CITIZENS UTILITY BOARD
Fighting for Illinois Consumers

Better Heat: The Economics of Residential Building Electrification in the City of Chicago

Introduction

Like many cities, Chicago has adopted a greenhouse gas ("GHG") reduction agenda to help mitigate the impact of climate change.[1] As part of its commitment to achieve 100% clean energy by 2035, the City is developing a building decarbonization strategy—a bold undertaking, given Chicago's cold winters and the primacy of natural gas heat in the region. The reasons for transitioning to a new form of heating are straightforward. While Chicago's overall GHG emissions have gone down since 2005, emissions caused by gas consumption increased over that time.[2] Indeed, energy usage in buildings now comprises the largest category of the City's GHG emissions (70%), with fossil fuel heat the main contributing factor.[3] Put plainly, Chicago cannot achieve its climate change goals without transitioning away from natural gas heating.

The necessity for this transition goes beyond environmental concerns. Heating bills are increasingly unaffordable for Chicago consumers. In September 2020, 29 percent of Peoples Gas' ("PGL") customers were assessed late fees, indicating that nearly 3 in 10 Chicagoans couldn't afford to pay their monthly gas bill—in the summertime. [4] By the end of September 2021, PGL arrearages totaled more than $120 million; an amount double ComEd's total arrearages, even though ComEd serves five times as many customers as Peoples Gas.[5] Unfortunately, consumer prospects will only get worse, as the main cause of the affordability crisis is an ongoing PGL pipeline-replacement program that is expensive, over-budget and

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[1] See City of Chicago Green Recovery Agenda: https://www.chicago.gov/city/en/progs/env/green-recovery-agenda.html

[2] City of Chicago Greenhouse Gas Inventory Report, December 2019. Page xii https://www.chicago.gov/content/dam/city/progs/env/GHG_Inventory/Chicago-2017-GHG-Report_Final.pdf

[3] City of Chicago Greenhouse Gas Inventory Report, Page ix

[4] A lot of Chicagoans late on heating bills—from summer, Crain's Chicago Business, Oct. 28,2020, https://www.chicagobusiness.com/utilities/lot-chicagoans-late-heating-bills-summer

[5] Also by way of comparison, suburban gas utility Nicor serves three times as many customers as Peoples Gas and its total arrearages were $50 million. See the 220 ILCS 5/8-201 10 (b) October 15, 2021 filings of Peoples Gas, ComEd, and Nicor Gas, available here: https://www.icc.illinois.gov/home/chief-clerk-office/filings/list?ft=3

projected to raise fixed charges from the already high $40 per month to as much as $80 per month by 2031.[6]

For both consumer and environmental reasons, then, the status quo is unsustainable, and Chicagoans must find a better way to heat homes. The purpose of this study is to assess the economic feasibility of building electrification using high-efficiency electric heat pumps.[7] Heat pumps have gained popularity as an effective, low-carbon heating and cooling solution. In the winter, it uses electricity to harness heat from the outside air and pump that heat indoors—operating like an air conditioner in reverse. Heat pumps continue to improve in quality and decline in price—but are they cost effective?[8]

Based on current data, we find that PGL customers would see significant savings by switching to electric-powered appliances and "cutting the pipe," with household savings ranging from $24,716 to $47,104, depending upon the scenario, potentially generating between $25.3 billion and $28.9 billion in total cumulative savings for Chicago residents over the next 34 years. While these are lifetime figures, monthly cost savings on "new-build" and end-of-appliance-life "replacement" scenarios begin immediately, provided that in the case of the replacement scenario both the furnace and central air conditioning (A/C) are at the end of their service life. If only the furnace is at the end of its life, payback ranges from three to six years for both multi- and single-family homes. Switching to electric heat pumps early, while the furnace still has life, has a longer payback period of course. However, even in this "retrofit" scenario, payback at 10 to 11 years is similar to other energy investments, such as installing solar panels, and not

[6] ICC Docket 16-0376, Direct Testimony of Sebastian Coppola on behalf of the Illinois Attorney General. Filed October 11, 2016.

[7] Building electrification describes the transition from fossil fuel-powered equipment like gas and propane furnaces, hot water heaters, and stoves — to clean, efficient electric appliances like heat pumps, heat pump water heaters and induction stoves.

