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Cities confront climate challenge: How to move from gas to electricity?

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In 1836, Philadelphians mostly used whale oil and candles to light their homes and businesses. That year, the newly formed Philadelphia Gas Works caused a stir when it lit 46 downtown street lamps with gas made from coal in its plant on the Schuylkill River. By the end of the Civil War, public thoroughfares and private dwellings in the core of most large Eastern cities were illuminated by gas, supplied through cast iron pipes buried beneath the busy streets — and the whale oil lighting industry was nearly dead.

Philadelphia's own pipe network has expanded over the past 185 years to encompass 6,000 miles of gas mains and service lines. But today, Philadelphia Gas Works (PGW) — the largest municipal gas utility in the country — is the incumbent business staring down existential threats, facing challenges from new technologies, upstart rivals, and a quickening 21st-century energy transition that aims to convert many buildings from gas to electricity.

In recognition of these forces and the city's own climate action plan, Philadelphia has commissioned a "**diversification study**" to find a new low-carbon business model for the nation's oldest gas utility, which delivers natural gas to 510,000 customers.

Earlier this year, Philadelphia **announced a target** of achieving net-zero greenhouse gas emissions by 2050. "There's just no way that can happen without PGW changing," said Tom Shuster, clean energy program director of the Sierra Club's Pennsylvania chapter, which advocates for wider building electrification. Gas sold by the utility is the single biggest source of the city's climate-warming pollution, accounting for 22 percent of its greenhouse gas emissions.

Charting a path forward that ensures both PGW's survival and the city's carbon neutrality will be a heavy lift, many advocates acknowledge. The task is even more daunting when considered on a national scale. While many cities are adopting or considering rules that require new construction to be all-electric, the much thornier problem is how to get fossil fuels out of existing buildings, which account for about 30 percent of U.S. greenhouse gas emissions.

Of the country's 120 million households, about 58 percent are **heated primarily** with natural gas. To zero out carbon emissions from those homes, all of their furnaces, water heaters, and other appliances will have to be fueled with "green molecules" (such as biogas, hydrogen, and synthetic gases) instead of fossil gas, or swapped out for heat pumps and other devices powered by renewable electricity.

Several states have already begun formally planning their long-term transition away from natural gas. Last June, the attorney general of Massachusetts **petitioned** the state's utility regulators to investigate how to transition away from natural gas. Spurred by their own climate action goals, California and New York have launched similar efforts. New Jersey's Energy Master Plan has set a goal of electrifying 90 percent of buildings' heating and cooling demand by 2050.

The menu for building decarbonization includes heat pumps powered with renewable electricity, geothermal systems, hydrogen fuels, and biogas generated from organic waste. Some of these solutions are in the early stages of development and deployment. Air-source heat pumps are the most mature technology, with decades of use in parts of Europe and Japan, and in the U.S. South, where heat pumps make up more than 20 percent of building heating systems. A few gas utilities are experimenting with blending hydrogen into their gas mix and testing how appliances handle it, in the hopes that "green hydrogen," created with renewable electricity, will help

them wring the carbon out of their operations. And Eversource, New England's largest energy utility, is partnering with Home Energy Efficiency Team (HEET), a Massachusetts-based nonprofit focused on cutting emissions from the building sector, to build an innovative pilot geothermal district heating and cooling system in the Boston area this summer.

In any scenario, a massive transformation of the way we use energy in buildings will be required to meet ambitious city, state, and federal emissions targets. Perhaps nowhere are these challenges as stark as in older cities in the Northeast, which remain heavily reliant on natural gas for heating and have some of the oldest, least energy-efficient housing stock.

In Philadelphia, overhauling PGW entails navigating a thicket of competing imperatives beyond cutting greenhouse gas emissions: plugging dangerous methane leaks, retaining or retraining the utility's 1,600-strong workforce, and ensuring that the most vulnerable Philadelphians aren't left carrying the burden of propping up an increasingly expensive gas grid.

Even before the pandemic led to a recent spike in unpaid bills, many Philadelphians faced an energy affordability crisis. Philadelphia has the highest poverty rate of any major U.S. city; roughly one third of PGW's customers are low-income. To be equitable, any transition for the utility must "make sure every last person reliant on natural gas has a way to keep warm in winter, cook their food, and heat their water," said Elizabeth Marx, executive director of the Pennsylvania Utility Law Project, which represents the interests of low-income utility customers. "If you're talking about shifting away from a system that's been built out with ratepayers for decades, you can't shift away easily without leaving people behind."

As more affluent customers abandon gas to install heat pumps and other clean-energy upgrades with higher upfront costs, many advocates for a "just transition" worry that lower-income ratepayers will be left to foot the bill for maintaining PGW's aging gas infrastructure.

"What you want to avoid is the situation where you have to maintain and spend money on the whole system, even while you sell less gas," said Mike Henchen, who leads the building decarbonization program at the energy thinktank RMI.

Meanwhile, some of that maintenance can't wait, for safety and environmental reasons. In December 2019, a leak from a 92-year-old gas main caused an explosion that killed two people and leveled five rowhouses in South Philadelphia. The methane in those leaks is also a potent climate-warming agent; a 2019 study that sampled air over Philadelphia and five other East Coast cities found methane levels 2.5 times higher than suggested by emissions inventories from the Environmental Protection Agency.

"Gas utilities are in a difficult bind," said Audrey Schulman, the founder and co-executive director of HEET, the nonprofit that initiated the Massachusetts geothermal project. "At the same time that they have to decarbonize, they have to replace these aging gas pipes."

