

GAS LEAKS **ALLIES**

# **ROLLING THE DICE**

ASSESSMENT OF GAS SYSTEM SAFETY IN MASSACHUSETTS



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*Rolling the Dice, Assessment of Gas Safety in Massachusetts* was written by Bob Ackley, Molly Fairchild, Sarah Griffith, Nathan Phillips, PhD, and Regina LaRocque, MD, MPH. While these individuals participate in the Gas Leaks Allies, a voluntary association, *Rolling the Dice* was written by the authors in their individual capacity and not as participants of the Gas Leaks Allies, nor on behalf of or with the endorsement of the Gas Leaks Allies or any organization.

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ARISE FOR SOCIAL JUSTICE  
BOSTON CLIMATE ACTION NETWORK  
BOSTON PARK ADVOCATES  
BROOKLINE GREEN SPACE ALLIANCE  
CLEAN WATER ACTION  
CLIMATE ACTION NOW—WESTERN MASSACHUSETTS  
CLIMATE REALITY PROJECT—MASSACHUSETTS CHAPTER  
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# EXECUTIVE SUMMARY



For decades, natural gas has been touted as clean, safe, and reliable. The September 13, 2018 catastrophic failure in the gas distribution system that caused explosions and fires in the Merrimack Valley focused attention on the risks inherent in piping explosive gas through communities and into homes.

What happened in the Merrimack Valley is the result of rolling the dice with public safety. Massachusetts residents, homes, businesses, and communities remain vulnerable as long as the state continues to rely on gas. Yet despite the magnitude of the problem, both immediate and longer-term improvements can provide the state with safer energy.

In response to the Merrimack Valley disaster, Governor Baker ordered “an independent statewide examination of the safety of the gas distribution system and the operational and maintenance functions of gas companies in the Commonwealth.” This report is the response of citizens and scientists motivated by a desire for a safe, healthy, and just energy system.

*Rolling the Dice: Assessment of Gas Safety in Massachusetts* analyzes documented incidents and publicly available data about the gas distribution system that add up to an urgent message to legislators, the executive branch, municipalities, and gas companies to take action now. It details ways that each of these decision-making entities can implement changes that will greatly enhance public safety in the near term and in the future.

In examining the gas distribution system, this report identifies three assumptions central to the engineering of the gas distribution system:

- Single-point failures can be prevented despite centralized distribution
- Cost-effective gas pipe materials exist that can contain a gas underground for decades
- Gas will only combust where it’s needed

The analysis of leak and incident data in this report seriously undermines each of these assumptions:

- **Centralized Distribution** Three transmission lines enter the state and feed 21,700 miles of gas mains, then 1.3 million gas service lines. A breakdown anywhere on the line causes an outage to all downstream customers.

- **Pipe Materials** The materials used in the system—cast iron and wrought iron, bare steel, and plastic—are all subject to leaking. Iron leaks at joints, bare steel corrodes, and plastic melts when exposed to heat or electric arc.
- **Combustion Likelihood** Gas is much harder to contain than liquid. Leaked gas travels and accumulates in both building spaces and underground, where it leads to combustion incidents, worsens public health, damages trees, and has a significant impact on the climate.

Inadequate utility management compounds these safety issues. Chronic problems with an understaffed workforce, safety processes, and lack of equipment required for the job can be corrected. Data collection and reporting on both infrastructure conditions and incidents should be improved and shared with municipalities and citizens.

Insufficient government oversight of gas utilities also erodes public safety. Department of Public Utilities (DPU) oversight of gas companies should be strengthened by:

- Ensuring independence of regulators
- Standardizing data definitions and measurements across utilities
- Controlling for errors in utility data collection and releasing fact-checked data to the public
- Coordinating communication between utilities and municipalities
- Enforcing emergency preparedness protocols, such as ensuring accessibility of emergency shutoff valves, sharing data with electric utilities, and providing for expert review of emergency preparedness plans

Given the multiple problems and hazards inherent in continuing to rely on an explosive gas as an energy source as well as the Commonwealth's commitment to reduce greenhouse gas emissions dramatically over the coming decades, this report makes over 50 recommendations toward a strategy of triage and transition.

