ELEVATE

Reducing Pollutants and Saving Energy by Electrifying Homes in Chicago

Electrifying residential buildings can decrease energy use, reduce carbon emissions, and lower utility costs. An additional benefit of electrification is the reduction of pollution caused by the combustion of fossil fuels, both inside and outside the home.

Case Study Summary

Removing these combustion sources from homes through electrification can improve indoor air quality by reducing pollutants like nitrogen dioxide (NO_2) that are known to cause health issues. Chronic exposure to low levels of NO_2 is associated with respiratory issues like coughing and chest pain and can exacerbate existing respiratory conditions like asthma.

This case study highlights the benefits of electrification for five homes in Elevate's Building Electrification Program (BEP), a multi-year electrification retrofit program targeting single- and multi-family homes in neighborhoods where household incomes are less than or equal to 80% of area median income. The homes assessed in this study all completed the initial phase of work, energy efficiency and weatherization retrofits, between February and October 2021 through a partnership with a local utility program and the Chicago Bungalow Association (CBA).

The next phase of work involved each home receiving complete electrification retrofits, meaning all fossil fuel appliances were removed from the home. This case study includes two parts: (1) monitoring NO_2 levels before and after

Case Study Information

- **Building Information**
  - (1) Single-Family, Pre-1942, Masonry Construction
  - (1) Single-Family, Pre-1942, Frame Construction
  - (3) Single-Family, 1942–1978, Masonry Construction
- **Upgrades Completed**
  - Air Source Heat Pumps
  - Electric Induction Stoves
  - Electric Water Heaters
  - Electric Clothes Dryers
  - Electric Service Panel Upgrade
  - Air Sealing and Insulation
- **Pollutant Reduction**
  - Average NO_2 decrease of 39% in kitchens
  - Average NO_2 decrease of 15% in bedrooms
- **Energy Savings**
  - Average energy savings ranging from 54% to 69%
- **Funding**
  - ComEd Energy Efficiency Program
  - BEP through philanthropy and ComEd

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electrification and (2) analyzing energy use before and after efficiency and electrification retrofits. The results of this analysis provide insight on the impacts of electrification in Chicago homes.

NO_2 Reduction

For each of the five homes in the study, NO_2 levels were measured for one week in December 2022, after weatherization but before any appliance change-out had occurred. NO_2 levels were also measured for one week in March 2023, after all gas appliances had been removed and replaced with electric alternatives. NO_2 monitors were placed outside of the home, in the kitchen, and in the bedroom. This variety of monitoring locations were chosen because indoor NO_2 can be the result of both infiltration of outdoor NO_2 (resulting from traffic exhaust, for example) and produced by combustion sources in the home (e.g. gas cooking and smoking). Monitoring multiple locations in the home provides insight into the sources of NO_2 and relative contributions of those sources. Results of the NO_2 monitoring are shown in Figures 1A-C below.

In almost all instances, the NO_2 ppb values decreased from the pre to post-sample periods. The kitchen levels decreased by an average of 39% and the bedroom values by 15%. These results were consistent with previous studies, showing that NO_2 levels were reduced throughout the home, and that this reduction can be largely attributed to the switch to an electric stove.

FIGURE 1 A-C: PRE AND POST ELECTRIFICATION NO_2 VALUES IN PARTS PER BILLION (PPB)

Figure 1-A: Kitchen Pre and Post Electrification NO_2 Values*

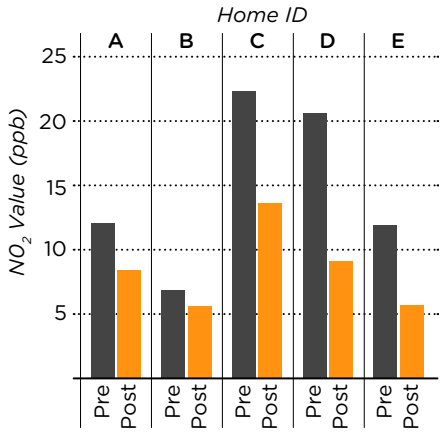


Figure 1-B: Bedroom Pre and Post Electrification NO_2 Values*

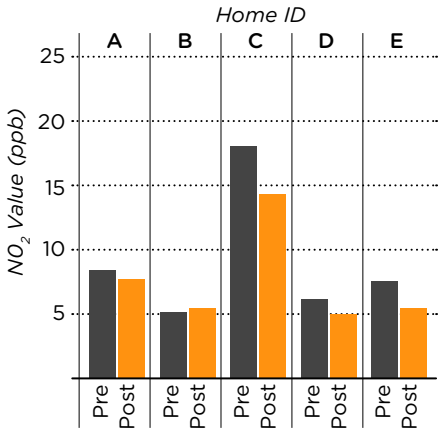
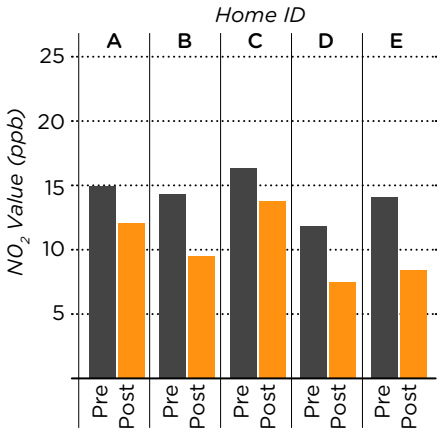


