Introduction to the SAFE Program: Promoting Electrification in Multifamily Buildings Through Displacement Strategies

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ABSTRACT

In New York City, two-thirds of greenhouse gas emissions come from buildings, making electrification integral to its climate change mitigation strategies. As the city aggressively pushes towards converting buildings to run on electricity generated by renewable energy, it is confronted with an old building stock incompatible with the infrastructure required for electrification. These buildings' inability to integrate this new system in their current state demands major costly electrical and envelope upgrades, which often makes the project cost-prohibitive. Displacement strategies are a means to start moving buildings toward full electrification as the city pursues electrification readiness across its building stock.

The Scalable Affordable Financeable Electrification program (SAFE) is a unique approach to electrification. The SAFE program, sponsored by the New York State Energy Research and Development Authority (NYSERDA), provides technical assistance for Domestic Hot Water (DHW) electrification retrofits in affordable multifamily buildings in New York City. Administered by Steven Winter Associates with support from Kinetic Communities Consulting, the program incentivizes the installation of electric heat pumps for DHW production, focusing on displacement strategies with favorable installation, operating costs, paybacks, and incentives. By partially electrifying a building's domestic hot water system, we can substantially reduce the project's equipment cost while also ensuring we keep the project within the electrical capabilities of the building to avoid additional project costs. SAFE can be used as a model for other DHW displacement strategy programs that can provide a path toward electrification as we prepare our buildings to transition toward all-electric systems.

Introduction

The urgency of implementing climate change solutions has never been more evident, with severe impacts being felt globally, nationally, and locally. To combat climate change, a range of solutions must be deployed, including the phase-out of fossil fuels through electrification. In New York City, there is a significant drive to shift buildings from fossil fuel systems to electricity-powered heat pumps as a key strategy for achieving carbon neutrality. Despite the growing support from policymakers, substantial barriers persist, primarily due to an aging building stock that is incompatible with heat pump technology. As a result, a ramp-up strategy is essential as New York City works towards making its buildings electrification-ready in the coming years.

While the pursuit of full electrification is crucial, other concurrent strategies should also be considered, such as electrification displacement strategies. Displacement strategies, where part of a building's fossil fuel system is replaced with heat pumps, can act as a bridge, allowing buildings to decarbonize now despite current deterrents to full electrification. The Scalable Affordable Financeable Electrification (SAFE) program demonstrates this practice by exploring the marketability of partial electrification of domestic hot water (DHW) systems. Through this program, multifamily affordable housing buildings receive technical guidance and incentives to

transition a portion of their domestic hot water production away from their existing fossil fuel system to air-to-water heat pumps. This program is exclusively available to multifamily affordable housing buildings, defined as having at least 25% of the residential units must be 80% or below the Area Median Income (AMI). SAFE specifically addresses DHW systems in a building where heat pumps installed through the program assist with the generation of hot water in the building. This tactic allows buildings to start transitioning away from fossil fuels, lowering greenhouse gas emissions without the cost-prohibitive measures that full electrification currently requires. SAFE can serve as a model for the proliferation of partial electrification programs, providing a pathway to the decarbonization of our building stock at a pace that matches electrification readiness efforts. Combining full electrification initiatives with displacement programs enables participants at various stages of electrification readiness to get involved now, ultimately aiming for the complete elimination of fossil fuels.

Electrification

Decarbonizing buildings requires electrification, where fossil-fueled end uses, primarily heating, are replaced with electric-powered technologies (York, Cohn, Morales, Tolentino 2022). When paired with a grid powered by renewable energy, electrification eliminates carbon dioxide emissions from fossil fuel combustion in buildings. For a building to pursue electrification, heat pumps need to be installed. Several types of heat pumps exist, but for multifamily residential buildings in New York City, air-source heat pumps are the most accessible. For domestic hot water (DHW), air-to-water heat pumps (AWHP) generate hot water through electricity. These systems consist of an outdoor compressor and an indoor storage tank, usually located in the boiler room of multifamily buildings. DHW accounts for, on average, 25% of an NYC building's total energy consumption, making it essential to electrify this system to achieve building decarbonization (Be-Ex 2023). DHW electrification plays a crucial role in decarbonizing buildings and thus meeting climate goals. SAFE offers a programmatic strategy on how to start decarbonizing centralized DHW systems now despite barriers to full electrification.

