the ban (MCC 2022).

Housing Policy

Housing policy can advance equitable electrification while mitigating negative impacts on residents. Policies should be enacted that address the financial and technical obstacles to completing comprehensive retrofit projects and lower energy costs for building owners and residents. Since high-performance building design may be unfamiliar to many affordable housing agencies and developers, education and technical assistance are critical to ensure optimal outcomes. Several examples of supportive housing policies are discussed below.

Adjust state housing finance agency funding criteria to support all-electric buildings with well-insulated and tight envelopes. State housing finance agencies (HFAs) administer billions of dollars annually to finance affordable housing through highly competitive programs like the Low-Income Housing Tax Credit (LIHTC) and tax-exempt bond financing for both new construction and substantial rehabilitation projects. Most HFAs implement strict cost containment requirements to maximize the number of housing units created or preserved. To improve their chance of being funded, developers will strive to keep rehabilitation construction and operating costs low. As a result, developers may be reluctant to convert existing gas-fueled appliances to high-efficiency heat pumps if it increases rehabilitation costs.

HFAs can signal to developers that they value high-efficiency electric design by modifying project selection criteria and design guidelines. For example, New York State Homes and Community Renewal (HCR) updated its design guidelines in 2021 to include the following: "High-efficiency electric heating systems and domestic hot water systems should be considered in place of fossil-fuel sourced appliances, except when: (1) Sufficient electrical service is not available and cannot be made available by the utility company in a reasonable time, or at a reasonable cost; (2) There is not sufficient equipment for the size of the project available on the market" (HCR 2021, 32). State HFAs can also incorporate incentives or requirements for well-insulated building envelopes to reduce operating costs and resident energy burdens. Some HFAs require applicants to pursue deeper energy savings through standards requiring high-performing envelopes, like Passive House and DOE Zero Energy Ready Homes (Bartolomei 2021).

Coordinate robust incentive programs with project financing timelines. Affordable housing developers need access to sufficient financial incentives to address the additional upfront costs of converting existing buildings to high-performing electric design. To be effective, these incentives must be well-coordinated with housing finance programs to ensure they are adequate and that the developer can include the incentive in the capital stack. A partnership between HCR and NYSERDA addresses these challenges. Co-administering the Clean Energy Incentives for High Performance Projects program, these two agencies are able to support highly efficient and all-electric affordable housing. Up to $25,000 per unit for existing buildings covers the incremental cost of installing high-efficiency heat pumps and achieving advanced envelope and air ventilation. The funding targets properties seeking financing from HCR's 4% Bond Finance and 9% LIHTC programs (HCR 2022). The program also offers technical assistance to assist developers in achieving high-performance standards.

Update utility allowances for electrification. Artificially high UAs based on electric resistance heating are a disincentive to electrify LIHTC properties because they reduce the total per unit rent received by the amount of the UA. HFAs and housing authorities should update UA schedules to include a heat pump option or consider alternative methods to calculate UAs more accurately.

Establish affordability requirements to ensure that residents are protected from rent increases or displacement. To ensure continued availability of affordable housing, public and utility programs providing funding that results in cost savings to housing owners should adopt minimum affordability requirements. Programs can consider requiring participating owners to agree not to raise rents because of the electrification upgrades. This is particularly important in naturally occurring affordable housing, where affordability covenants are not in place. The California LIWP program, for example, requires owners of buildings without an existing affordability covenant to add one to the property (AEA 2019).

Bill Assistance and Rate Design

Bill assistance and rate discounts address energy costs in the short term, while rate design and other emerging strategies are important to support equitable electrification in the long term.