Figure 1-C: Outdoor Pre and Post Electrification NO_2 Values*



**Home B already had an electric stove in the pre retrofit period*

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Energy Savings

In addition to the benefit of reduced NO_2 concentrations, the homes in this study also benefit from energy savings. All five homes received air sealing and weather stripping, and the sole frame home received wall insulation. The four brick/masonry constructed homes did not receive full wall cavity insulation, but all received some insulation in small amounts in areas of the home, where feasible. Every home received full electrification packages including heat pumps, heat pump water heaters, electric ranges, and electric clothes dryers. After all efficiency work was completed and heat pumps were installed, post-retrofit energy use data was collected, including therms, kilowatt hours, and costs. Table 1 shows basic building and equipment characteristics for each home and pre- and post-weatherization air sealing.

Post-retrofit energy use data began as soon as heat pump installation was complete, typically in January 2023, even though full electrification work was not completed until March and continued through April. Thus, the post-retrofit analysis reflects some gas usage. After retrofit work was completed, the energy savings realized through the energy efficiency, weatherization, and electrification work were calculated, using energy usage data from energy bills. All energy use data was weather normalized before calculating changes in energy use. Table 2 shows each home's type, gas usage, electricity usage, and energy savings for the time period analyzed[1].

TABLE 1: BUILDING AND EQUIPMENT CHARACTERISTICS

Home ID	Year Built	Exterior	Size (sq ft)	Heating System (Pre)	Cooling System (Pre)	CFM50 (infiltration) pre air sealing	CFM50 (infiltration) post air sealing
A	1921	Frame	880 sq ft	Forced Air Furnace	Window	4579	2142
B	1953	Brick	1,008 sq ft	Forced Air Furnace	Central	3947	1728
C	1945	Brick	1,232 sq ft	Forced Air Furnace	Window	3939	2022
D	1927	Brick	896 sq ft	Forced Air Furnace	Central	4415	1195
E	1947	Brick	1,056 sq ft	Forced Air Furnace	Central	4128	1248

1. Period of analysis for Home A & E: Jan - Mar 2021, 2023; period of analysis for Home B & C: Jan - Mar 2020, 2023; Period of analysis for Home D: Jan - Feb 2021, 2023.

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TABLE 2: HOME TYPE AND ENERGY USE (PARTIAL YEAR)

Home	Priority Home Type	Gas Use (Therms)		Electricity Use (kWh)		Total Energy Use (MMBTU)	
A 	Single Family, Frame, Pre-1942	Pre	778	Pre	626	Pre	79.9
		Post	130	Post	5,025	Post	30.1
		Change	-83.3%	Change	702.7%	Change	-62%
B 	Single Family, Brick, Mid-century 1943-1978	Pre	583	Pre	1,632	Pre	63.9
		Post	5	Post	5,601	Post	19.6
		Change	-99.1%	Change	243.2%	Change	-69%
C 	Single Family, Brick, Mid-century 1943-1978	Pre	642	Pre	2,027	Pre	71.1
		Post	126	Post	5,230	Post	30.4
		Change	-80.4%	Change	158.0%	Change	-57%
D 	Single Family, Brick, Pre-1942	Pre	261	Pre	841	Pre	29.0
		Post	5	Post	3,374	Post	12.0
		Change	-98.1%	Change	301.2%	Change	-59%
E 	Single Family, Brick, Mid-century 1943-1978	Pre	602	Pre	1,672	Pre	65.9
		Post	20	Post	8,259	Post	30.2
		Change	-96.7%	Change	394.0%	Change	-54%

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Energy Savings

Table 2 shows that each home achieved total energy savings of over 50%, ranging from 54% to 69% savings. These results contribute further evidence supporting Elevate's finding that greater than 50% energy savings can be achieved using retrofit packages that include off-the-shelf technologies, standard building envelope air sealing and insulation measures, and high-efficiency heat pumps.

Together, these findings provide an insightful case study of energy and non-energy impacts of electrification in Chicago homes. This snapshot analysis has limitations to generalizable conclusions, yet the case study approach provides valuable insights, especially for future program delivery and research. Elevate recommends that utilities and other home retrofit programs continue to incentivize the replacement of gas stoves in homes, particularly in income-eligible households. Utilities should continue to leverage electrification program data, like the data published in this case study, to understand better the importance of envelope efficiency measures, such as insulation and air sealing, on indoor air quality, heat pump performance, and customer bill impacts.

Finally, related to health impacts, this case study highlights the importance of tracking, contributing to, and leveraging existing and emerging industry research to quantify the health-related non-energy benefits of deep energy efficiency whole home and electrification retrofits.

Learn More

Elevate works with owners to remove and replace on-site combustion of fossil fuels at their properties. Visit **ElevateNP.org/Building-Electrification** to learn more about our services and visit **ElevateNP.org/Research-and-Innovation** to learn more about our Research and Innovation projects.