Policy

New York State has set ambitious goals for carbon emission reduction through the Climate Leadership and Community Protection Act (Climate Act), aiming to reduce economy-wide greenhouse gas (GHG) emissions by 40% by 2030 and 85% by 2050 from 1990 levels (New York State Climate Action Council 2019). The Climate Act mandates the majority of new purchases for space and water heating to be heat pumps, envisioning 85% of the state's building sector to be electrified with heat pump technology by 2050. Along with electrification efforts, New York is greening its grid with clean energy resources including land-based wind, solar, offshore wind, and hydropower. New York aims to generate 70% of statewide electricity from renewable sources by 2030 and achieve a zero-emission system by 2040. With a green grid powered by renewable energy, the state aims to encourage the proliferation of heat pump technology to transition space and water heating away from fossil fuel.

In 2019, New York City introduced the Climate Mobilization Act, which included Local Law 97 (LL97). LL97 requires most buildings over 25,000 square feet to meet ambitious carbon reduction targets from 2024 through 2050 or face fines (Torres, Kallos, Rosenthal 2019). This law targets multifamily buildings since 70% of the city's greenhouse gas emissions come from buildings, and it is projected that 90% of buildings currently standing will still remain by 2050,

as illustrated by Figure 1 (New York City Mayor's Office of Sustainability 2014). This law, aimed at reducing the city's carbon emissions by 80% by 2050, sets aggressive decarbonization caps on buildings. LL97 promotes electrification by providing credits toward decarbonization mandates for early adopters through "beneficial electrification." Implementing heat pumps is key to achieving the sustainability goals set by the state and city.

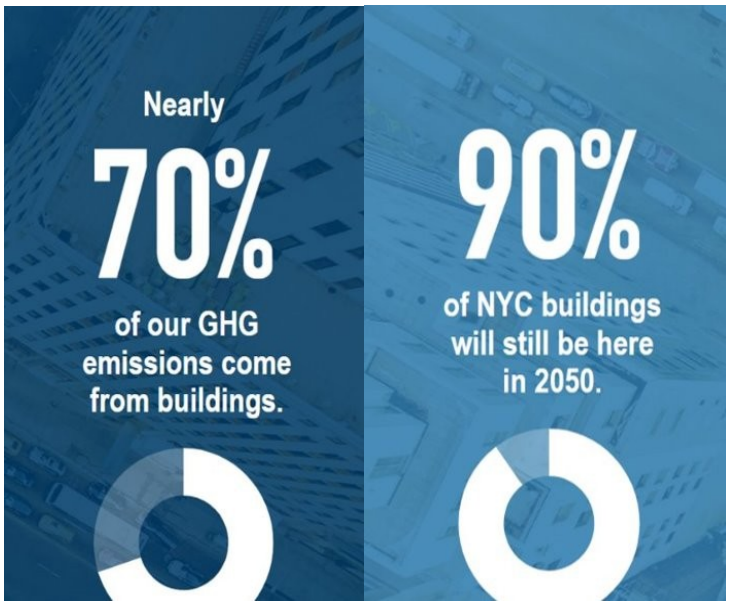

Figure 1. Percentage of greenhouse gas emissions from buildings in NYC and percentage of existing buildings that will remain in 2050. *Source:* New York City Mayor's Office of Sustainability 2014

Barriers

While all levels of government are encouraging the implementation of heat pumps, a wide array of barriers are preventing the adoption of heat pumps at the rate encouraged by legislators. For many, the installation of heat pumps is cost-prohibitive. Several factors contribute to the exorbitant cost of transitioning NYC's old building stock to run fully on electricity, but the key culprits include the electric capacity of these old buildings and the comparative fuel cost of natural gas and electricity in the current market.

New York City hosts one of the country's oldest building stocks. The average age of a building in New York City is over 100 years old; the average year built for a building is 1921 as shown in Figure 2 (Lawrence 2017). As a result, most of the city's buildings are hosting electric infrastructures from the early 20th century that are not compatible with the required electric capacity of modern building systems such as heat pumps. In their current state, these buildings cannot handle the power draw of heat pumps. To implement heat pumps most buildings require electric service upgrades, which can be very costly (Nadel 2019). Even if the economics of converting to an all-electric system accrues greenhouse gas and utility savings, the additional cost of upgrading the electrical capacity of the building to accommodate heat pumps may make the project too expensive and deter implementation (Borgeson, Deason 2019). Converting to electric equipment and appliances typically requires electrical service upgrades as well as upgrades inside apartments. This may also impact utility billing and billing arrangements, such as converting to resident-paid electric heat pumps for heating (Be-Ex 2019). Electrification

readiness in NYC usually implicates electric service upgrades, an expensive but necessary project for buildings to undertake.