Preserve and streamline bill assistance for customers who electrify. Bill assistance programs that offset LMI households' utility expenses are another means of assuring that electrification retrofits do not increase energy costs. To effectively serve this role, bill assistance programs need to be funded at a level sufficient to serve the eligible population. Based on its 2020 funding levels, LIHEAP only serves approximately 18% of eligible households (NEADA 2021). Program rules and practices should also be updated to ensure that households are not penalized for fuel switching either by needing to re-enroll or by having their assistance levels reduced in ways that do not reflect actual energy costs. Bill assistance formulas that reflect household-specific income and cost characteristics provide a way to avoid energy burden thresholds for a larger share of households and can be responsive to changing energy costs in both the near and long term.

Expand income-qualified utility rates and Percentage of Income Payment Plans (PIPP). Discounted rates for qualified low-income households can significantly improve the customer economics for electrification projects. For example, many customers on California Alternate Rates for Energy (CARE), the discounted low-income rate, currently realize operating cost savings from electrification (Hopkins et al. 2018). While E3 found that HPWH bill savings did not show a clear trend in the general market (E3 2019, 59), the economics were better for customers on CARE because discounts for electricity are higher than the discounts for gas, 30-35 percent for electricity and 20 percent for gas (CARE/FERA 2021). PIPPs offer an alternative approach that reduces energy burdens by limiting the amount that low-income customers pay towards utility bills to a percentage of monthly income. Under Ohio's longstanding PIPP, households that heat with gas have a monthly payment equal to 5 percent of household income for their natural gas bill and 5 percent of household income for their electric bill. Customers with electric heat have a monthly payment equal to 10 percent of household income. The balance of these utility bills is subsidized by the state of Ohio (ODD 2022).

Advance electrification and time-of-use (TOU) rates. Emerging electrification-focused TOU rates (i.e., PG&E E-ELEC and SCE TOU-D-PRIME in California) can also improve customer economics. These rates combine TOU elements to promote load shifting with fixed charges to lower volumetric rates so that customers who are electrified are not penalized for higher consumption.

Emerging Strategies. States are beginning to incorporate equity considerations into "future of gas" proceedings and studies. These proceedings, such as those currently underway in California, New York, and Massachusetts, provide critical information to states and regulatory commissions on balancing risks to utility systems and ratepayers while achieving climate goals. In particular, studies can help regulators and stakeholders determine the optimal timing for LMI electrification efforts that target natural gas customers, based on each state's current electric and gas rates and pace of transition to a renewable electric grid. Future of gas proceedings and studies can also illuminate options to control the long-term costs and risks of the gas system, such as zonal electrification. More "radical" proposals to advance equitable electrification involve lowering electricity rates by collecting some social policy costs through other means, such as funding

California's wildfire-related system upgrades through taxes rather than electricity rates or moving fixed costs into an income-based fixed charge (Chhabra 2022).

Conclusion

This paper describes an "affordability catch-22": many natural gas customers could experience energy cost increases from building electrification in the near term, yet are at a high risk of energy cost increases in the long term if they do not electrify. Building electrification is critical to meeting climate goals, but we must ensure that LMI customers that rely on natural gas can participate in electrification without increasing their energy bills. We have identified numerous strategies to advance electrification for LMI households while protecting affordability, including project design and planning, technology advancement, weatherization and utility programs, housing policy, bill assistance and rate design, and emerging strategies.

Together, these strategies can support electrification that is not only beneficial, but equitable. We conclude by suggesting a new definition of equitable electrification that builds on the widely cited Regulatory Assistance Project (RAP) definition of beneficial electrification. RAP defines beneficial electrification as electrification that meets the at least one of the following conditions without adversely affecting the other two: (1) saves consumers money over the long run; (2) enables better grid management; and (3) reduces negative environmental impacts (Farnsworth et al. 2018, 6). We propose a modification to the first condition: to be considered equitable, beneficial electrification should save consumers money over the long run *without increasing energy costs for LMI households in the short run.*

This affordability-oriented definition builds on the Greenlining Institute's equitable building electrification framework, which outlines an inclusive and community-centered approach to electrification (Greenlining 2019). True equitable electrification will prioritize communities in planning and decision-making, while also striving to avoid negative energy cost impacts on LMI households in the near term and the long term.

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