- **Triage** Reduce short-term risks to safety, health, and property by enhancing statewide gas leak classification standards and prioritizing the largest and most hazardous leaks for repair, not pipe replacement.
- **Transition** Eliminate long-term risks intrinsic to reliance on a combustible gas by deploying a managed, just transition to cleaner, safer, and more cost-effective heating and cooking solutions.

This overarching recommendation is supported by an economic analysis showing that large investment in the current system will result in stranded assets and the near-certain demise of the current gas distribution companies.

Instead of rolling the dice by continuing to rely on gas, Massachusetts can strengthen public safety now while developing smart policies and implementing safer, innovative technologies to power homes, businesses, communities, and the Commonwealth into the future.



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# ***ROLLING THE DICE***

ASSESSMENT OF GAS SYSTEM SAFETY IN MASSACHUSETTS



On September 13, 2018 shortly after 4 P.M., an alarm sounded at a NiSource Company control center in Ohio indicating a pressure malfunction in the Columbia Gas distribution system in Lawrence, Massachusetts. Within minutes, three towns in that area went from a calm 70° day to a massive conflagration. A series of explosions erupted in eighty fires. Electricity and street lighting went down, communications infrastructure failed, and visibility was cut by billowing smoke.

According to the preliminary November 15, 2018 report of the National Transportation Safety Board (NTSB),<sup>1</sup> a control system meant to repressurize the system had failed. The incident began with errors made during a nearby gas pipe replacement that quickly collapsed the gas system. Pilot lights in homes became blow torches and basements became combustion chambers.

One young man died, 25 people were injured, and 30,000 residents were evacuated. Five homes were destroyed, 131 structures were damaged, and the heat for 8,517 homes and buildings across three towns was cut off. Nine hundred businesses were affected; thirty percent are still struggling to recover a year later.<sup>2</sup> To date, \$1.01 billion<sup>3</sup> has been spent refurbishing the homes, compensating the three towns, and replacing 44 miles of gas distribution pipelines and over 5,000 service lines.<sup>4</sup> As part of the response to the disaster, Governor Charlie Baker ordered the Department of Public Utilities (DPU) to commission a comprehensive, independent assessment of the gas distribution system.<sup>5</sup>

*Rolling the Dice: Assessment of Gas Safety in Massachusetts* is designed to complement the state's assessment and to offer the perspective of concerned citizens informed by the work of the Gas Leaks Allies. The Gas Leaks Allies formed in response to a 2013 study<sup>6</sup> that exposed thousands of gas leaks in Boston and indicated that the problem was widespread across cities with aging infrastructure in Massachusetts. After a 2014 law<sup>7</sup> required gas companies to report the location of leaks across the Commonwealth, the nonprofit HEET<sup>8</sup> created gas leak maps for over 200 municipalities,<sup>9</sup> stimulating public awareness

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1 National Transportation Safety Board, Safety Recommendation Report, Natural Gas Distribution System Project Development and Review (Urgent), November 15, 2018, <https://www.nts.gov/investigations/AccidentReports/Reports/PSR1802.pdf>, accessed August 22, 2019.

2 Allison Hagan, The Boston Globe, "Marketing campaign aids Merrimack Valley businesses still recovering from gas incident," July 9, 2019, <https://www.bostonglobe.com/business/2019/07/09/merrimack-valley-businesses-plead-for-help-after-gas-incident/iwJzHd26kJU3XOnrPGGPUJ/story.html>, accessed July 24, 2019.

3 Lisa Kashinsky, Boston Herald, "Columbia Gas parent company says cost for Merrimack Valley gas disaster could hit \$1B," May 1, 2019, <https://www.bostonherald.com/2019/05/01/nisource-ups-cost-estimates-for-merrimack-valley-gas-disaster/>, accessed July 24, 2019.

4 Craig LeMoult, WGBH, "What's Happened In The 6 Months Since The Merrimack Valley Gas Fires," March 13, 2019, <https://www.wgbh.org/news/local-news/2019/03/13/whats-happened-in-the-6-months-since-the-merrimack-valley-gas-fires>, accessed July 24, 2019.