[8] Heat pumps achieve efficiencies several times higher than conventional heating technologies. Because they use air conditioning technology, they can also bring cooling to homes that otherwise have none, helping residents stay comfortable and safe during extreme heat events. And one heat pump system can replace both a furnace and central A/C, leading to overall cost savings.

unreasonable given the substantial public health and environmental benefits of transitioning away from fossil fuels.[9]

Data

The data used in this study were pulled from public filings with the Illinois Commerce Commission (ICC) from both PGL[10] and ComEd,[11] the electric utility that serves Chicago, and the Energy Information Administration's (EIA) most recent Annual Energy Outlook (AEO).[12] Cost and efficiency estimates for heat pump appliances were taken from two studies, performed in Massachusetts[13] and California, respectively,[14] and publicly available databases.[15] We also use PGL's cost projections for its Advanced Mainline Replacement Program (AMRP), a pipe-replacement program that has led to rapidly rising heating bills for Peoples Gas customers.[16]

Methodology

Projected PGL Bills

To estimate the annual therm usage of the average PGL customer, we divided total residential therm deliveries by the total number of PGL heating customers. The average total usage was divided into three usage categories: space heating, water heating, and other uses, according to estimates on the percentage of end-use consumption from the AEO.

Because the electric utility ComEd has separate rate classes for single-family and multi-family customers, it was necessary to generate distinct consumption profiles by estimating the difference in space heating usage between the two classes. Using the AEO estimate for the

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[9] On the substantial public health benefits in Illinois that could be achieved by transitioning away from fossil fuel heat, see https://rmi.org/health-air-quality-impacts-of-buildings-emissions#IL . "In Illinois, air pollution from burning fuels in buildings led to an estimated 1123 early deaths and $12.574 billion in health impact costs in 2017."

[10] ICC Docket 14-0225, Part 285.5010, Schedule E-01
[11] ICC Docket 20-0393, ComEd Exhibit 7.01
[12] AEO 2021
[13] Navigant, "Ductless Mini-Split Heat Pump Cost Study," 2018
[14] Energy and Environmental Economics, Inc, "Residential Building Electrification in California," 2019
[15] https://www.homewyse.com/services/index.html
[16] ICC Docket 16-037, AG Exhibit 2.6. Filed October 11, 2016

percentage of electricity that goes toward space cooling, we compared the average cooling kilowatt-hour (kWh) requirements for single-family and multi-family customers to the average requirement for all customers. We found that single-family homes use 22% more for cooling than average, and multi-family homes use 44% less than average for cooling.

By multiplying the average space heating therm usage by these figures, we estimated space heating requirements for the two classes, allowing us to generate separate annual averages. We then generated projected bills for both classes for 2021 through 2055, based on PGL's current rate structure, AMRP cost projections, and a gas commodity price that reflects PGL's 2021 average price per therm (roughly 51 cents at the time of this analysis) and increases annually according to AEO projections by 0.5%.[17]

Electrification Projection

To compare the costs of electrification using high-efficiency electric heat pumps, we simulated 2021-2055 residential ComEd bills under three different scenarios: new-build, replacement and retrofit. The new-build scenario posits investment in new-construction electric heating and cooling systems.

The replacement scenario assumes that current appliance(s) in an existing dwelling unit are at the end of their service life and thus money must be invested in a new system either way. Within the replacement scenario there are two additional subcategories. We analyzed a scenario where only the furnace is replaced and one where both the furnace and central A/C are at the end of their service life and need replacement. We also examined cost differences between ducted heat systems and ductless radiator systems.

[17] Given current market conditions both the PGL therm cost and the AEO inflation adjuster might be considered conservative assumptions. To the extent future natural gas prices are higher than the 51 cents and/or 0.5% inflation factor assumed, cumulative savings from electrification would be even greater. To the extent they are lower the reverse would be true and savings would be smaller.

Finally, the retrofit scenario assumes the current appliances are not at the end of their service life and thus the comparison case for remaining with PGL does not include any purchase or installation costs.

To begin the analysis, we simulated average ComEd bills for current Chicago customers in the Single-Family, Non-Space Heat (SFNH) and Multi-Family, Non-Space Heat (MFNH) rate classes for 2021-2055, under the current rate design and assuming current average kWh usage. Then, we estimated the kWh increase, for single- and multi-family customers that would result from replacing all natural gas therm usage with electricity.