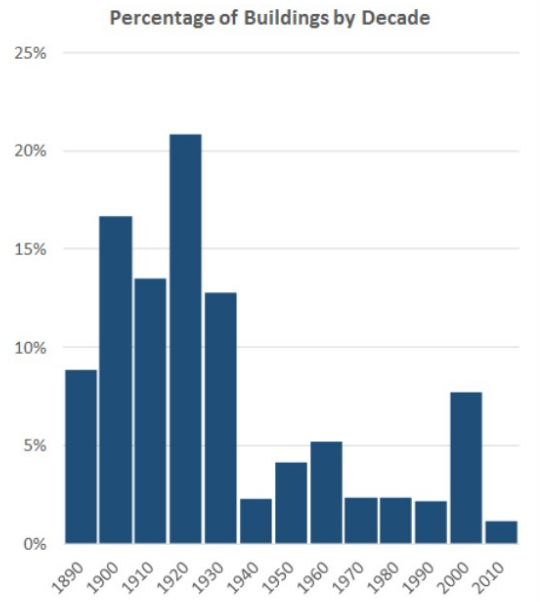

Figure 2. Bar graph indicating the percentage of existing NYC's building stock built by decade. *Source:* Building Ages and Rents in New York 2017.

Another cost-related barrier to electrification is the current price of natural gas compared to electricity. New York area households paid an average of 24.1 cents per kilowatt hour (kWh) of electricity in December 2023, up from 23.1 cents per kWh in December 2022, as shown in Figure 3. The average cost of utility (piped) gas at $1.621 per therm in December was down from $1.845 per therm a year earlier, as shown in Figure 4 (U.S Bureau of Labor Statistics 2023). The continuing trend of natural gas prices falling while electric rates rise has dissuaded buildings with gas systems from making the transition as the finances prove to be more expensive on an all-electric system currently. The generally low cost of natural gas across the US has made heat pumps a tough sale for existing homes with gas systems. The useful life of a building's system also plays a major role in the economics of an electrification project. If the change-out occurs before the end of the useful life of the existing direct fuel equipment, this effectively raises the cost of the replacement (Nadel 2019). Ultimately, if full electrification remains cost-prohibitive, buildings will not make the transitions despite enthusiasm and policy support.

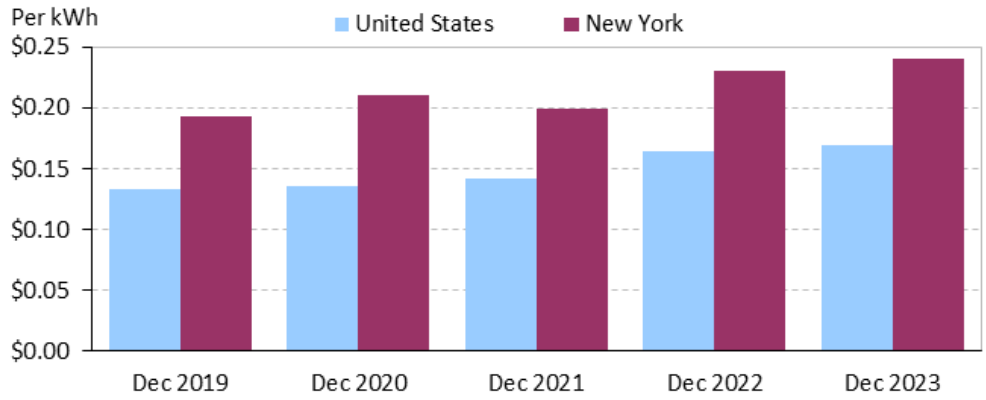

Figure 3. Bar graph of electric rates in December for the U.S. and New York. *Source:* U.S Bureau of Labor Statistics 2023.

