Climate Change Impacts of Natural Gas - Policy Memo

1. Introduction

This policy memo is presented to the City Council of Cambridge, Massachusetts to help inform decisions regarding natural gas infrastructure in new construction buildings in the city. This memo will convey the state of the science of natural gas infrastructure and highlight how incorporating natural gas energy into new construction buildings will have negative environmental consequences for decades to come. Investing in natural gas energy in any new construction building will commit the City of Cambridge to further reliance on fossil fuels and further delay the city from reaching their climate action goals. Natural gas energy has potential to contribute to climate change across its lifecycle, from production at the site of hydraulic fracturing ("fracking") to distribution under city streets. Natural gas fracking has potential to significantly damage watersheds and pollute the air and water in nearby communities, while fugitive emissions from leaking natural gas distribution infrastructure contributes to greenhouse gas emissions and can lead to street tree mortality/morbidity. In order to reach carbon neutrality by 2050, any building with natural gas will need to be transitioned to electric energy therefore encouraging electrification from the onset will expedite the city's climate agenda.

2. Research Question and Methodology

The goal of the following policy memo is to convey scientific evidence in support of building electrification and reducing or eliminating natural gas energy in newly constructed buildings in order to achieve carbon neutrality by 2050. Data to inform this policy brief was compiled from published peer-reviewed literature dating back to the 1970s, through current research. 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 climate change impacts of natural gas energy, both at the site of fracking and at the point of distribution through infrastructure underneath urban streets. Additional data was collected through publicly available databases, including the location of known gas leaks reported by the gas utility company in Cambridge as of the summer of 2020.

3. Key Findings

Three specific climate change impacts of natural gas energy stand out considerably in the literature including, 1) air and water pollution at the site of fracking, 2) significant methane emissions from leaking and aging natural gas distribution infrastructure, and 3) damage and death to street trees serving urban populations. Although there are serious climate change and environmental justice issues at the site of fracking for natural gas, no fracking sites are located in Cambridge, MA so while worth noting, this environmental impact will not be reviewed in this memo.

3.1 Methane emissions from natural gas infrastructure

Important for Cambridge to consider when planning for their energy future is the age and condition of natural gas distribution pipelines running under the streets across most of the city. Originally brought onto the energy market as a greener alternative to coal, natural gas energy had been associated with climate benefits since its installation decades ago.[1] Recently, research has emerged to show the leakage of methane associated with natural gas sourcing and distribution infrastructure erases any climate benefits of natural gas.[2] Atmospheric methane is a potent greenhouse gas with a *global warming potential* 86 times more potent than carbon dioxide over a 20-year time period and methane is the primary constituent of uncombusted natural gas traveling through distribution pipelines.[3,4] As the distribution pipelines age underneath city streets, pipes spring leaks. Some pipes are more leak-prone than others, such as cast iron, wrought iron, and unprotected steel.[5] These leak-prone distribution pipes make up roughly 30% of the distribution infrastructure in the MA contributing to many gas leaks across the state.[6] Figure 1 shows the location of currently unrepaired natural gas leaks in Cambridge, MA as reported by the gas utility to the Massachusetts Department of Public Utilities.

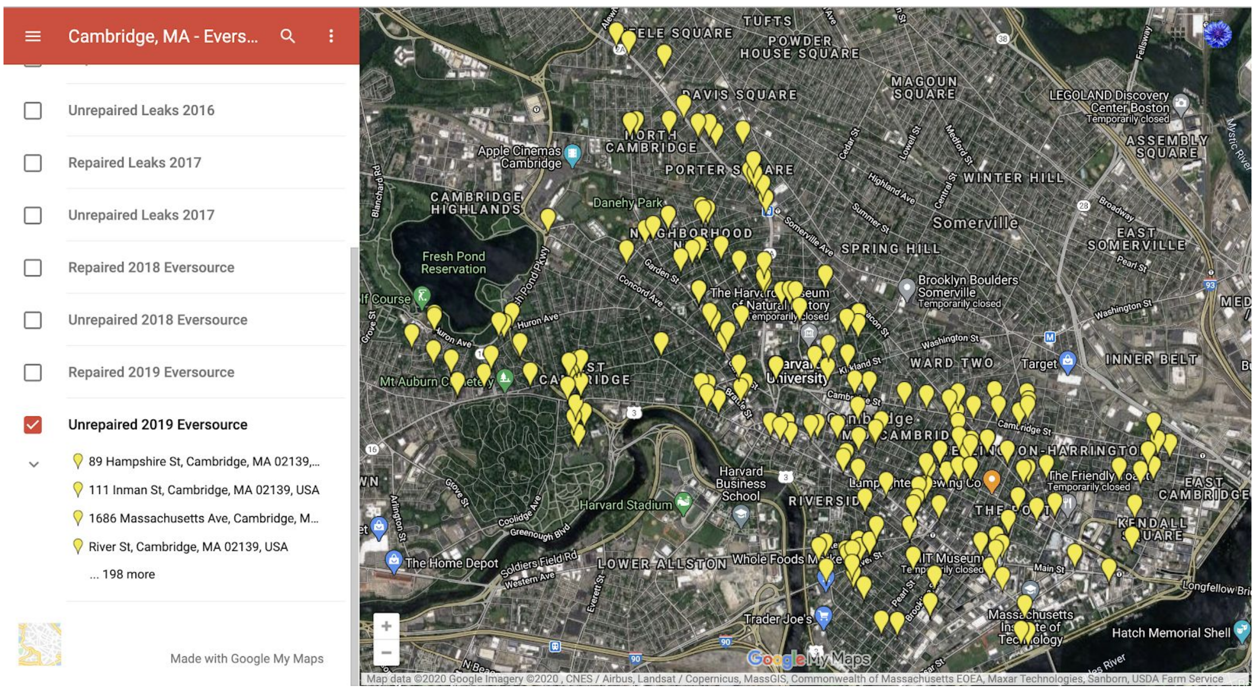

Figure 1. 202 unrepaired gas leaks in Cambridge, MA from 2019 Eversource utility report to the MA D.P.U. Google map courtesy of HEET, a Cambridge-based home energy non-profit organization. URL: https://heetma.org/gas-leaks/gas-leak-maps/ *accessed: August 24, 2020.*