The larger dilemma for Philadelphia's officials — and for other municipal leaders around the country — is how long, and how much, to keep spending on gas infrastructure before "leapfrogging" to wider building electrification.

When Philadelphia Gas Works applied for an increase in its base rate to the state's Public Utility Commission last year, the Sierra Club intervened, claiming that spending on pipe maintenance beyond what's required by immediate safety concerns is unwise. "You're asking for money to replace this entire system," said the Sierra Club's Shuster, "but in doing so you are likely putting in infrastructure that will not see the end of its useful life before it's taken offline."

The city commissioned the diversification study to address those kinds of tough tradeoffs. "There's no clean silver bullet," said Christine Knapp, director of Philadelphia's Office of Sustainability. "It will probably wind up being a piecemeal strategy that gets us to our goals — a certain amount of renewable natural gas, geothermal, electrification, and weatherization, for example, that add up to having a bigger impact."

Philadelphia Gas Works did not respond to requests for comment. But in testimony at a **2019 City Council hearing** about the proposed diversification study, a PGW official emphasized regulatory and legal limits on the utility's ability to evolve beyond its narrow mission of delivering natural gas. Through its own direct advocacy and its membership in the American Gas Association, an industry trade

group, the utility has **opposed** the updating of building codes that would have encouraged state and city governments to require more efficient appliances and electrification-ready wiring.

In one of the paths being studied, PGW would keep its pipe-based system and simply add more low-carbon gas molecules to its fuel mix. For instance, SoCalGas, the nation's largest gas utility, has heavily **pushed** the promise of wider use of biogas (also known as "renewable natural gas") made from organic waste as a rationale for preserving and expanding gas infrastructure, and for resisting calls to ban the use of gas in new construction. Many other gas utilities have been promoting their **nascent efforts** to decarbonize by blending biogas and hydrogen into their natural gas supply.

Several **recent studies** have found that fully electrifying buildings is a lower-cost way to decarbonize than going the "green molecules" route. In one, researchers estimated that the monthly cost of running a heat pump would range from $34 to $53, whereas running a gas furnace on renewable natural gas would cost $160 to $263. Heat pumps' appeal to both homeowners and policymakers is on the rise even in the cold Northeast: Maine, for example, has a mandate to install 100,000 heat pumps in homes and businesses by 2025.

But even if operating a heat pump is likely cheaper over the long run than firing a furnace with biogas, the upfront cost of buying and installing one — including upgrading wiring and circuit breakers to handle heavier loads — remains high relative to a conventional gas heater. Those costs are still well beyond what many Philadelphians can afford.

One company is advancing a new way to overcome that hurdle. BlocPower is a Brooklyn-based startup that specializes in energy retrofits of large urban buildings, with a focus on converting affordable housing and multi-family buildings from fossil fuel heating to renewably powered heat pumps. With over 1,000 building retrofits in New York under its belt, BlocPower is expanding to cities across the country, including Los Angeles and Chicago. The company sees Philadelphia as fertile terrain.

"Philadelphia has many pre-war-era walkups and multifamily buildings in dense areas that we deem to be very similar and applicable to the work we've been doing to date," said Ian Harris, BlocPower's business manager.

BlocPower began working with Philadelphia in 2014, participating in a multi-family housing pilot project led by the Philadelphia Energy Authority. This month it plans to launch BlocMaps Philly, a software tool that helps city planners and individual building owners model the potential for reducing both emissions and energy bills by installing air-source heat pumps and other systems, such as batteries and solar microgrids. Within the next 12 months, the company aims to complete 500 projects in Philadelphia.

"We see a great opportunity to transition as many as people as possible off fossil fuels in Philadelphia," said Harris.

Others still see a role for pipes in the city's energy future. This summer, Eversource Gas, the investor-owned private utility in the Boston area, will break ground on the first demonstration of HEET's innovation. The nonprofit has developed a concept called the **GeoMicroDistrict**, which would link buildings on a given street or block into a networked geothermal energy system. The system is powered by ground-source heat pumps, extremely energy-efficient devices that use water as a medium for sharing thermal energy between buildings, sending heat where it's needed and away from where it isn't. The geothermal districts tap the constant temperature of the ground, and can themselves be further linked together into larger networks.

The biggest upfront costs are associated with installing the system, including the drilling of shallow, six-inch-wide boreholes; after that, operating costs are low. Utilities like PGW could absorb those steep capital costs and spread them out over time and over their wide user base, taking advantage of economies of scale, said Zeyneb Magavi, the co-executive director of HEET. The geothermal pipes could be laid in the same rights-of-way already used for gas pipes. Geothermal systems could also preserve more jobs, she added, leveraging the expertise of utility workers, many of whom are trained to install the same kind of plastic pipes.

"We have to work with the pieces we have," said Magavi. "The fastest way forward is to flip utilities' financing mechanisms and customer networks, all these pieces that we can redirect toward building a better energy system."

Whatever decarbonization path Philadelphia chooses, as a first step Mike Henchen of RMI would like to see PGW identify one segment of the city's gas network — a neighborhood, a street, a discrete block of buildings — to shut off. "They can work to support every

building served by that portion to convert to a carbon-free alternative to gas, and then decommission an actual pipe in the ground," Henchen said. "Close the valve."

This kind of strategic abandonment, he argues, would be the most transformative step that PGW could take — one that would acknowledge that a smaller gas delivery system is needed in any likely scenario, and that would signal to city, state, and utility leaders around the country where the future is heading for the entire gas distribution industry. "If they could do that," said Henchen, "that would really be ground-breaking."

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