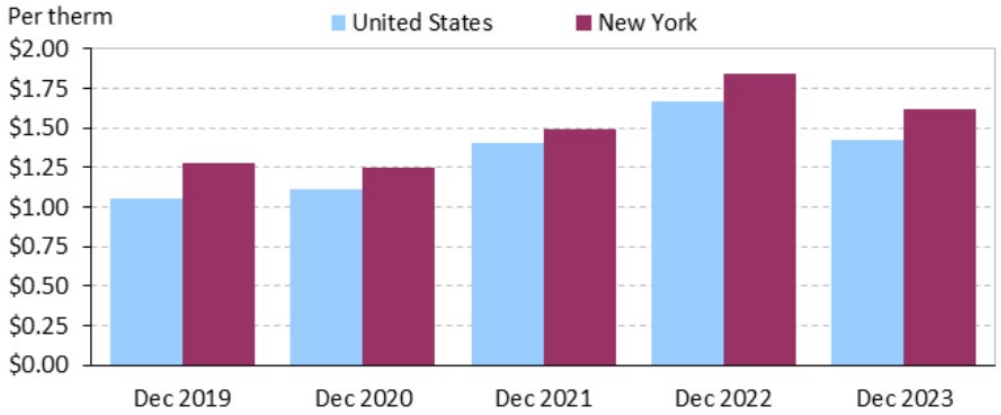

Figure 4. Average prices for utility (piped) gas, the United States and New York-Newark-Jersey City, NY-NJ-PA, 2019-23 (as of December 2023) *Source:* U.S Bureau of Labor Statistics 2023.

The Scalable Affordable Financeable Electrification Program

The barriers presented by full-scale building electrification created a market gap that necessitated displacement solutions like the Scalable Affordable Financeable Electrification program. The SAFE program, sponsored by the New York State Energy Research and Development Authority (NYSERDA), provides technical assistance for DHW electrification retrofits in affordable multifamily buildings in New York City. Administered by Steven Winter Associates with support from Kinetic Communities Consulting, the program incentivizes the installation of electric heat pumps for DHW production, focusing on displacement strategies with favorable installation, operating costs, paybacks, and incentives. Partial electrification allows buildings to take steps towards electrification, providing emissions reductions and a pathway towards full electrification

Background

In NYC, there are 26,000 buildings between 10,000 square feet and 100,000 square feet. This statistic makes small to medium multifamily buildings the 2nd largest market segment in New York State, next to single-family homes based on NYC Local Law 87 data (DOB 2019).

Water heating represents 20% - 50% of fossil fuel use in this demographic of buildings. Additionally, 96% of small to medium multifamily buildings have central mechanical rooms for domestic hot water generation. Compared to a retrofit with a constrained scope and application, addressing hot water production provides the opportunity for a universal upgrade that can be applied to a large swath of buildings. Addressing DHW production also provides the greatest flexibility when it comes to delivering targeted peak gas demand reductions. The integration of Air to Water Heat Pumps (AWHPs) with central mechanical equipment for the purpose of generating DHW represents a non-invasive upgrade that can be deployed without the costs, headaches and safety concerns associated with in-unit retrofit work.

How it works

SAFE is a pilot program from the New York State Energy Research and Development Authority (NYSERDA) that is administered by Steven Winter Associates (SWA) with the support of Kinetic Communities Consulting. NYSERDA funds the program through the system benefit charge, a fee paid by New State residents through their utility bills; the funds from this fee are used to create energy efficiency programs deployed by NYSERDA. NYSERDA also provides incentives to individual projects that go through SAFE. Steven Winter Associates designed the program and administers its implementation, coordinating with NYSERDA and Con Edison on incentives, designing the most cost-effective heat pump schematics for each building, connecting with manufacturers on equipment, training contractors on installation, and monitoring the system post installation to make sure the system is working properly. Kinetic Communities Consulting is subcontracted under Steven Winter Associates to conduct outreach and provide building support, connecting eligible buildings to the program, and assisting building decision-makers through the entire process. With the combination of the engineering and design expertise provided by Steven Winter Associates and Kinetic Communities' expansive experience with affordable housing support, SAFE wholistically supports buildings through all aspects of the program.