5 Office of Governor Baker, "Baker-Polito Administration Announces Utilities Will Adopt Comprehensive Pipeline Safety Management Standards," November 21, 2018, <https://www.mass.gov/news/baker-polito-administration-announces-utilities-will-adopt-comprehensive-pipeline-safety>, accessed August 12, 2019.

6 Kathryn McKain et al, "Methane emissions from natural gas infrastructure and use in the urban region of Boston, Massachusetts," <https://www.pnas.org/content/pnas/112/7/1941.full.pdf>, accessed September 2, 2019.

7 Massachusetts Sessions Laws Chapter 149, "An Act Relative to Natural Gas Leaks." June 26, 2014, <https://malegislature.gov/laws/sessionlaws/acts/2014/chapter149>, accessed September 2, 2019.

8 HEET, <https://heetma.org/>, accessed September 1, 2019.

9 HEET, Gas Leak Maps, updated annually, <https://heetma.org/gas-leaks/gas-leak-maps/>, accessed September 1, 2019.

and leading to the first gatherings of concerned organizations who became Gas Leaks Allies.<sup>10</sup> Since then, its participants have collaborated to pursue legislation, shape regulations, analyze data, publish white papers, and educate the public about gas leaks.

While the Merrimack Valley gas disaster was an order of magnitude larger than other gas incidents in Massachusetts, 24 incidents in the state in the past 18 years have merited an investigation and report by the Pipeline Engineering and Safety Division of the DPU. Hundreds of other incidents have no public record other than what appears in media stories. An analysis of the 24 reported incidents reveals multiple safety issues related to the explosive nature of gas, the vulnerable state of the infrastructure, gas company practices, and lack of government oversight. The point is not that too many people have died, but that it's a roll of the dice as to who suffers mortality, injury, or property loss.

Identifying the causes of gas incidents is the first step. The next step is to decide how to address problems so that ratepayer funds are used responsibly and energy is provided reliably, safely, and equitably across the state. This report analyzes the current system and makes recommendations for immediate or near-term implementation. It also considers the gas system holistically as a connected physical and operational system and suggests a longer-term strategy.

This report is organized in five sections.

- “[Massachusetts Gas System Safety](#)” on page 13 describes the system and its vulnerabilities.
- “[Longer-Term Safety Concerns](#)” on page 39 considers the system and use of gas as a whole.
- “[Beyond State Boundaries](#)” on page 47 looks at the implications for bringing gas into and out of the state.
- “[Recommendations: Triage and Transition](#)” on page 51 lists the short-term and long-term actions the legislature, state agencies, and utilities can take to resolve the issues identified in this report.
- “[Conclusions](#)” on page 57 looks back at the thesis of this report and proposes a vision of the future.

For the convenience of the reader, recommendations are placed adjacent to issues they are meant to resolve as well as summarized in [Recommendations: Triage and Transition](#).

Working together, the legislature, executive branch, cities and towns, utilities, unions, and citizens can address the causes of gas safety issues systematically to move Massachusetts toward a safe, healthy, and just energy future.



# MASSACHUSETTS GAS SYSTEM SAFETY

The Massachusetts gas distribution system delivers an essential service to 1.6 million customers. Gas heats homes and businesses, supplies hot water, and provides fuel for cooking.

From three large high-pressure transmission lines that run through the state, local gas distribution lines owned and managed by local distribution companies branch off to deliver methane under pressure to urban and suburban areas. The first gas lines were installed over 150 years ago, and the system has continued to expand.

Delivering gas safely to customers through this system rests on these implicit assumptions:

- Gas system design can be centralized, with pipes radiating out from single sources to many local areas.
- Affordable pipe materials are available that can contain a gas and withstand underground conditions over long periods of time.
- Despite its flammable and combustible properties, gas can be distributed safely to its designated use.

This report demonstrates the flaws of each assumption.

Multiple years of data<sup>11</sup> from tracking gas leaks and an analysis of 24 gas incident reports<sup>12</sup> demonstrate persistent, embedded safety risks throughout the Massachusetts gas distribution system. The report asserts that the system will never be able to achieve its goal of safe, affordable energy delivery. The report also recognizes that while overnight change is not possible for such a large system, creative, responsible solutions must be pursued expeditiously—starting now.

