Public Health Impacts of Natural Gas - Policy Memo

1. Introduction:

This policy memo is presented to the City Council of Cambridge, Massachusetts to inform decisions regarding a transition away from natural gas infrastructure in new construction buildings in the city. This memo will convey the state of the science of natural gas infrastructure and its public health and safety impacts on communities serviced by this energy type. A review of the science on public health and natural gas energy would be incomplete without noting the public health and safety impacts associated with hydraulic fracturing (fracking), the sourcing of natural gas. Fracking has become increasingly common in residential areas and has led to an increase in cardiovascular disease in populations near fracking sites, as well as significantly degraded air quality.[1,2] Cambridge is not located near a fracking site but the health impacts throughout the natural gas lifecycle are significant, for example in Pennsylvania, Virginia. However, it is important to remember that our gas habits contribute significantly to public health issues in states close by. In the Marcellus Shale Region, located throughout western New York, Pennsylvania, and Ohio, there is a considerable amount of natural gas fracking. Research has shown that the chemicals used in fracking can damage the lungs, liver, kidneys, blood, and brains of people living nearby.[3] While these pollutants are more common in areas of heavy fracking, there is emerging research suggesting that some of these chemicals, some of which are carcinogens, may find their way downstream to the distribution network of the Greater Boston Area.[4] Below, the public health impacts of natural gas energy in residential households and municipalities like Cambridge is reviewed.

2. Research Question & Methodology

The goal of the following policy memo is to provide scientific evidence in support of building electrification with a focus on protecting the public health and safety of Cambridge residents, both current and future. In addition to protecting the health and well-being of residents, electrifying new construction buildings will help Cambridge stay on track to becoming carbon neutral by 2050. Data to inform this policy brief was compiled from published peer-reviewed literature. A keyword search was completed using a variety of peer-review journal databases, such as Web of Science and Science Direct, as well as citations collected from the author's 4 years of research in the field of natural gas energy. Keywords and papers were selected for their focus on the public health impacts of methane and combustion byproducts associated with natural gas energy. Additional data was collected through publicly available databases, including the location of known gas leaks currently reported in Cambridge as of the summer of 2020.

3. Key Findings

Natural gas extraction and distribution has detrimental effects on both indoor and ambient air quality, which has direct impacts on public health.[5] Natural gas generation relies heavily on combustion processes, which release particulate matter and harmful gases, such as nitrogen oxides, sulfur dioxide, volatile

[1] McKenzie et al. 2019.
[2] Mac Kinnon et al. 2018.
[3] Finkel & Law, 2011.
[4] Woolhouse, 2018.
[5] Mac Kinnon et al. 2018

organic compounds (VOCs), and carbon monoxide. Additionally, there are significant greenhouse gas emissions associated with natural gas generation that contribute to global warming and can cause damage to urban vegetation including the tree canopy.[6] Promoting a robust urban tree canopy is important for public health because trees in urban areas help to mitigate the urban heat island effect, lowering temperatures and providing shade while diminishing energy consumption, and contributing to the community's well-being.[7]

Building electrification has the potential to significantly decrease the greenhouse gas emissions from the city, reducing the climate change impacts associated with elevated levels of carbon dioxide and methane emissions.[8] Methane is a greenhouse gas and a product of natural gas energy, however, there is little to no research available regarding the direct impacts of methane on human health. Narrowing the scope to the public health consequences of natural gas in Cambridge, MA brings attention to two distinct public health concerns: the danger of combustion byproducts in homes with natural gas powered appliances, and the loss of beneficial public health ecosystem services like vegetative cooling, as climate change impacts are intensified in urban areas.[9,10]

3.1 Natural gas and combustion byproducts

The most significant public health threat from natural gas energy occurs in homes serviced by natural gas powered appliances, including gas stoves, gas boilers (for home heating and hot water) and clothes dryers.[11] Gas stoves are perhaps the most common and significant threat to residents because of the on-site combustion reaction that happens at the burner when the stove is turned on. These pollutants are referred to as combustion byproducts and are caused by an incomplete combustion reaction.[12] Combustion byproducts include carbon monoxide, nitrogen dioxide, and particulate matter. Carbon monoxide is a colorless, odorless gas that can cause headaches, dizziness, and nausea. Nitrogen dioxide, another combustion byproduct can cause irritation in the eyes, nose, and throat, and in high concentrations can lead to an increased risk of respiratory infections. Particulate matter released during combustion can cause irritation in the lungs, damage to lung tissue if inhaled, and can lead to an increased risk of cancer. Lastly, incomplete combustion reactions can create water vapor, which can increase the humidity in a home, creating an environment for mold or dust mites.[13]

Combustion byproducts from gas-powered appliances are a serious threat to human health and serious concerns about outdated and improper use of gas-powered appliances have emerged. A recent report published out of Australia found that replacing gas stoves in all homes with newer gas models or electric appliances and encouraging the use of proper ventilation hoods could lower asthma prevalence from indoor air pollutants nearly 10%.[14] Proper ventilation and newer gas stoves, without a pilot light, have been shown to help reduce the amount of combustion byproducts from gas stoves and help negate the

