Hybrid to Whole Home: Making Partial Heat Pumps a Step, Not a Stop

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ABSTRACT

As utilities and policymakers accelerate building electrification, many households are adopting partial displacements as a first step, supplementing existing HVAC systems with heat pumps. While this approach lowers initial costs and reduces emissions, it may also create new challenges in the future by creating a "stall point" where customers do not complete the transition to full heating electrification. This paper examines the programmatic, policy, and practical factors that influence whether, and how, homes move from partial to full electrification heating.

Using a set of representative household archetypes, this paper explores technical pathways from partial to full displacement, comparing the economics and performance of each. Key metrics include net present value (NPV), participant cost-effectiveness, and cumulative emission reductions over time. The analysis considers the number and timing of interventions required, as well as the potential compounding costs of delayed or piecemeal transitions.

In our analysis, we find that partial displacements can provide emissions reductions competitive with full displacements, can be upgraded to full displacements later with lower lifecycle costs than immediate full displacements, and can even provide lower per-dollar emissions reduction costs. By identifying the leverage points within current electrification initiatives, the paper aims to inform strategies that ensure early partial displacement installations serve as a practical foundation for complete electrification rather than an endpoint.

Introduction

Residential building electrification is central to decarbonization, but is beset by the issue of affordability. Installations of new equipment are expensive, new technologies are faced with skepticism by consumers, and the relative cheapness of natural gas incentivizes its use for heating. Two characteristics of heat pumps that help them overcome the issue of affordability are their efficiency and modularity. In terms of efficiency, homeowners can replace their air conditioning unit which provides monthly savings in the summer months, making the decision economically beneficial if incentives are available to cover enough of the incremental cost. In terms of modularity, homes can install ductless mini-splits in rooms not served by a central system. A common "partial displacement" scenario is when homeowners install a heat pump system to replace their traditional air conditioning system. As this heat pump system also provides heat in the winter, its use will cause emissions reduction as it partially displaces the gas-based system.

However, this partial displacement of the heating system does not target the deeper savings and emissions reductions of a whole-home project, nor does it combat the long-term lock-in of natural gas infrastructure. In addition, taking the "low-hanging fruit" of summer cooling savings can make the economics of switching from a hybrid system (defined here as a home with both a gas-fired system and a heat pump) to a fully electric system less favorable.

Designing utility programs which meet customers "where they are" is central to decarbonizing. This means considering the customer's financial constraints, concerns about volatile energy prices, and skepticism about new technologies. Utility programs that provide flexibility for customers, whether they want to only replace their cooling load, or should they want to fully move to electric heat later, will be able to maximize their emissions reductions and garner positive customer sentiment.

This paper focuses on these partial displacements from a consumer, programmatic, and technical perspective. This topic is not covered extensively in the literature, and thus the purpose of this paper is to be illuminative, rather than prescriptive. That is, there are many benefits and drawbacks to pursuing partial displacements. At the current stage of heat pump proliferation in U.S. building stock, there is not necessarily a "wrong" way to pursue home decarbonization (other than not at all); the purpose of this paper is to discuss the strengths and weaknesses of different strategies.

Background

A helpful characteristic of heat pumps to program administrators is that they do not need to completely displace the central HVAC system to provide meaningful benefits. A single-zone mini-split can be cheaply installed, providing heating and cooling to an area of the building not served by the existing system. This facilitates installments in households which cannot afford a full replacement for their system. A summary of the relative advantages of partial and full heat pump displacements is provided in Table 1.

Perspective	Relative Advantage: Full Displacement	Relative Advantage: Partial Displacement
Customer	• Removal of air quality risk from combustion within the home. • Potential to eliminate natural gas monthly service charge. • Upgrading in a single event is easier to size than an eventual two-event upgrade.	• Lower upfront costs. • Allows customer to retain their backup system, engendering trust. • Can be staged over time, easing behavioral transition. • Two fuel sources give customers a natural hedge against energy price volatility.
Contractor	• Larger project scopes enabled by incentives, increasing revenue per job.	• Reduced risk of customer callbacks and complaints for comfort issues.
Policymakers	• Enables the removal of natural gas infrastructure.	• Prioritizes immediate reductions in emissions.

	• Maximizes the depth of savings relative to the costs of outreach.	• Allows the customer base to build familiarity with the technology, improving public perception of decarbonization measures. • Expands market reach—more homes can adopt heat pumps sooner.

Table 1: Relative advantages of full and partial displacements from the perspectives of customers, contractors, and policymakers pursuing decarbonization.