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<sup>11</sup> See [gasleaksallies.org](https://gasleaksallies.org) for gas leak summary data.

<sup>12</sup> See “[Analysis of Gas Incidents in Massachusetts](#)” on page 21 of this document.

# Condition of the Gas Distribution System

## PIPE MATERIALS AND AGE

The gas distribution infrastructure in Massachusetts, an asset owned by local distribution companies and part of the rate base for customers, is one of the oldest in the country. Fifteen percent of the system predates 1940, with some pipes installed as early as the start of the Civil War in 1860.

can leak gas.<sup>15</sup> Corrosion rates of pipe vary depending on composition, soil and moisture conditions, and length of time underground.

Service lines connect gas distribution mains to buildings. According to Pipeline Hazardous Materials Safety Administration data, Massachusetts lists 212,523 service lines



Figure 1. Examples of pipe materials recovered from underground. From left: cast iron, bare steel, and plastic.

Gas distribution pipes are made of cast iron or wrought iron, bare steel, coated steel, or plastic.<sup>13</sup> Some gas lines are made of copper or ductile iron.<sup>14</sup> Cast iron and wrought iron pipes are the oldest and are prone to leak at pipe joints, which occur approximately every 12 feet.

Some cast iron pipes were originally joined with jute, a plant material that decomposes over time. Bare steel corrodes all along the pipe, resulting in pock-marked pipes that

that were installed prior to 1940 or are of unknown age, presumably prior to 1940. The majority of leak-prone service lines are bare steel, servicing 147,064 addresses.<sup>16</sup> In 2018 alone, 1,809 hazardous corrosion leaks were repaired on service lines. A 1984 explosion in Southborough exemplifies the type of incident that a corrosion leak can cause. A service line in Southborough exploded, destroying the home and causing \$70,000 in damages.<sup>17</sup>

13 [Mass.gov](https://www.mass.gov/service-details/natural-gas-distribution), Pipeline Safety Division, "Natural gas distribution," <https://www.mass.gov/service-details/natural-gas-distribution>, accessed July 18, 2019.

14 Interview with Bob Ackley, Gas Safety, Inc., July 23, 2019.

15 Interview with Bob Ackley, Gas Safety, Inc., July 23, 2019.

16 PHMSA Pipeline and Hazardous Materials Safety Administration, "Pipeline Mileage and Facilities," October 13, 2017, <https://www.phmsa.dot.gov/data-and-statistics/pipeline/pipeline-mileage-and-facilities>, accessed August 12, 2019.

17 Sharon Machlis, Middlesex News, "Gas Leaks Can Happen Anywhere," January 26, 1984.

## PHMSA REPORTED DATA ANALYSIS

### MASSACHUSETTS VERSUS NATIONAL

At the end of 2017, Massachusetts operators had:

- 21,669 miles of natural gas mains or 1.6 percent of national gas main inventory
- 1,336,690 natural gas service lines, 1.95 percent of national gas service lines
- Bare steel, cast iron, and wrought iron are considered leak-prone due to their susceptibility to corrosion over time.

#### BARE STEEL INVENTORY

- 1,206 miles of unprotected bare steel pipe. Six percent of Massachusetts gas main miles compared with three percent nationally.

#### CAST OR WROUGHT IRON INVENTORY

- 3,049 miles cast or wrought iron gas mains. 14 percent in Massachusetts compared with two percent nationally.

#### SYSTEM AGE

3,269 miles or 15 percent of the Massachusetts system was installed prior to 1940, compared with four percent nationally.

Figure 2. Summary of the materials and age of pipes in Massachusetts according to Pipeline and Hazardous Materials Safety Administration (PHMSA). Sources for this information and additional data are offered on [gasleaksallies.org](http://gasleaksallies.org).

Plastic pipes are expected to last 50 to 70 years, but they can leak if improperly installed or inspected, and plastic is vulnerable to heat. Two incident reports, detailed below, show that electrical failures can cause fires and indoor pipes near heaters can cause gas leaks and incidents.