SAFE aims to meet 30-70% of the DHW load with heat pumps, with the remaining load met by the existing plant. This approach offers a cheaper alternative to fully electrifying the DHW load, providing a quicker and more attractive payback. Displacement strategies avoid many barriers faced by comprehensive retrofits, such as capital planning and equipment end-of-life timing, which can create unfavorable project economics. SAFE integrates AWHPs into existing DHW systems, circumventing the costs and effort associated with decommissioning the current DHW plant. When the fossil fuel system nears the end of its useful life, buildings can transition the full DHW load to heat pumps more feasibly.

Project leads at Steven Winter Associates designed SAFE to implement LG high-temperature Hydro Kit with an air source heat pump system. Heat pumps are installed alongside the existing water heater or combination boiler plant. The heat pump system meets 30-70% of the domestic hot water (DHW) load, and the existing equipment will continue to meet the rest. The 120-gallon hot water tank provides some thermal storage to maximize the heat pump’s performance. Dedicated LG digital controls integrate the heat pump equipment with the existing system and allow for remote verification of heat pump operations. SWA will assist building staff in monitoring these controls during the first year to ensure the system is operating seamlessly. Heat pumps supply some DHW load while the existing system generates the rest, with a storage tank maximizing the heat pumps’ performance. This setup avoids costs and barriers associated with accessing tenant spaces. Figure 5 demonstrates how all systems interact through this design

to provide tenants with a reliable source of hot water while decreasing the building's greenhouse gas emissions (Steven Winter Associates 2019).

Figure 5. Illustration of how customers are served by an integrated system, including the existing boiler, new supplemental heat pump, hot water storage, and control for the co-generation of DHW. *Source:* Steven Winter Associates 2019.

SAFE is centered on a minimally invasive design that lends itself to the current state of the building and minimizes disruption to tenant's units. Buildings utilize the LG Hydro Kit (High Temperature) and Multi VS air source heat pump, which is installed on the floor inside the building, near the existing domestic hot water plant. The Multi VS air source heat pump is installed outdoors, at ground level, where possible. These units are designed to operate in cold climates and have a nominal power consumption of 3.75 kW + 2.3 kW @ 208V 1-phase and a circuit breaker size requirement of 40A + 25A. Figure 6 illustrates how the proposed schematic equipment will be installed in participating buildings.

Figure 6. Close up image of indoor Hydro Kit module and outdoor heat pump unit with a proposed schematic of how units would be floor mounted at a rear wall of a typical multifamily building
Source: Steven Winter Associates 2024.

SAFE's Approach

The displacement approach championed by SAFE leverages the flexibility of DHW systems, allowing for seamless co-generation of hot water by different fuel systems. This model can be replicated in future programs, targeting DHW for noninvasive upgrades that do not require in-unit work and can be completed independently of space heating and electrification. DHW electrification presents an attractive option for replacing worn-out fuel oil and propane water heaters due to the high cost of those fuels compared to electricity. Moreover, space constraints are resolved through SAFE's approach, avoiding disruptions to tenants from installing electric equipment in common spaces or balconies.

SAFE prioritizes buildings with the right conditions in order to maximize the economics of a project, seeking ideal candidates who will have the best return on investment. Kinetic Communities Consulting connects with prospective candidates and collects information from the building that is then analyzed by engineers at Steven Winter Associates, who identify the buildings with the best economics for the projects. Buildings with the fastest payback for the program are smaller buildings under 25,000 square feet but more than ten units and on oil that are open to converting to time-of-use electric rate. The second-best payback is for buildings between 25,000-50,000 square feet on natural gas and open to converting to a time-of-use electric rate. The last group of buildings with an attractive payback are mid-size buildings around 50,000 square feet, on oil with a fixed electric rate. These tiers of payback are displayed below in Figure 5 (Steven Winter Associates 2019). Projected payback is calculated by assessing fuel prices in comparison to electric rates. Oil buildings produce the most favorable payback since electric rates are currently cheaper than the price of heating oil. Although natural gas buildings can participate in the program and accrue savings, their payback is not as favorable as oil due to natural gas being cheaper than electricity, as illustrated in the barrier section above. Payback calculation considers building size as well. Smaller buildings with less DHW load require fewer

heat pump compressors, lowering the overall project cost, but buildings under 10 units are too small, leading to a more expensive oversized design. Electric rates are also considered as a factor impacting project economics. Buildings that opt to convert to a time-of-use rate will see greater savings by operating heat pumps during off-peak hours when electricity is the least expensive. Buildings that operate heat pumps 24/7 and are eligible for demand response curtailment payments may find additional savings to the project by reducing their electricity usage during peak periods and cycling the heat pumps off for additional incentive payments. In addition to the quick paybacks that are available to ideal program candidates, SAFE is supported by state and utility incentives. NYSERDA provides participating buildings an incentive of $14,000, and electric utility provider Con Edison, also provides additional incentives in the amount of greenhouse gas emissions savings produced through the project under their electrification program, Clean Heat (Con Edison 2024).