Partial Displacements in Practice

What is a partial displacement in practical HVAC terms? And what does it mean to go from a partial displacement to a full one?

For the purposes of this study, we look at upgrades to two types of systems. The first is a non-ducted system with a boiler, which heats water and pumps it through the house, distributing heat in individual rooms through radiators. The second is a ducted system, which heats air with a furnace and distributes it into rooms through vents.

For a non-ducted system, the partial displacement practically means using modular minisplit heat pumps to supplement the existing system. A full displacement is replacing the boiler with an air-to-water heat pump, with the radiators continuing to be utilized in the electric system, with additional radiators being added if needed. After the full displacement, the modular minisplits can stay, with the two systems (minisplits and air-to-water heat pump) running in tandem.

For a ducted system, the partial displacement is modeled as an air-to-air heat pump which is sized for 80% of either the cooling or heating load. As a ducted system uses a single air handler, the furnace and the heat pump cannot run simultaneously. The full displacement then takes the form of upgrading the heat pump to a larger size model, creating some sunk cost from the remaining life of the smaller unit. Partial displacements for ducted systems can also take the form of modular minisplits, as with the non-ducted systems, and may be the appropriate pathway for many customers. However, in our modeling (discussed later) this pathway was less economic and thus was not used in this study.

Operational Issues with Partial Displacements

An area where partial displacements forego savings is their interaction with the existing heating system. This is because there is not a universal way to connect an existing heating system with a new heat pump. Many of the improvised methods used unintentionally cause inefficiencies with the combined system. For example, one method to run both heating systems is to set the heat pump at the desired indoor temperature, with the backup system set 3-5 degrees lower. This allows the backup system to run at its full capacity, reaching its setpoint, while the heat pump makes up the difference (referred to as the “droop” method). However, a heat pump user survey in Maine found that homeowners often mistakenly attempt to employ this method by setting both thermostats to the same level. Unfortunately, this causes the backup system to take the full heating load (Leonard et al. 2024).

Contractor Perspectives

Underscoring this issue, a study of heat pump usage from Vermont found that heating load from heat pumps was roughly half of what was expected from the surveyed homes (Vermont Department of Public Service 2026). The most reliable method to efficiently run a hybrid system is with integrated controls that automatically set the equipment to run efficiently. However, this requires the customer to upgrade their thermostat, which does not always happen.[1]

From the perspective of heat pump installers, partial displacements also have an appeal. A survey of contractors in Maine found that roughly 20% of heat pump installations fully displaced the existing heating system, while the rest were supplementing an existing system (Leonard et al. 2024). This survey also noted that some installers did not trust multi-zone heat pumps, preferring instead to install multiple single-zone heat pumps, with some contractors noting the benefits of the redundancy of systems.

Sizing a heat pump correctly is essential to achieve a heat pump's maximum efficiency; however, sizing the system to design temperature makes the system more vulnerable to outlying low temperatures, when more heating capacity is needed. For this reason, heat pump installers often prefer to leave the existing heating systems in place to handle edge cases of abnormally low temperatures. A house which has a correctly-sized heat pump as its sole heating source is more likely to be unable to provide enough heat in extremely cold conditions; for this reason, a 2024 survey in Massachusetts found that experienced installers associated full displacements with higher customer callbacks (Arnemann 2025).

Utility/Grid Perspective

Underscoring the relative benefits of each, full and partial displacements have both been prioritized in different jurisdictions with the same aim of achieving climate goals. In Québec, partial displacements are used to reduce winter peak: the strategy taken here is to have natural gas heating displace heat pumps at low temperatures, when heating demand rises and the efficiency of a heat pump decreases. To do this, Hydro-Québec (in partnership with Energir) introduced a novel temperature-based electricity rate for dual fuel customers (using natural gas and electricity). Under this rate, the price of electricity increases when outdoor temperatures drop below -12°C (10.4 °F), encouraging households to switch to natural gas heat (Hydro-Québec 2026b).[2] This rate aims to reduce peak winter load by 2 GW by 2030 compared to a strategy centered around full displacements (Hydro-Québec 2026a).

Conversely, some jurisdictions have indicated that partial displacements cannot be a long-term strategy. In docket 20-80-B, the Massachusetts Department of Public Utilities stated that they were not convinced that a broad hybrid heating strategy was prudent, given that cold climate heat pump technology was already to a point where backup systems were unnecessary. They emphasized that maintaining a second energy system for a subset of heating hours would be extremely costly and that the gas system would largely need to be retired to comply with 2050 climate goals (Salkowski 2023).