### MAINTENANCE OF AGING INFRASTRUCTURE

With a distribution system that dates back to the 1800s, Massachusetts gas utilities must maintain over 21,000 miles of pipes and 1.3 million service lines of varying lengths. Because gas companies have never been required or incen-

tivized to find and fix all leaks, decades of neglect compound the problems inherent in old pipes.

Maintaining the gas distribution system is hazardous work, and utility company repairs can cause incidents. For example, an attempt to fix a gas leak in Roslindale on December 31, 2018 triggered a fire that lasted for two days.<sup>18</sup> Through the Gas System Enhancement Program (GSEP), utilities are paid to replace pipes rather than to repair them. While pipe replacement could seem like the safer course, incidents can also occur during replacement, particularly due to human error and lack of redundant protocols or inspections, as happened in the Merrimack Valley gas disaster.



### RECOMMENDATIONS

Utilities, from information they have on locations of leak-prone gas infrastructure, should inform:

- Property owners about their local service line data, including date of installation, material, and whether it is considered leak-prone.
- Public officials about the age and condition of local gas distribution pipes in their cities and towns. With this information, municipalities can work with the gas utilities to replace infrastructure when other infrastructure is under construction, cutting costs through synergistic scheduling.

### GAS ACCUMULATION UNDER STREETS

Gas from leaks can accumulate within a space rather than disperse into the atmosphere. Underground space for electric, telephone, cable, communications, and sewer structures can become containers for gas to accumulate or pathways for gas to migrate into basements or other confined spaces.

<sup>18</sup> Haley Glatter, The Boston Globe, "Gas Main Fire in Roslindale Extinguished," January 2, 2018, <https://www.bostonmagazine.com/news/2018/01/02/gas-fire-roslindale/>, accessed July 17, 2019.

While this analysis of gas incidents in Massachusetts provides details on gas accumulation in homes and buildings, gas leaking from aging infrastructure can also build up



Figure 3. Recent example of a Grade 1 leak in a utility manhole in the westbound lane of Washington Street at Harrington Street, Newton, Massachusetts. Combustible gas in a confined space becomes hazardous at 4%; the concentration in this utility manhole was a sustained 8%.

under streets and sidewalks with the potential to transform protective maintenance or manhole covers into dangerous projectiles.

**Underground Utility Spaces** Underground areas used by utilities for pipes or other structures accumulate leaking gas that can reach concentrations approaching and at times exceeding explosive levels. From direct observations by authors of this report, concentrations of gas in underground utility structures were observed to vary with weather conditions. During high atmospheric pressure or

fair-weather systems, gas dissipates quickly, while in low atmospheric pressure, gas concentrations increase. As gas fluctuates with weather conditions, a leak can oscillate in and out of explosive range.

Current leak classifications at many gas companies use four percent gas concentration in a maintenance hole—right at the explosive range—as a threshold for repair. Because weather conditions can increase or decrease readings in manholes, experts in the Gas Leaks Allies community strongly recommend a buffer of plus or minus three percent, meaning that any reading of one percent should be immediately repaired.

**Maintenance Covers** Gas concentrated in manholes can cause explosions and fires, often throwing the maintenance or manhole cover up to two stories high. From the public perspective, maintenance cover explosions seem to occur randomly—a roll of the dice.<sup>19</sup>

- In Natick in 2004, a teenager was struck by a flying maintenance cover. No explanation was reported publicly.<sup>20</sup>
- In Dorchester in 2008, a utility worker was hit and injured by a flying maintenance cover.<sup>21</sup>
- In Roslindale in 2013, a man and his dog narrowly missed being injured when the maintenance cover they had just walked over exploded.<sup>22</sup>

The safety of maintenance holes and covers currently receives little to no government oversight. One common utility practice is to drill out or replace manhole covers with slotted covers, venting the gas to lower the concentration of gas to below explosive thresholds, but adversely promoting a greater leak rate and impact on air and climate pollution.

