BUILDING EFFICIENCY VIA ELECTRIFICATION OF DOMESTIC WATER HEATING — THE NEXT FRONTIER OF SUSTAINABILITY

BY RICHARD GERBE

PEER REVIEWED BY KEITH BOHLING

The commercial and residential building stock consists of many structures that are energy inefficient, resulting in serious pollution, supply challenges and excess emissions contributing to global warming. These buildings are responsible for approximately 40 percent of the energy and 70 percent of the electricity used annually in the U.S.,[1] as well as 39 percent of the carbon dioxide (CO_2) emitted each year in the nation.[2]

Although steps are being taken to make buildings more efficient, such as better lighting, ventilation and air tempering, these efforts don't cover all building efficiency opportunities. Initiatives are falling short in a key area: domestic water heating. Making up this deficit could push building efficiency to new levels. This is the next frontier of building sustainability.

Heat pump water heaters (HPWHs) provide a relatively simple solution to resolve the shortfalls of water heating in most buildings. When combined with electricity supplied by renewables, these systems support carbon-reduction efforts, such as New York City's 80x50 plan to cut greenhouse gas (GHG) emissions 80 percent by 2050[3] and Boston's goal to be carbon-neutral by 2050.[4]

Electric HPWHs could bolster the efficiency and sustainability of all buildings currently using fossil fuels to heat water. Given their higher efficiency, their use of grid power that is becoming cleaner and the decreasing costs of renewable energy, HPWHs are an option that we must embrace to meet our GHG reduction goals.

CHALLENGES OF CONVENTIONAL DOMESTIC WATER HEATING

Domestic water heating poses sustainability challenges because the majority of hot water in North American cities is produced via conventional gas-fired heaters. These older systems emit large amounts of CO_2 and have a low coefficient of performance (COP) since they expend considerable energy to heat water, thereby wasting energy. They are in direct contrast to carbon-reduction initiatives.[5]

Further, gas-fired heaters require extensive investments by utilities to establish and maintain costly gas lines. The reality is that many new urban housing projects, particularly multifamily buildings, will be built in areas with undersized gas lines and, in some instances, places where gas lines aren't feasible.

MULTIFAMILY BUILDINGS FACE MANY HURDLES

Domestic water heating poses acute challenges for multifamily buildings due to sizeable hot-water needs and a reliance on fossil fuels,[6] which is a big problem for the environment. Domestic water heating alone is responsible for 22% of the GHG emissions discharged by New York City's multifamily buildings.[7]

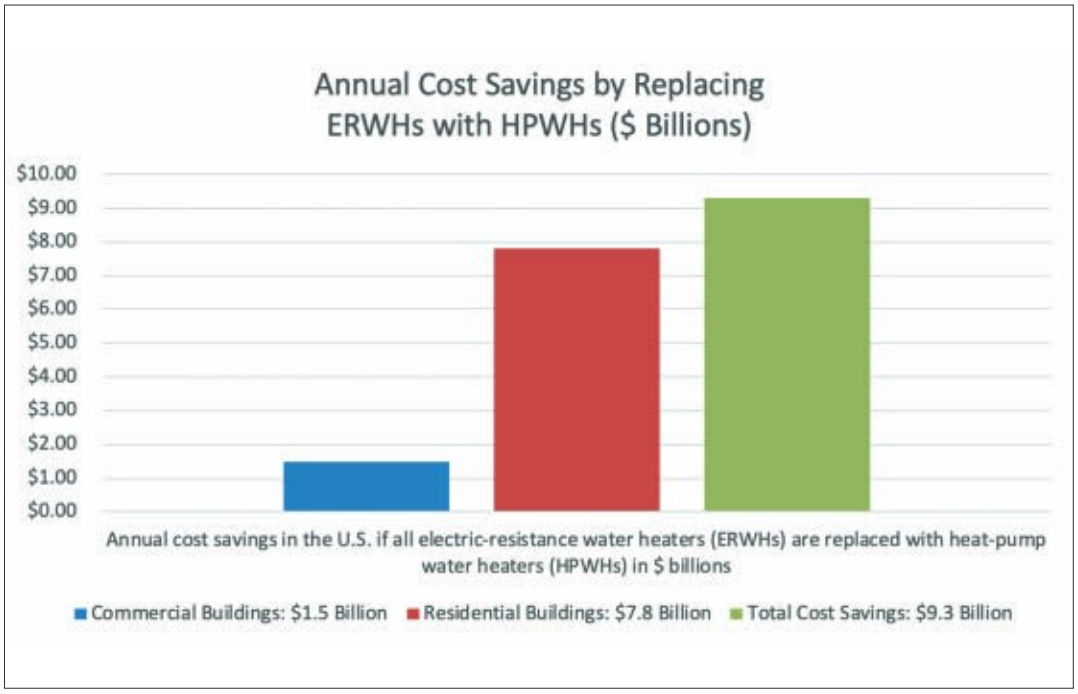
The energy needs of multifamily housing are significant. For example, in New York City, the sector represents over 40 percent of the total building area and nearly 30 percent of GHG emissions.[8] With apartment construction at a 30-year high in the city,[9] multifamily developments are sprouting up everywhere.