[1] While thermostat upgrades make for a small portion of project costs (roughly $200 for a smart thermostat), the combination of the added cost, contractors not mentioning the technology to the customer, or the customer wanting to keep their existing thermostat causes there to remain homes with dual fuel heating and not a dual fuel thermostat.
[2] In some areas, this switchover temperature is -15°C. Residents are alerted of the change in electricity price by an indicator light.

Existing Utility Program Context

Utility energy efficiency programs typically do not distinguish between full and partial displacements, instead providing rebates for the installation of a heat pump and not putting contingencies based on the size of the heat pump relative to the whole-home heating load, or whether the existing heating system remains. Here we highlight some of the few programs nationally which do consider the relative size of the heat pump or the fate of the prior heating system, and the relative strengths and weaknesses of these approaches.

In Massachusetts, separate programs are available for partial and full displacements, with different requirements for each. When pursuing a partial displacement, customers are required to also install an integrated control to optimize the remaining fuel usage (Mass Save 2026). When pursuing a full displacement, the existing fuel heating system must be fully removed or disconnected. While this program is more stringent in its requirements for its rebates, as other programs do not require the proof of disconnection, having a partial displacement program leaves options for customers not interested in removing their existing system.[3]

Puget Sound Energy provides incentives for both partial and full displacements, as well as incentives for upgrading an existing heat pump system. These incentives allow a home to transition from gas heating to heat pump heating entirely, to transition from gas heating to a hybrid system, or to transition from an partial heat pump system to a full one (Puget Sound Energy 2026). By having this flexibility, a utility can avoid abandoning customers along their decarbonization journey; no matter what heating system you have, there is an incentive for you to increase your home's energy efficiency.

In its 2026-2030 Clean Heat Plan, New York State requires that heat pumps receiving rebates be sized to fully displace the heating load (New York Utilities 2025). By allowing the existing heating system to remain in place, New York's program provides customers with the financial safeguard of having a cheaper source of heat for the coldest days of the year, while also requiring them to install a system which can fully displace the existing system at the end of its effective useful life.

This approach is more customer-friendly, as it allows the user to adjust to and build trust with the new technology. It also sets up the customer to make a financially confident decision to not replace their boiler or furnace once their existing one fails. If the customer has become familiar with their heat pump system at the point when their old heating system expires, they may prefer to rely on the system that is sized to heat their whole home. However, it also requires customers to make a larger investment in energy efficiency, which may turn away some potential participants.

Methodology

We chose to address this issue from a quantitative perspective to see if there were any clear intervention points that stood out as clear winners, to inform potential programmatic designs. At an individual building level, this issue and the best answer will vary significantly, but at population levels there may be best fit solutions. For this section of our analysis, we used building models representing single-family housing stock in the U.S. to model the relative economics and emissions of a baseline natural gas fired system, partial displacements of the

[3] Notably, Massachusetts is also the first state to require utilities to offer seasonal heat pump specific rates to reduce the gap in cost between gas heating and heat pumps (Mass.gov 2026).

heating system followed by a full displacement at the end of the life of the existing heating system, and full displacement by a heat pump. By running these financial and technical analyses, we illustrate the relative tradeoffs, for the customer and the policymaker, of various “customer journeys” of HVAC electrification.

Data Aggregation

We focused on single-family houses in Wisconsin and New York. These locations were chosen for several reasons. Both states are in relative “hot spots” of heat pump incentive programs nationally. Both states also straddle climate zones, allowing us to compare climate zones 5 and 6 according to the IECC 2024 designations (deemed “Cool” and “Cold,” respectively) within a confined geographic space and similar weather patterns. (The New York City metropolitan area is in climate zone 4 and was thus excluded from our analysis.) Single-family detached homes were exclusively used in the analysis, as the economics of single-family housing are significantly different from those of multifamily housing, and single-family attached homes are relative anomalies in Wisconsin and ex-urban New York. We only included natural gas heated homes, because the economics of switching from electric resistance, oil, or propane heating to heat pumps are very favorable, and because gas-consuming homes make up most of the housing stock.

From the model outputs of NLR’s ResStock,[4] we created representative aggregate building model outputs for the various housing types (e.g., Wisconsin 6A Ducted Heating Furnace, Wisconsin 6A Non-Ducted Heating Boiler, etc.) (NLR 2024). These were paired with weighted average aggregate weather files for each of these data buckets.