To estimate the energy required to replace natural gas appliances, we multiplied average usage for each separate usage category (space heat, water heating, and other) by the efficiency rating of the current natural gas technology. These values were then multiplied by 100,000 to convert from therms to BTU; divided by 3.413 to convert the BTU into kWh; and the kWh requirements were divided by the efficiency ratings of the electric alternatives to complete the calculation.

Finally, we simulated bills for single- and multi-family customers with the new annual kWh usage, using the current rate designs for ComEd's Single Family, Space-Heat and Multi-Family, Space-Heat rate classes. We then estimate annual savings to equal the avoided PGL bill, minus the increase in ComEd bills and the difference in electric and natural gas installation costs in year one.

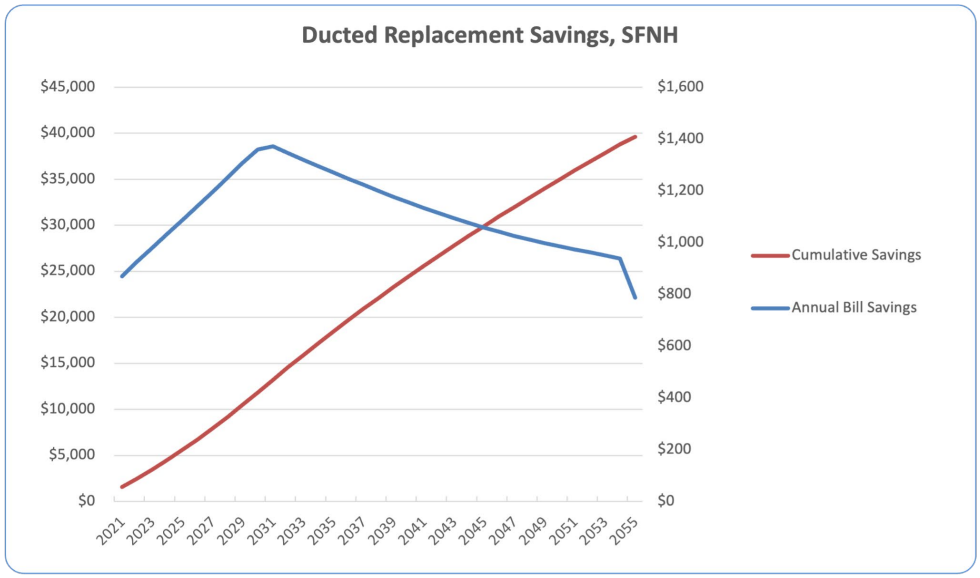
Results

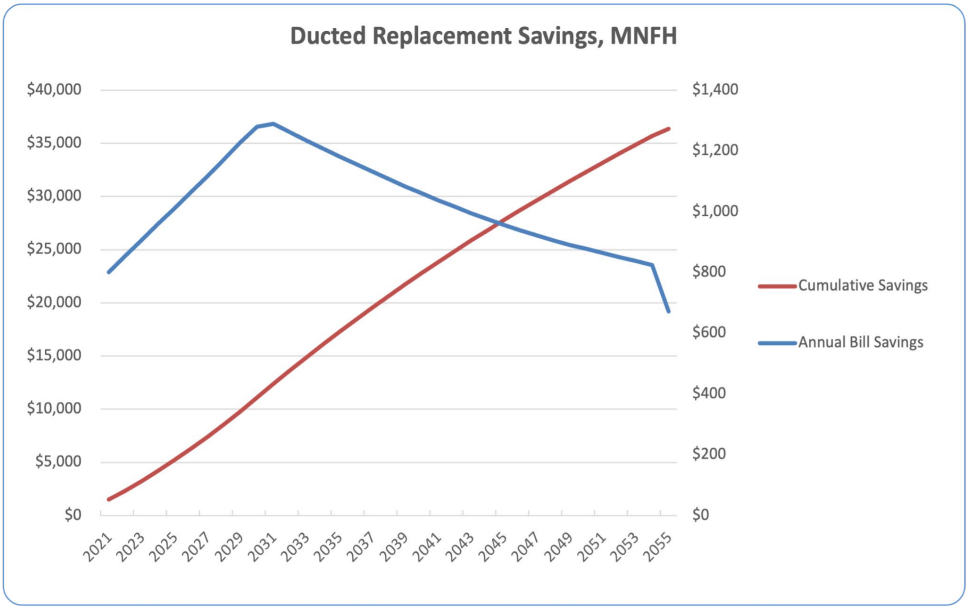
The replacement, new-build, and retrofit scenarios all demonstrate that customers would save money through electrification. This comes from avoiding high (and increasing) PGL fixed charges and bills, lowering energy needs through higher appliance efficiency, and switching from ComEd's Non-Space Heat rate classes to Space-Heat classes, which pay a significantly lower volumetric delivery rate.