ELECTRIC HPWHS AS THE SOLUTION

There's a better way to provide domestic hot water and that's via electric HPWHs. This technology offers commercial, residential and industrial users of sanitary hot water an energy-efficient means of heating water to temperatures as high as 185°F in a single pass, without using any natural gas.

Electric HPWHs use the same operating principle as air conditioners and domestic refrigerators. The heat pump gathers energy from the surrounding air, and, through the refrigeration cycle, deposits the energy into water at a useable temperature.

Moving energy with a heat pump, rather than generating it via fossil fuels or electric resistance, makes HPWHs the best energy-conservation choice. Depending on the temperature of the source air or water, domestic water can be heated using one-third to one-fourth of the energy required by electric resistance or gas.



ANNUAL COST SAVINGS IN THE U.S. BY REPLACING ERWHS WITH HPWHS IN $ BILLIONS [16]

CREDIT: U.S. DEPARTMENT OF ENERGY (DOE)

Electric HPWHs are a strong complement to carbon-reduction programs being adopted in many cities in the Northeast and across North America. So much so that utilities, such as New York's Con Edison, are increasingly eyeing electrification of domestic water heating as a way to reduce customer gas demand.[10]

HPWHs historically were less efficient in colder temperatures, but technological advances have enabled them to excel in cold climates. No technology is without challenges, and HPWHs can have higher upfront costs than conventional water heaters; however, HPWHs also have lower operating costs that offset initial expenses in time.[11]

RESULTS OF USING HPWHS

Implementing electric HPWHs will lead to many positive results, including:

- **No gas:** Electric HPWHs eliminate all gas needs for domestic water heating.
- **Fewer emissions:** GHG emissions from buildings are reduced.
- **Downsized HVAC equipment:** Eliminating the complex infrastructure associated with gas enables HVAC equipment to be minimized.
- **Furthering carbon-reduction efforts:** Key support is provided for carbon-reduction initiatives throughout the Northeast and North America.
- **Increased efficiency:** The amount of energy transferred by electric heat pumps can be three or four times larger than the power consumed, thus giving heat pumps a COP of 3-4, as opposed to just 1 for electric-resistance water heaters (ERWHs).[12] The best gas-fired boiler fares even worse with an efficiency rating of .90.[13] In other words, heat pumps are 300-400% more efficient than ERWHs or gas boilers.
- **Massive cost savings:** The U.S. Department of Energy (DOE) found that if all ERWHs were replaced with HPWHs in the U.S., commercial buildings would save $1.5 billion[14] and residences $7.8 billion in annual costs.[15]

IN SUMMARY

Domestic water heating via conventional heaters is inefficient, costly and polluting. Such antiquated systems are holding back efficiency efforts and run counter to emissions-reduction goals dependent on more efficient and sustainable buildings. There is a better way to heat water in our commercial, residential and institutional buildings.