Heat Pump Models

The source data for our heat pump models came from the NEEP air-source heat pump database (NEEP 2026). Using representative information on COP and capacity at set design temperatures, we interpolated COP and capacities for each temperature point from -20 to 110°F, as well as bands for relative performance. This allows us to model the interactive effects between changing heat pump capacity and COP. The modeling of the electricity usage of the heat pump began with the hourly required heating load from the ResStock outputs. We used this as our input as this modeling considers previous temperatures, humidity, insulation, and other real-world factors and presents the thermal load any heating system (heat pump, furnace, or boiler) would need to provide. This heating load was then compared to both the outdoor air temperature (OAT) and its proportion to the heat pump’s nominal capacity. As shown in **Error! Reference source not found.**, the COP of the system at this capacity and OAT can then be located, with the final electric consumption calculated from these values.

[4] 2024.2 Release, March 2024, AMY 2018.

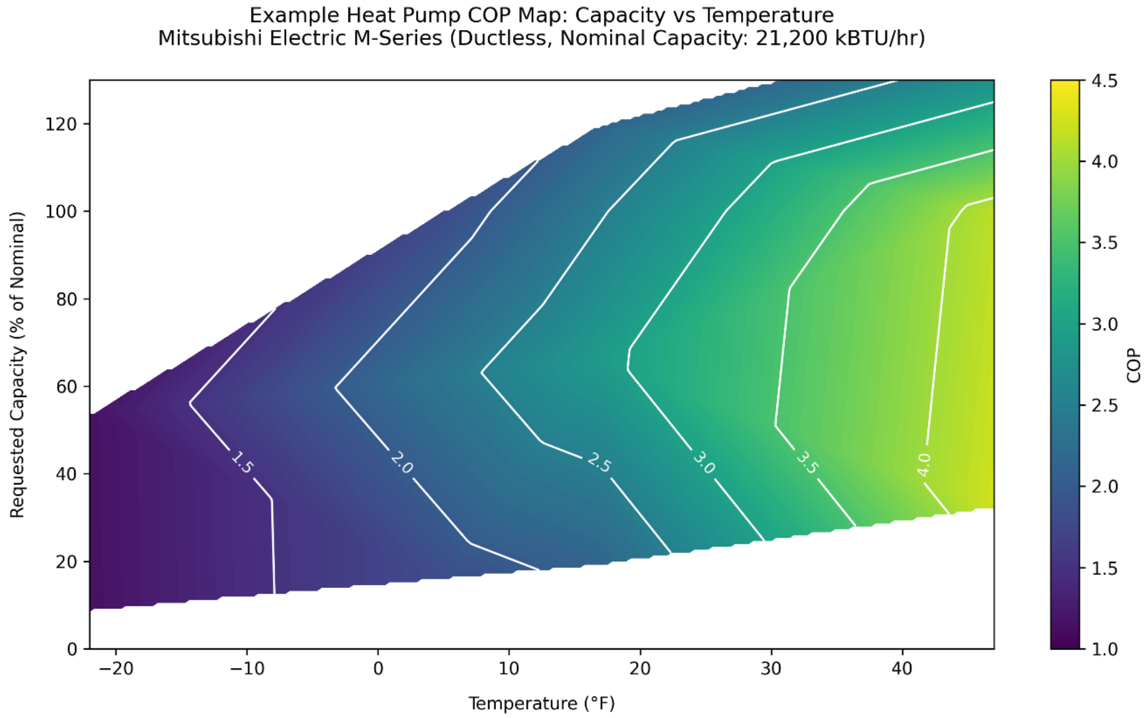

Figure 1: COP map for example heat pump.

Model Sizing

For full displacements, heat pumps were sized to satisfy heating load at the 99th percentile. We used the capacity de-rate factors from the modeled heat pumps to determine the needed cooling tons to appropriately service the identified heating load, to ensure sufficient capacity at design temperatures.

For partial displacements, two separate sizing techniques were examined. The first was a cooling-sized: The sizing needed for the heat pump to displace the current air conditioning system, again using the 99th percentile cooling load for reference. The second was the size needed to displace 80% of the heating load. This is a larger capacity than the cooling size, but still depends on the auxiliary system during the coldest parts of the year.