Results Summary	Ducted Replacement				New Build/Ductless Replacement				Retrofit	
	A/C Replacement		No A/C Replacement		A/C Replacement		No A/C Replacement			
	SFNH	MFNH	SFNH	MFNH	SFNH	MFNH	SFNH	MFNH	SFNH	MFNH
Payback Period, Yr	0	0	6	6	0	0	3	4	10	11
Avg. Billing Savings	$1,118	$1,026	$1,111	$1,022	$1,270	$1,029	$1,257	$1,022	$1,191	$1,059
Max Billing Savings	$1,371	$1,289	$1,364	$1,286	$1,523	$1,292	$1,510	$1,286	$1,444	$1,322
Cumulative Savings	$39,587	$36,365	$32,433	$29,348	$47,104	$38,770	$39,721	$31,648	$29,313	$24,716
Upfront Cost	($693)	($693)	$6,207	$6,207	($2,993)	($2,993)	$3,907	$3,907	$12,122	$12,122

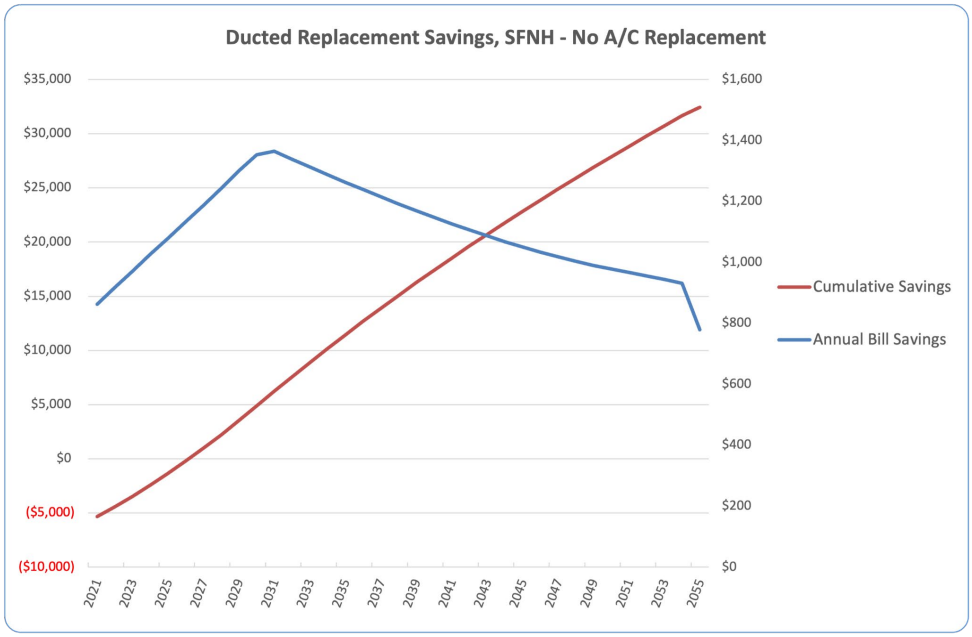
Replacement Scenario-Ducted Heat

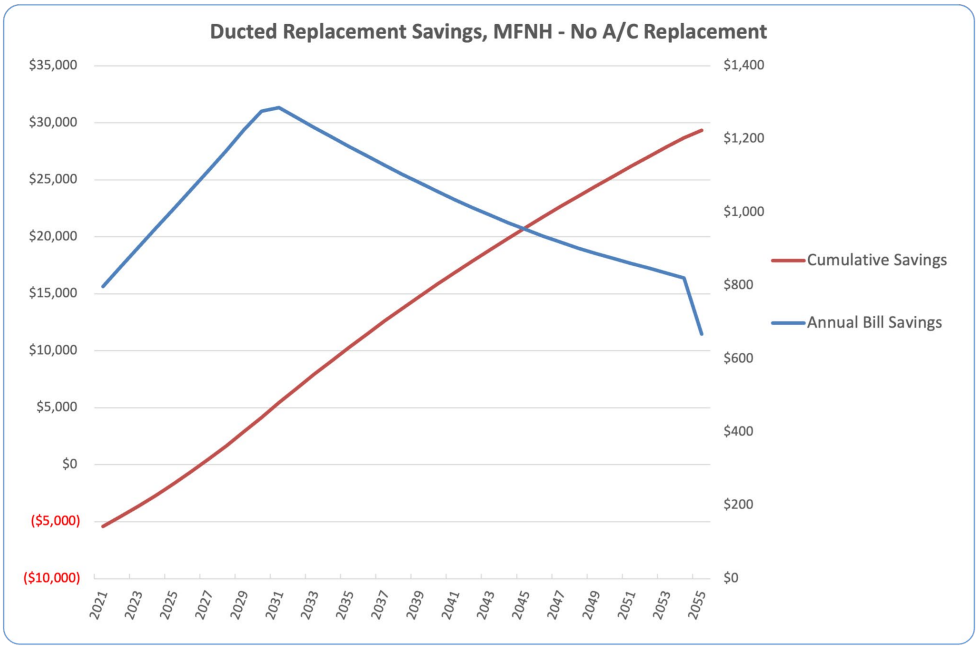