Although pipeline replacement projects have increased in recent years, gas leaks across municipalities still contribute to greenhouse gas emissions. Measuring exact methane concentrations from leaking natural gas infrastructure has proved challenging, in part due to the outdated standards for estimating

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[1] Delborne et al. 2020.
[2] Howarth, 2014.
[3] Brandt et al. 2014.
[4] *Global warming potential* - "Each gas has a specific global warming potential, which allows comparisons of the amount of energy the emissions of 1 ton of a gas will absorb over a given time period… compared with the emissions of 1 ton of CO2" - Valero, 2019.
[5] EPA, 1996.
[6] D.O.E., 2017.

methane emissions from gas pipelines that the US Environmental Protection Agency (EPA) is still utilizing.[7] Recent studies have tried to update these methane emission standards to better understand the contribution of leaking gas infrastructure to total greenhouse gas emissions. Hendrick and co-authors focused in the Greater Boston Area and found that not all gas leaks are equal and from their survey of 100 gas leaks, found that the top 7% of leaks contributed to 50% of the total methane emissions measured.[8] Although the science of methane emissions from natural gas distribution infrastructure is still emerging, there is consensus that methane emissions from natural gas leaks cannot be overlooked when making decisions about achieving carbon neutrality and electrifying Cambridge.

3.2 Natural gas leaks and street trees

Another area of climate change concerns associated with natural gas infrastructure is the damage to urban vegetation and street trees that results from aging and leaking distribution pipelines. When methane leaks from a pipe buried underneath a city street, a path of least resistance for the gas to reach the atmosphere exists in the soil pits where street trees and other urban vegetation is planted. Studies dating back to the 1970s characterize the interactions between methane and the soil of tree pits.[9,10] As methane enters the soil, it begins to displace the oxygen in the soil, leaving less oxygen available for the roots of urban vegetation to take up.[11] Additional changes occur in the microbial communities in these tree pits, as the influx of methane causes a growth in *methanotroph* populations, which further deplete oxygen available for the tree.[12,13]

More recent research conducted in Chelsea, MA aimed to quantify the effects of natural gas leaks on urban street tree health.[14] This study concluded that dead or dying street trees across Chelsea were 30 times more likely to have been exposed to methane, compared to healthy control trees. Damage to urban street trees and vegetation have significant climate change impacts due in large part to the ecosystem services provided to cities by a robust urban canopy. Street trees have demonstrated ability to reduce urban temperatures through shading and *evaporative cooling* which can help address issues associated with the *urban heat island effect*.[15,16,17] Additionally, street trees provide flood control, consume carbon

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[7] Lamb et al. 2015.
[8] Hendrick et al. 2016.
[9] Davis, 1977.
[10] Hoeks, 1972.
[11] Trees and other vegetation require oxygen in the soil to respire. When the sun is not out, or it is night, plants require oxygen from their roots to create energy to grow. - Plaxton et al. 2006.
[12] Adamse et al. 1971.
[13] *Methanotroph* - a microbial organism that oxidizes methane for energy. Bridgham et al. 2013.
[14] Schollaert et al. 2020.
[15] Norton et al. 2015.
[16] *Evaporative cooling* - refers to a phenomenon in trees caused by the evaporation of water on the leaves. Trees release water into the atmosphere through transpiration, and as this water turns from a liquid to gas, the surrounding air is cooled. USDA. 2019.
[17] *Urban heat island effect* - refers to the phenomenon "whereby ambient temperatures are significantly higher in cities than in rural areas due to the absorption and accumulation of heat in pavements and other physical interactions" Carpio et al. 2020.

dioxide, and provide aesthetic and recreational value.[18,19,20] According to the Cambridge Urban Canopy report from 2016, Cambridge does well at caring for their tree canopy, compared to estimates in other cities at 96.7% for young trees and 90.8% for old trees.[21] Maintaining current practices for caring for street trees and removing further threat from natural gas leaks will be crucial moving forward to promote a robust urban canopy in Cambridge.

4. Recommendations / Next Steps

Promoting building electrification will help to prepare the City of Cambridge to reach its goals of carbon neutrality by 2050 and reduce the environmental impacts of natural gas energy. 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 and grow the beauty of Cambridge's urban canopy and promote a sustainable and equitable future for the city, transitioning off of natural gas will be key. Banning natural gas in new construction buildings in favor of electrification 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 achieve its climate action goals. A failure to do so could delay achievement of the city's climate change goals, continue to damage the environment, and commit the city to a future reliance on natural gas and fossil fuels that is unnecessary.

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[18] Soares et al. 2010.
[19] Freedman et al. 1996.
[20] Bolund & Hunhammar, 1999.
[21] Boukili et al. 2016.

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