The two configurations we applied to each heat pump scenario were a full displacement and a partial displacement with a switchover temperature. For non-ducted systems we also applied a partial displacement with a droop setting.[5] Under the switchover temperature configuration, the heat pump provides the heating load above a certain temperature (27 degrees Fahrenheit in this study), below which the heat pump becomes less effective at providing heat. At this temperature, the heat pump is turned off and the furnace or boiler turns on. Under a droop configuration, the heat pump is operated at all temperatures, but as the outdoor temperature drops and the efficiency of the heat pump decreases, the furnace or boiler is turned on to make up the difference. In our modeling, this was determined by taking the heating load required by the

[5] In the results, the configuration with better economics was chosen to represent partial displacement. This is assumed to reflect the real-life assistance of a contractor helping a customer choose the optimal system.

home, calculating the heating load the heat pump provides at that temperature, and assigning the rest to the backup system. Ducted systems were not modeled with a droop configuration, as the air handler required for a ducted system can only handle one source at a time.

Customer Journeys

In addition to modeling the initial partial displacement, we modeled a second intervention at an assumed point when the original heating system reaches a point of failure. For comparison points, we also modeled full displacements. Our full list of modeled customer journeys is as follows:

1. Baseline system → Full displacement
2. Baseline system → Cooling-sized partial displacement → Full displacement
3. Baseline system → Heating-sized (80%) partial displacement → Full displacement
4. Baseline system → Cooling-sized partial displacement → Partial displacement with resistance heating backup
5. Baseline system → Heating-sized (80%) partial displacement → Partial displacement with resistance heating backup

Assumptions

Secondary interventions occurred after a set number of years. For our initial run, we used an assumed period of 8 years, running sensitivities for other points of intervention. Simulations were run on a 20-year timeframe.

We used a discount rate of 5%.

Equipment costs were derived from the Energy Information Administration (EIA) report on building technology costs (Guidehouse 2023) for fossil fuel based systems and the Mass Save evaluation on heat pump costs for heat pump systems (Guidehouse 2024; NMR Group 2026). As this report relies on invoice analysis, the resulting prices incorporate related costs such as panel and duct upgrades.

The baseline of electricity costs were taken from the EIA's Electric Power Monthly and were escalated using the 2024 Cambium data, using the assumptions for their mid-case for ISO-NE (Energy Information Administration 2026a; Gagnon et al. 2026). The gas cost baseline was taken from EIA residential prices and was escalated using the EIA projections of Henry Hub prices in the 2025 Annual Energy Outlook (Energy Information Administration 2026b, 2025). Emission factors for electricity were taken from Cambium (Gagnon et al. 2026). The final figures for these metrics are shown in Table 3.

Ducted buildings were modeled using air-to-air equipment, while non-ducted buildings with boilers and radiators were modeled using air-to-water heat pumps.

Year	Electric Price ($/kWh)	Gas Price ($/MCF)	Electric Emissions (kg CO_2e/MWh)
1	$ 0.27	$ 18.25	219
2	$ 0.26	$ 17.35	209
3	$ 0.24	$ 16.59	200
4	$ 0.22	$ 17.29	190
5	$ 0.20	$ 18.33	181
6	$ 0.18	$ 19.52	171
7	$ 0.21	$ 20.45	154
8	$ 0.23	$ 23.47	137
9	$ 0.26	$ 26.00	120
10	$ 0.28	$ 27.48	103
11	$ 0.31	$ 28.06	86
12	$ 0.33	$ 28.04	78
13	$ 0.35	$ 27.71	71
14	$ 0.37	$ 27.31	64
15	$ 0.39	$ 26.90	57
16	$ 0.41	$ 27.05	49
17	$ 0.41	$ 27.54	47
18	$ 0.41	$ 28.02	44
19	$ 0.41	$ 28.87	42
20	$ 0.41	$ 29.40	39
21	$ 0.41	$ 29.77	37

Table 3: Nominal prices and emissions assumptions.

Results

Customer Economics

Considering energy and capital costs, we conducted a 20-year net present value (NPV) analysis on the 5 customer journeys. Across the eight building archetypes, a cooling-sized initial displacement followed by a full displacement provided the best economics, as shown in Figure 2. Heating-sized initial displacements and baseline-to-full displacements provided similar economics, with some building archetypes having marginally better economics in one displacement type or another. Uniformly, a partial displacement with resistance backup heating was the most expensive for customers. All of the pathways were more expensive than the natural gas pathway, primarily driven by the spark-spread of the baseline energy commodity costs and the high capital cost of heat pump technologies.