[6] Hoeks, 1972.
[7] City of Cambridge, 2020.
[8] Tarroja et al. 2018.
[9] Schollaert et al. 2020.
[10] Salmond et al. 2016.
[11] EPA, 2017.
[12] *Id.*
[13] *Id.*
[14] Knibbs et al. 2018.

effects on gas-powered appliances on indoor air quality.[15] Newer gas stoves and the use of a ventilation hood when cooking can significantly reduce one's exposure to combustion byproducts but these best practices are not always practical in every person's home environment, especially for renters who do not have control over what type of appliances are in the unit.[16]

There are underlying themes of environmental justice issues surrounding gas leaks and their impact on public health. Homeowners have a clear advantage as they have control over their fuel for heating/cooling and cooking. Renters can struggle with dictating their fuel type, although even among renters, there is a divide, as wealthier renters have more options and control over what type of infrastructure they will choose to live with. This disparity is one example of the disproportionate effects an energy transition can have on communities. Low-income communities and communities of color have historically been marginalized and disadvantaged when it comes to environmental stewardship and sustainable living and the energy transition case is no exception. Energy transition, if not handled properly, will negatively affect disadvantaged communities by exacerbating prevalent energy insecurity and issues of environmental racism.[17]

3.2 Natural gas and vegetation loss

Additional concerns about natural gas and public health are broader but equally important. Aging natural gas distribution infrastructure is springing leaks and from these leaks, uncombusted methane, a highly potent greenhouse gas, escapes into the urban atmosphere.[18] This gas can also escape into street tree pits and damage urban vegetation. A robust urban canopy has many public health benefits that are depleted when trees die or are removed due to damage from a gas leak.[19] Massachusetts has a significant problem with leaking gas infrastructure because over 11% of the pipeline distribution network in the state is made of leak-prone pipe material, like cast iron, compared to only 0.9% of leak-prone pipes across the country where older infrastructure has been replaced.[20] Urban vegetation is associated with many public health benefits including, improvement to air quality and associated respiratory outcomes, cooling temperatures in urban areas and reducing the urban heat island effect, improvement of physical and mental health through the promotion of recreational activity, and increased perceptions of personal safety.[21,22] A recent study in Chelsea, MA demonstrated that unhealthy or dying street trees were 30x more likely to have elevated methane in their soils from a nearby gas leak than healthy street trees.[23]

As Cambridge is working to improve their urban forest, considering the effects of gas leaks on street trees is of the utmost importance. Cambridge has developed a comprehensive Urban Forest Master Plan with the aim of protecting and promoting a robust, healthy, and sustainable urban canopy.[24] The benefits of

[15] *Id.*
[16] Lunden et al. 2015.
[17] Carley & Konisky, 2020.
[18] Schollaert et al. 2020.
[19] Nowak et al. 2013.
[20] PHMSA, 2018.
[21] Salmond et al. 2016.
[22] Kuo et al. 1998.
[23] Schollaert et al. 2020.
[24] City of Cambridge, 2020.

such an urban canopy cannot be overlooked from both an environmental and a public health perspective. As highlighted by the study in Chelsea, MA from above, gas leaks pose a significant threat to street trees and can seriously degrade the urban canopy over time.[25] Promoting a robust urban canopy can also help to alleviate environmental and public health stressors, not only related to gas leaks but issues of air pollution and the urban heat island effect, in low-income environmental justice communities. To successfully reach the goals outlined in the Urban Forest Master Plan and to provide street trees for the most dire communities, Cambridge will be forced to address the issues of aging gas infrastructure lying under the street.

4. Recommendations / Next Steps

Encouraging building electrification will prepare the City of Cambridge to reach its goals of carbon neutrality by 2050 and reduce the public health impacts of natural gas energy. Improving the indoor air quality of Cambridge residents, homeowners, business workers, and renters alike, can be achieved by switching from natural gas to electric appliances and heating. Incorporating electric infrastructure in new construction buildings from the start of construction will save health effects, time, and money down the road as Cambridge looks towards a clean energy future. Additionally, aging natural gas infrastructure will continue to leak and spew uncombusted gas, primarily methane, into the atmosphere contributing to the greenhouse gas emissions of the city and damaging urban vegetation and street trees. In order to maintain Cambridge's urban canopy and the countless public health services provided by these street trees, reducing the mortality of these trees due to leaking gas infrastructure will be key.

Electrifying new construction buildings is a logical place to start because there will be no additional reliance on the aged natural gas system moving forward. Beginning a climate forward development plan for the city, and creating jobs in the process, will help the city not only achieve its climate action goals but improve the health and well-being of its residents.

[25] Schollaert et al. 2020.

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