We estimate that choosing electric technology to replace aging gas appliances and central A/C units would save customers in the initial outlay. Annual bill savings begin in the first year, with annual net savings starting at $925 after one year for single-family customers, and peaking at $1,371 in year 10, when AMRP costs are at their highest. Annual net savings are lower for multi-family customers due to lower overall volumes, starting at $854 and peaking at $1,289. Total cumulative savings by 2055 for the two classes are $39,587 and $36,365, respectively.





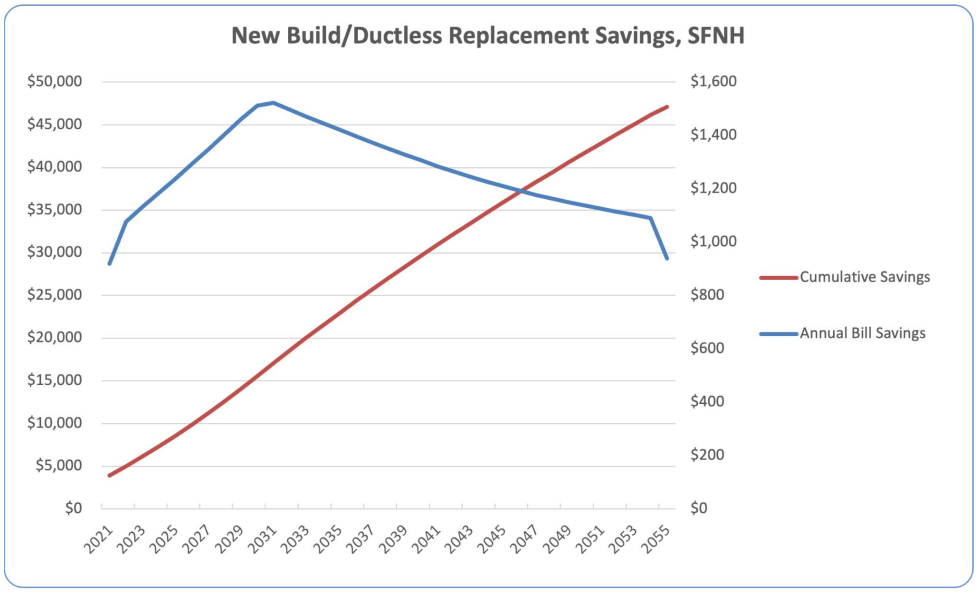
If customers replace only their gas-powered appliances while maintaining existing central A/C systems, the payback period becomes six years, for both Single- and Multi-Family homes. Single-Family homes will save an average of $1,111 in annual bills, for a cumulative savings of $32,433. Multi-Family homes will save $1,022 in average annual bills, for cumulative savings of $29,348.