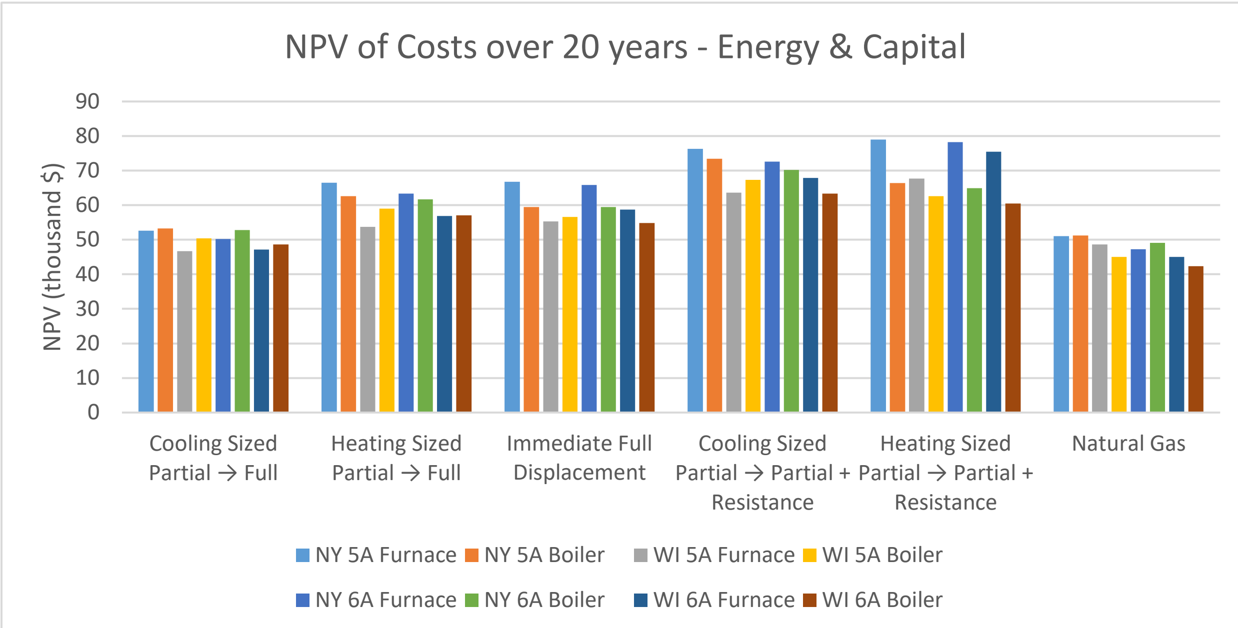

Figure 2: Customer economics of various displacements

When considering site emissions, the baseline to full conversion was predictably the most beneficial scenario, as shown in Figure 3. Here, the resistance heating scenarios fared slightly better, with the rightmost scenario (heating-sized initial displacement followed by a resistance backup) having comparable levels to the leftmost scenario (a smaller cooling-sized initial displacement followed by a full heat pump displacement), though they were still the least preferable. Still, all of these scenarios provided significant reductions when contrasted with a baseline case of no intervention.