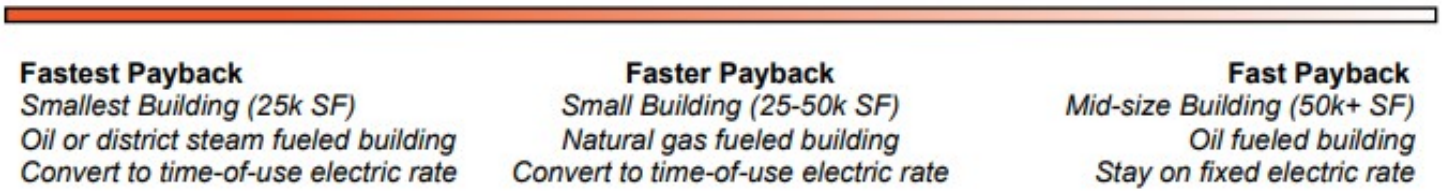

Figure 5. Breakdown of fastest payback for the program based on building size, fuel system, and electric rate. *Source:* Steven Winter Associates 2019.

As a part of the SAFE program, equity is baked into the programmatic design through the green dividend. The green dividend integrates tenants into the program's process, educating them on the program, Air Source DHW Heat Pumps, and energy efficiency. Additionally, the green dividend provides an opportunity for further energy-saving projects alongside the main heat pump installation. Utility cost savings realized from the heat pump installation will fund the green dividend in the form of additional energy efficiency measures. These measures will be packaged based on the amount of available utility savings and shared with building leadership for approval; they will then be presented to tenants during an engagement event for discussion and final approval. Through the green dividend, the hope is to create a space for tenants to be active participants in the decarbonization of their building while also providing them with useful resources and information on behavioral changes they can implement individually to reduce building emissions further. All these factors in play will ideally lead to the reduction of their carbon footprint and, in turn, their building's greenhouse gas emissions.

SAFE officially launched in the fall of 2021, targeting affordable housing in New York City. For a participant to be eligible for the program, a building must have at least 25% of the residential units with 80% or below the Area Median Income (AMI). Once a building qualifies, building information is requested to provide program engineers with insight into the building's system and infrastructure, which is used to generate quotes on projected construction costs and incentive amounts. Buildings then receive assistance with the development and submission of utility incentive applications, primarily Con Edison's Clean Heat program. SAFE also connects buildings to participating contractors who have been trained in the execution of the program to facilitate the bidding process. Lastly, a building chooses a contractor bid to pursue. Program leads provide technical assistance and oversight through the implementation of the program.

After installation, the green dividend goes into effect, tenants are engaged to learn about the project and choose other energy efficiency measures that will be funded by savings accrued by the new system. Steven Winter Associate also provides support and collects data on the new system to ensure it is operating effectively and efficiently.

Currently, 41 buildings are engaged in the program, and 21 have signed site agreements indicating their commitment to pursue project implementation through the program. Despite the interest SAFE has received, the program has experienced several delays due to funding pauses from electrification incentive programs that fund a large portion of the cost share of the project. As a result, SAFE has yet to move a building to completion as of July 2024. Another setback has been the drastic increase in DHW heat pumps since the pandemic. The higher prices demanded switching heat pump manufacturers in order to make the cost of the project accessible to affordable housing. SWA also onboarded more contractors onto the program in order to provide more competitive biding to the program and thus lower project costs. Despite the aforementioned setbacks, SAFE has received an extension from NYSERDA to continue operating and assisting the buildings that have been engaged in the program. We expect to move our current pipeline to completion through the end of 2024.