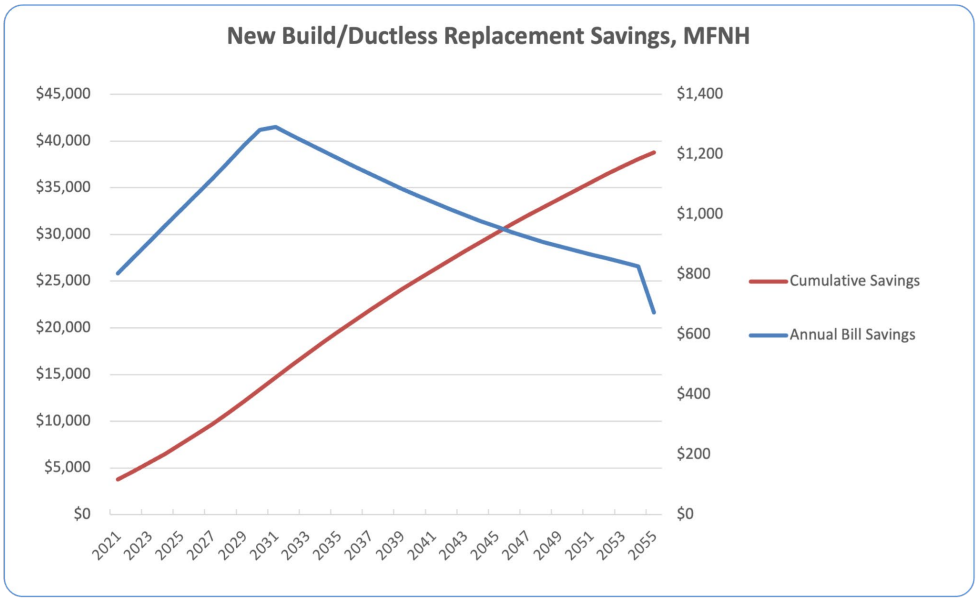




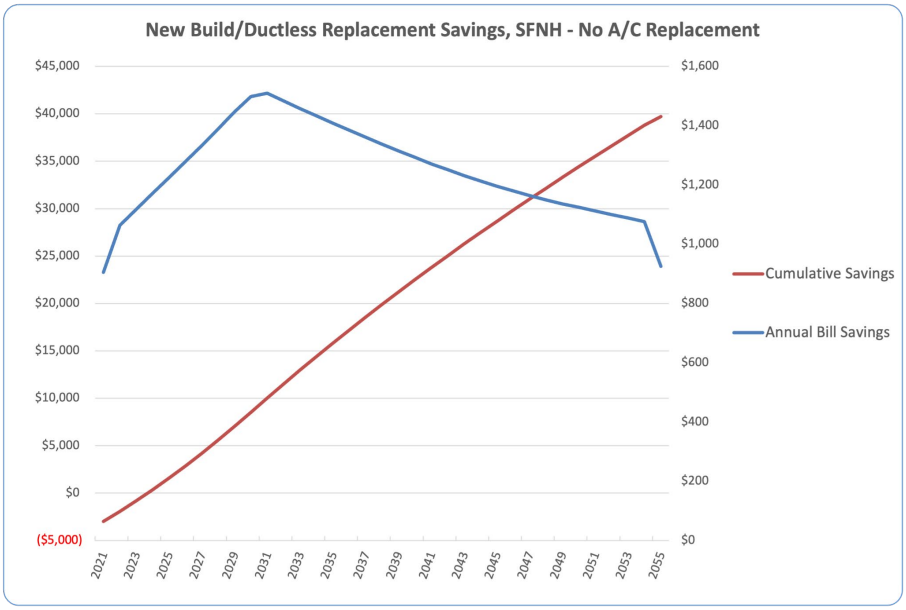
New-Build/Ductless Heat Replacement Scenario