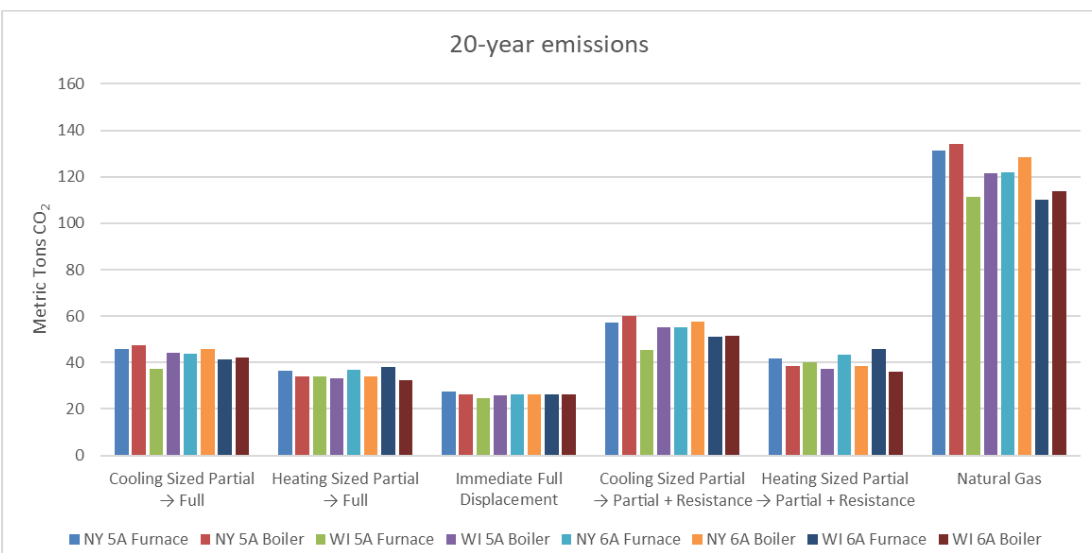

Figure 3: Emissions levels of various displacements

Pulling the two datasets together by calculating the implicit dollar cost per ton of carbon reduction[6] achieved by pursuing electrification by each of the intervention pathways, we find a more differentiated dataset, as shown in Figure 4. Cooling-sized initial displacements then leading to a full displacement have $/ton values ranging from $-26 to $89 per ton, representing a modest $/ton saved carbon value when compared to contemporary valuations. Directly converting to full displacement and heating-sized displacements are the next clear category of carbon valuation, while the electric resistance-based options have $/ton carbon valuations in the $200-400 range, putting them as the least preferable.

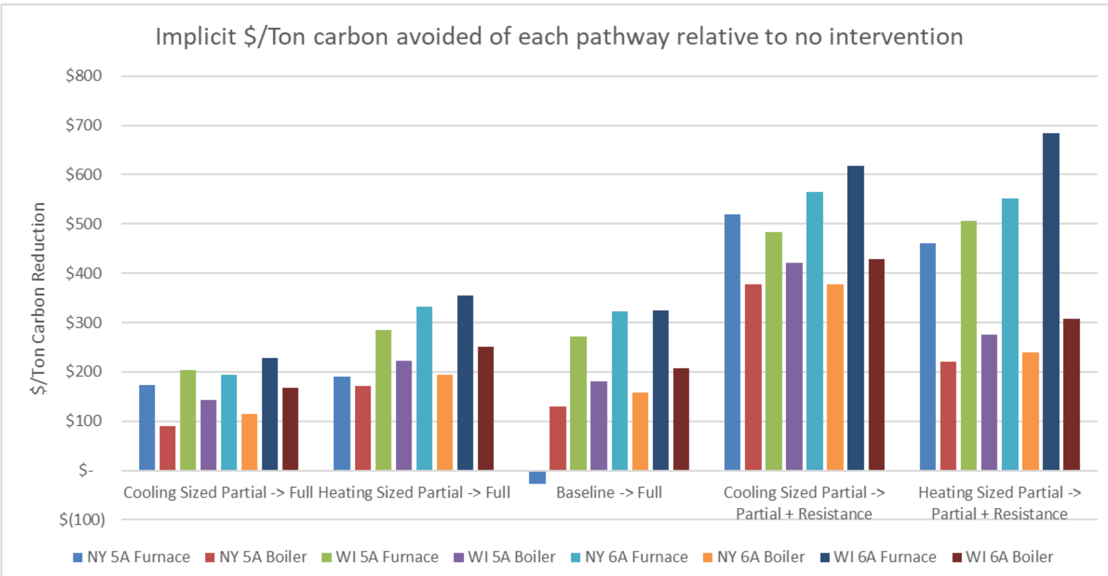

Figure 4: Implied dollar per ton carbon reduction of each pathway relative to baseline case

Taking all three views of the analysis into consideration, the replacement of air-conditioning systems is a critical intervention point for electrification. The easiest and cheapest intervention of replacing simple one-way air-conditioning systems with more flexible two-way heat pump systems should be prioritized in getting initiate heat pump adoption, both for the low cost-initial intervention, but also for slightly more favorable long-term outcomes. Upsizing at this time of intervention does carry additional carbon benefits, but it is not clear that it carries economic benefits for the host customer, at least with the assumptions embedded in this analysis.

When comparing the pathways of “Cooling Sized Partial → Full” and “Heating Sized Partial → Full,” the advantageous economics of the cooling-sized system can be seen to come from lower equipment costs, as shown in Figure 5.[7] The heating-sized partial system requires a significantly larger heat pump, over doubling the capital expenditure. However, the energy expenses only decrease (relative to the cooling-sized partial) by about 15%. This is because the savings of a heat pump come largely through cooling, where it uses less electricity than the baseline case of air conditioning, providing savings no matter the price environment. A cooling-sized partial displacement is calculated to optimize these savings, and ultimately has similar fuel costs to the baseline system. While the heating-sized partial can provide more efficient heating

[6] Modeled over a 20-year timeframe.
[7] While the costs for this are shown using the NY 6A furnace example, other building archetypes had similar results.

through the winter months, and ultimately has the lowest energy costs of any of the systems, these savings are eclipsed by the larger sizing of the initial displacement.