19 Douglas Moser and Karen Hensel, [necn.com](https://www.necn.com/news/new-england/Underground-Danger-No-State-Oversight-of-Utility-Manhole-Inspections-422063763.html), “Underground Danger: No State Oversight of Utility Manhole Inspections,” May 12, 2017, <https://www.necn.com/news/new-england/Underground-Danger-No-State-Oversight-of-Utility-Manhole-Inspections-422063763.html>, accessed August 11, 2019.

20 Peter Ruell, accessed Metrowest Daily News, “Manhole Explosion Victim, NSTAR Settle Suit,” September 19, 2007, <https://www.metrowestdaily-news.com/x1646710476>, accessed July 23, 2019.

21 adamg, Universal HUB, “Exploding manhole in Dorchester,” May 2, 2008, <https://www.universalhub.com/node/14326>, accessed August 11, 2019.

22 adamg, Universal HUB, “Manhole explodes in Roslindale Square just after man, dog walk over it,” March 2, 2013, <https://www.universalhub.com/2013/manhole-explodes-roslindale-square-just-after-man>, accessed August 11, 2019.



## **R**ECOMMENDATIONS

Legislature should clarify and standardize gas leak classification, specifically:

- Lower the threshold to one percent gas in a confined space, and categorize any detectable gas within 15 feet of a building foundation as a Grade 1 hazardous leak.
- Categorize any detectable gas less than one percent in a confined space as a Grade 2 leak.
- Specify that ongoing, intentional release of methane gas into the atmosphere is no longer an acceptable leak solution.

## SYSTEM DESIGN

The Merrimack Valley disaster exposed the weakness in the hierarchical system design of the gas distribution system. Gas is transmitted from one of three high pressure trunk lines to intermediate pressure branch lines, then typically to lower pressure distribution pipes running under streets and sidewalks. Gas company distribution or main lines of varying lengths connect to the service lines that enter homes and businesses. Failure at one point in the network impacts all pipes and buildings downstream from that point, potentially affecting thousands of customers, as vividly illustrated in the Merrimack Valley.

This design creates a major safety concern. Changes in pressure at one point can cause the failure of multiple downstream gas lines. Pressure disruptions are especially dangerous in systems like those in the Merrimack Valley that do not have pressure regulators and automatic shutoff valves on downstream service lines.

Of special concern with single-point pressure events that impact multiple locations are incidents that occur during

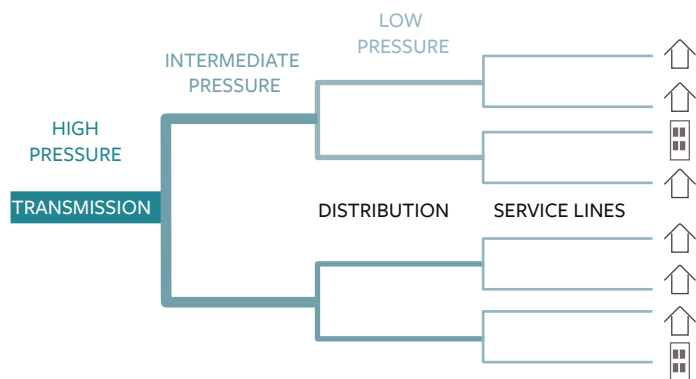


Figure 4. Schematic depicting the cascading design of the gas distribution system in Massachusetts.

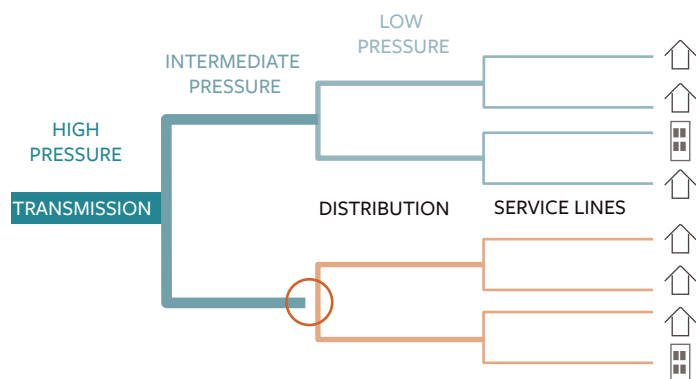


Figure 5. Schematic depiction of a single point failure. In the Merrimack Valley, a low-pressure distribution pipe that was taken offline accidentally triggered overpressurization from an intermediate line into over 8,000 low pressure service lines.

the coldest times of the year, exposing residents to potentially dangerous low temperatures.