Opportunity

The displacement approach championed by SAFE builds on the opportunities created by DHW systems, capitalizing on the ability to seamlessly take on the co-generation of hot water by two different fuel systems. This is a model that can and should be replicated in future programming. A benefit of the electrification of DHW is its noninvasive nature, as it does not require work inside of units and can be completed with or separately from heating and cooling electrification (Be-Ex 2023). Moreover, DHW is a worthwhile target as replacing worn-out fuel oil and propane water heaters with heat pump water heaters is cost-effective in nearly all U.S. climates, and in some cases, early replacement can provide attractive payback, especially in the case of oil furnaces (Nadel 2019). Additionally, the national average energy prices show that heat pump water heaters are attractive relative to oil or propane water heaters (Borgeson, Deason 2019). Space constraint issues are also resolved through SAFE's approach. In full electrification projects, the locations of electric equipment, such as outdoor units for heat pumps and ductless heat pumps, may affect residents, particularly if located in common spaces, balconies, or other locations that could disrupt tenants. This is particularly the case for very tall buildings, which may require dedicated usable floor space for mechanical rooms every few floors (Bastian and Cohen, 2022). DHW is a major building system that can address the phase-out of fossil fuels while simultaneously being financially viable for many. Centering programming on DHW maximizes the opportunities afforded naturally by the nature of this system, which lends itself to displacement strategies.

With displacement, there is sizing flexibility in the number of AWHPs installed, creating business flexibility and laying a foundation for exponential scaling. This strategy is particularly relevant in light of climate policies that are pushing buildings toward electrification in the coming decades. A displacement approach for air source heat pump integration in 1-4 family homes is well established as a cost-effective space heating retrofit strategy for utility programs (Advanced Energy Center 2018). This program model leverages these proven approaches and extends the displacement strategy to DHW in larger multifamily buildings where there is high fuel use intensity. Scaling up an AWHP solution will provide a toehold with a large cross-section

of the market that can be leveraged over time to deliver additional upgrades, including, over the long term, moving from partial DHW electrification to full DHW electrification.

SAFE also emphasizes the need to expand electrification programming for multifamily affordable housing. Affordable housing lacks the funds to keep up with the accelerated electrification policy demands due to a lack of reserves and a multitude of maintenance issues that usually take precedence over decarbonization measures. Without funding or technical assistance, affordable housing will not be able to electrify at the pace policymakers are pushing to meet climate change goals. This will widen the gap between the quality of affordable housing and market-rate buildings. While market-rate buildings invest in decarbonization, increasing the comfort and performance of their buildings, affordable housing continues to fall behind to the detriment of its residents. SAFE not only provides funding and support to electrify these buildings, but they also champion a displacement strategy that meets the building where they are currently, allowing them to engage in electrification without being left behind. Also, addressing these buildings' DHW system provides a strategy that is not invasive to multifamily tenants while allowing them to reap the benefits of electrification and the option to have a say on how the building will continue to decarbonize through the green dividend. While full electrification is the aspirational goal, in order to start electrifying multifamily affordable housing, cost-effective strategies like displacement of hot water generation through heat pumps is a model that can be used in other cities to ensure equitable electrification across the country.

Conclusion

The daunting task of transitioning all our buildings has created a chasm where buildings are being pushed to electrify but are incapable of making the shift at the scale and speed policymakers are seeking. Programs focused on a displacement approach are missing in the market, a missed opportunity to meet buildings where they are at and maximize carbon reduction now. While policymakers unveil programs that promote the widespread implementation of electrification, adoption has been slow due to the cost-prohibitive nature of these projects; most buildings require electrification readiness measures before making the transition. Although the goal is full electrification to meet the global, state, and local climate change goals, the electrification of our buildings demands a flexible approach in this early stage. Flexibility through displacement strategies will allow buildings to move toward heat pumps at a financially feasible pace.

SAFE presents a viable partial electrification model for domestic hot water systems that can be replicated in cities that host a small to medium multifamily building stock. This program also demonstrates an equitable electrification strategy for affordable housing, a demographic that has the least resources to electrify, providing these vulnerable buildings with both technical and funding assistance to improve their performance and reduce the emissions of their buildings. Pairing full electrification programming with displacement programming will allow participants at all levels of electrification readiness and all levels of economic means to engage now, resulting in the ultimate goal, the phase-out of fossil fuels.

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