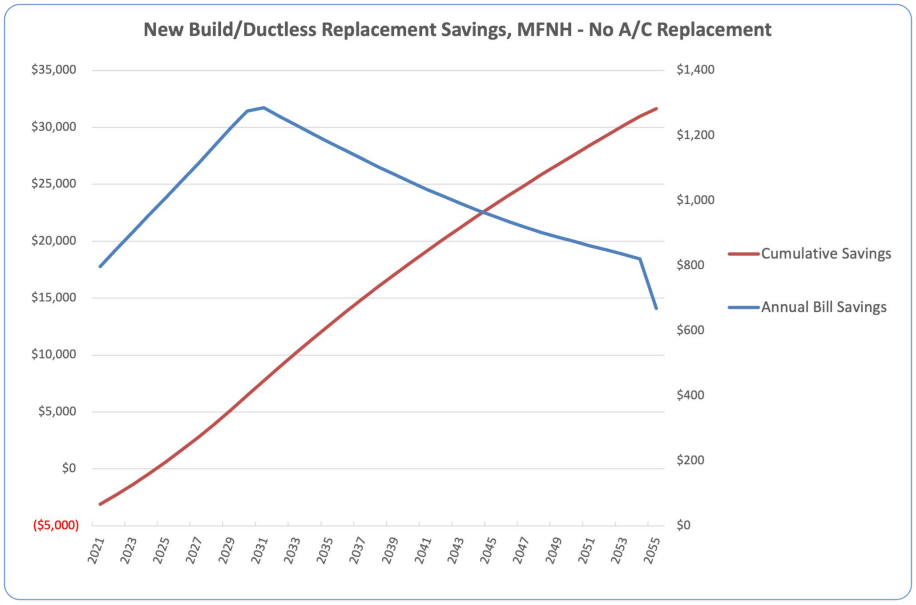
Due to the lower cost of ductless heat pump systems, the initial savings from installing heat pump technology is highest in this scenario, at $2,993. Annual net savings show the same trajectory for both classes as in the replacement scenario. Single-family customers would see annual bill savings of $1,077 after a year, with a peak of $1,523 in year 10, and cumulative savings of $47,104 in 2055. Multi-family customers would save $857 on their bills after a year, with a peak of $1,292 in year 10, for cumulative savings of $38,770 by 2055.





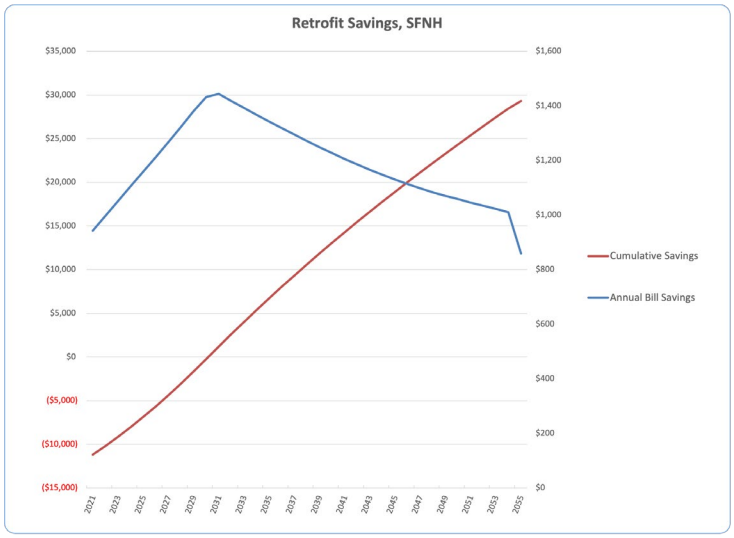
As in the Ducted Replacement scenario, Ductless customers who choose not to replace existing central A/C systems will see longer payback periods. Single-Family homes who do not need to replace existing A/C will see payback in year three post-replacement, with average annual bill savings of $1,257 and cumulative savings of $39,721. Multi-family homes in this situation will see payback in year four, with average annual savings of $1,022 and cumulative savings of $31,648.