Electric HPWHs are the solution since they don't use gas and can produce hot water using a quarter of the energy used by traditional equipment. By implementing these systems in North American cities, GHG emissions will be substantially curbed and all buildings can take their efficiency performance to the next frontier of sustainability.

ABOUT THE AUTHOR

Richard Gerbe, *CEO and Co-Founder of HIGHMARK NY, is a 2017 ENR New York Top Young Professional and a 2016 Consulting-Specifying Engineer 40 Under 40 Award Winner. As a visionary HVAC authority with two decades of experience, his robust knowledge and expertise in the best and most innovative technologies available today for boosting building efficiency are unparalleled. Gerbe is committed to challenging the HVAC industry's status quo and bringing efficiency to the built environment. To learn more, visit: www.highmark-ny.com.*

ABOUT THE PEER REVIEWER

Keith Bohling, *Senior Project Manager with NYSERDA, has 30 years of experience remodeling homes, performing diagnostic examinations and designing improvements for existing homes. His background includes working with Habitat for Humanity on new construction and remodeling projects, work as a remodeling contractor and as a project manager. Keith's current position combines a Master's degree in Communication with his experience to help homeowners understand what's performing well with their homes and what efficiency opportunities will pay the most dividends.* BUSINESS MEMBER

ENDNOTES

1. "About the Building Technologies Office," U.S. Department of Energy, http://energy.gov/eere/buildings/about-building-technologies-office.
2. "Buildings and Climate Change," U.S. Green Building Council, https://www.eesi.org/files/climate.pdf.
3. "80 x 50," NYC Sustainability, https://www1.nyc.gov/site/sustainability/codes/80x50.page.
4. "Reducing Emissions," City of Boston, Mayor Martin J. Walsh, Department of the Environment, https://www.boston.gov/departments/environment/carbon-free-boston.
5. "80 x 50," NYC Sustainability, https://www1.nyc.gov/site/sustainability/codes/80x50.page.
6. "New York City's Energy and Water Use 2013 Report," The City of New York, Mayor Bill de Blasio, Mayor's Office of Sustainability, August 2016, https://www.urbangreencouncil.org/sites/default/files/nyc_energy_water_use_report_2016.pdf.
7. "NYC Carbon Challenge Handbook for Multifamily Buildings," New York City Mayor's Office of Sustainability, October 2016, http://www.nyc.gov/html/gbee/downloads/pdf/nyc_carbon_challenge_handbook_for_multifamily_buildings.pdf.
8. Ibid.
9. Betsy Kim, "NYC Apartment Construction Highest in 30 Years," GlobeSt.com, February 27, 2018, https://www.globest.com/2018/02/27/nyc-apartment-construction-highest-in-30-years.
10. "Gas Demand Response Pilot Implementation Plan, 2018-2021," Con Edison, April 26, 2018, http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7B22BB3E67-11BC-445F-AE14-3DBB8568A0D0%7D.
11. "Heat Pump Water Heaters," Energy Saver, U.S. Department of Energy (DOE), https://www.energy.gov/energysaver/water-heating/heat-pump-water-heaters.
12. "Heat pump," Wikipedia, https://en.wikipedia.org/wiki/Heat_pump.
13. "Types of Heating Systems," SmarterHouse, https://smarterhouse.org/heating-systems/types-heating-systems.
14. "Heat Pump Water Heaters," Better Buildings Initiative, U.S. Department of Energy, https://betterbuildingsinitiative.energy.gov/heat-pump-water-heaters.
15. Carl Shapiro and Srikanth Puttagunta, "Field Performance of Heat Pump Water Heaters in the Northeast," U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, February 2016, https://www.nrel.gov/docs/fy16osti/64904.pdf.
16. Two sources were used to compile this chart: 1) "HEAT PUMP WATER HEATERS," Better Buildings Initiative, U.S. Department of Energy, https://betterbuildingsinitiative.energy.gov/heat-pump-water-heaters and 2) Carl Shapiro and Srikanth Puttagunta, "Field Performance of Heat Pump Water Heaters in the Northeast," U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, February 2016, https://www.nrel.gov/docs/fy16osti/64904.pdf.