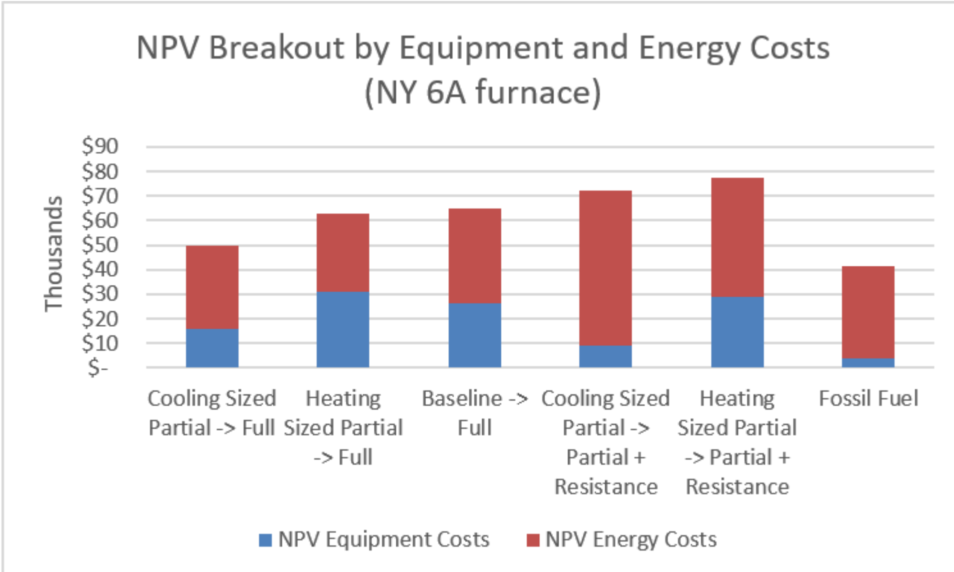

Figure 5: NPV of upgrades, by equipment and energy costs.

Electric resistance has a complicated role in residential electrification. With high flexibility in installation, high reliability, and relatively low capital cost it is clear why it is an enticing addition to heat pump installations for contractors and customers alike. However, it is also clear that its usage as a consistent source of heat, and not as an emergency backup heating element, is greatly detrimental to both the long-term economics of electrification and the emissions savings. Given that auxiliary strip heat is being installed alongside many ducted heat pumps today, it should be a priority to ensure that the resistance heat is only being used in emergency situations or at exceptional loads and not being used in any sort of regular capacity.

Analysis and Limitations

Full displacements provided the greatest emissions reduction, and for that reason, are the optimal case program administrators should attempt to achieve. However, with the financial constraints of the real world, starting with a heat pump replacement of the air conditioning system provides noticeable savings in terms of NPV for seven out of eight considered building types, and even provides a lower per-unit emissions reduction.

Something that NPV and other traditional financial metrics cannot capture is the effect of a liquidity constraint on households. While the NPV of the heating-sized partial and immediate full displacement are similar, the upfront cost of the immediate full displacement is a barrier noted by many energy efficiency researchers. While the use of a discount rate does capture aspects of the economic behavior of households, it also obfuscates aspects of the "kitchen table discussion." By first upgrading the home to a partial displacement and then to a full one eight years later, the household effectively pays for a full displacement in two installments. This, in theory, allows the customer journey we are analyzing to act as a form of financing. Again, since it's not explicitly financed, this benefit cannot be captured and considered in our accounting. However, as utilities work to understand customer perspectives better and design programs which account for the real-life economics of homeowners and their families, this limitation must be considered.

Conclusion

The emission benefits of whole-home heat pump projects are reaffirmed in our analysis, underscoring how full decarbonization is the optimal goal program administrators should aspire to. However, as affirmed by our analysis, a customer being able to first displace their cooling load, followed by the full heating load, provides deep emissions reductions while improving customer economics.

This approach of a two-step decarbonization journey is facilitated by the modularity of heat pump technology. Not only does it allow potentially skeptical customers to experience summertime savings to acclimate to the new technology, but it also can be installed in stages, unlike traditional systems. This two-stage conversion works with customer financial needs, breaking the upgrade into separate installments and avoiding the high upfront cost of a full conversion project, without financial instruments.

Overall, efficiency programs must move from the perspective of homeowners. The negative behavioral economics of a program which requires decommissioning of a backup system is simple; it requires, however, for the program to be designed with the customer's experience in mind. With this analysis, we hope to show the benefit, environmentally and economically, of providing flexibility to customers' preferences.

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