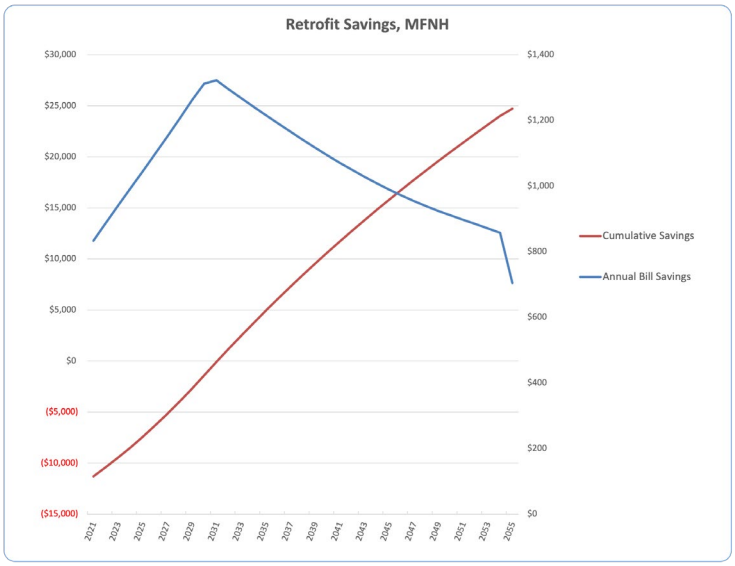




Retrofit Scenario

Since this scenario assumes all existing appliances are still functional, it does not include replacement costs for natural gas appliances and a traditional A/C unit in the PGL counterfactual. For this reason, the initial outlay for customers is only the cost of heat pump and electric appliance installation, $12,122. However, annual bill savings make up for this initial cost in year 10 for single-family homes, and year 11 for multi-family homes. Annual net savings range from $998 in year one to $1,432 for single-family homes, and $887 in year one to $1,295 for multi-family homes. Total savings for the two classes are $29,313 and $24,716.





Conclusion

Switching from natural gas heating to high-efficiency electric heat pumps would result in substantial lifetime savings for Chicago households, with a range of $24,716 to $47,104, depending upon the scenario. These savings come from avoiding high and increasingly rising gas utility bills, the better efficiency of modern electric heat pumps, and from lower volumetric delivery rates paid by ComEd space-heat customers. Savings begin immediately for new construction and for those households replacing both gas furnaces and central A/C appliances at the end of their service lives. Payback is 3 to 6 years for households just replacing a furnace at the end of its life; and is 10 to 11 years in retrofit scenarios where electrification occurs early while existing appliances still work.

These results provide reason for optimism. Residential building electrification will save Chicagoans substantial amounts of money even before taking into account the public health benefits that would result from eliminating fossil fuel heat. Were all PGL customers to fully replace their appliances now, the total cumulative savings for Chicago residents would be between $25.3 billion and $28.9 billion over the next 34 years. With the Peoples Gas pipeline replacement program driving the City toward structural energy poverty, these projections point the way toward an alternative future in which achieving the City's climate change goals would provide significant savings to Chicago households. To the extent that the study's assumptions prove too conservative, the overall economic benefits of building electrification would rise. Long-term savings may be higher, as this analysis assumes that the price of natural gas is essentially flat moving forward and that electric heat pumps stay at existing efficiency and price levels in perpetuity. Importantly, it also does not take into account potential economies of scale that might be achieved by connecting neighborhoods to community geothermal heat pump systems.

But this analysis also raises a significant concern. Given the favorable economic and environmental benefits of building electrification, it is likely that an increasing number of households will switch to electric heat pumps as PGL bills rise. This could leave the most vulnerable heating customers—those who can't afford capital outlays or live in rental units

whose landlords have no incentive to electrify—paying ever higher costs that have to be shared among a shrinking customer base. If 5% of PGL customers switch out their gas-powered appliances within five years, for example, average annual bills for those who remain would increase by an average of $56, for a total cumulative billing increase by 2055 of $1,671. And if defections increase to 15% of PGL customers in that same period, average annual bills for those remaining on gas heat increase by $187, for a cumulative increase of $5,603.

These findings should serve as a call to action for policymakers. Chicago needs to begin implementing a plan for an orderly transition to efficient electric heat for all residents, with a particular focus on protecting low- and moderate-income consumers. This strategy to triage the gas distribution system and transition to a new sustainable way to heat will be a complex undertaking, of course, but it doesn't need to happen overnight and the earlier Chicago starts the process the better off residents will be.[18] New opportunities may arise soon: There could be synergies with Chicago's efforts to replace lead water service lines, and federal funding possibilities could emerge from the pending federal infrastructure package. One thing is certain: The existing natural gas heating system is unsustainable on both financial and environmental grounds, so sticking with the status quo is not an option.

[18] To meet its climate change goals, Chicago needs to decarbonize heat by 2050.