From 2011 to 2016, Columbia Gas had five separate overpressurization events that were not disclosed to the Department of Public Utilities at the time of occurrence. The most recent was in Taunton in February 2016, where an undetermined number of downstream homes and businesses were at risk because of overpressurization.<sup>23</sup>

<sup>23</sup> Ally Jarmanning, WBUR, "Columbia Gas Fined \$75,000 For 2016 Pipeline Pressure Spike Only After Recent Explosions," February 4, 2019, <https://www.wbur.org/bostonmix/2019/02/04/columbia-gas-merrimack-valley-explosions>, accessed August 11, 2019.

In January 2019, a single valve failure at a gas regulator station in Weymouth apparently caused a gas outage across 7,100 homes in Aquidneck, Rhode Island.<sup>24</sup>

From December 31, 2017 through January 2, 2018, a fire in the Roslindale neighborhood of Boston on a gas main that was not classified as a critical main put as many as 8,500 homes at risk of a gas outage during a period of record cold days—almost as many addresses as were affected in the Merrimack Valley.<sup>25</sup> Although a federal incident report was filed, the damage does not meet the standard requirements for a Massachusetts DPU Incident report.

**CASE STUDY**  
**GAS FIRE IN ROSLINDALE BOSTON**  
 Event timeline: December 31, 2017–January 2, 2018  
 Cause: Unknown; gas workers attending to leak-prone gas main at 340 Hyde Park Ave.  
 Key statistics: Three gas workers hospitalized; up to 8,500 homes at risk of gas outage during record cold event.  
 Key lesson learned: System risks occur that by sheer luck escape major consequences, and therefore public awareness.

Hazardous systemic pressure incidents include:

- In Lexington in November 2005, an overpressurization event destroyed an historically important home, injured two individuals, and left 1,634 homes without gas.<sup>26</sup>
- In East Boston in 1983, a broken water main flooded a gas regulator, causing it to fail, overpressurize the system, and explode in a series of fires.<sup>27</sup>

24 Alex Kuffner, Providence Journal, "In vast gas network, single valve suspected," January 22, 2019, <https://www.providencejournal.com/news/20190122/in-vast-gas-network-single-valve-suspected>, accessed August 26, 2019.  
 25 Haley Glatter, Boston Magazine, "Gas Main Fire in Roslindale Extinguished," January 2, 2018, <https://www.bostonmagazine.com/news/2018/01/02/gas-fire-roslindale/>, accessed July 23, 2019.  
 26 Boston Business Journal, November 10, 2005, "KeySpan: Human error caused Lexington explosion," <https://www.bizjournals.com/boston/stories/2005/11/07/daily50.html>, accessed July 23, 2019.  
 Mass DPU, Pipeline Engineering and Safety Division, "Incident Report, 3 Hancock Ave., Lexington, November 9, 2005," June 2007, <https://www.mass.gov/files/documents/2018/07/31/11-9-05-lexington.pdf>, accessed August 11, 2019.  
 27 Wikipedia, "East Boston Gas Surge," February 13, 2019, [https://en.wikipedia.org/wiki/East\\_Boston\\_gas\\_surge](https://en.wikipedia.org/wiki/East_Boston_gas_surge), accessed July 23, 2019.  
 28 Kelsey Bode, Salem News, "Merrimack Valley gas disaster similar to 1990 Danvers emergency," September 14, 2018, [https://www.salemnews.com/news/local\\_news/merrimack-valley-gas-disaster-similar-to-danvers-emergency/article\\_f4f114759-17bd-5d7a-9810-d3548ade6918.html](https://www.salemnews.com/news/local_news/merrimack-valley-gas-disaster-similar-to-danvers-emergency/article_f4f114759-17bd-5d7a-9810-d3548ade6918.html), accessed July 23, 2019.

- In Danvers twenty-eight years before the Merrimack Valley incident, gas pressure was accidentally increased in distribution pipes, causing explosions and multiple fires.<sup>28</sup>

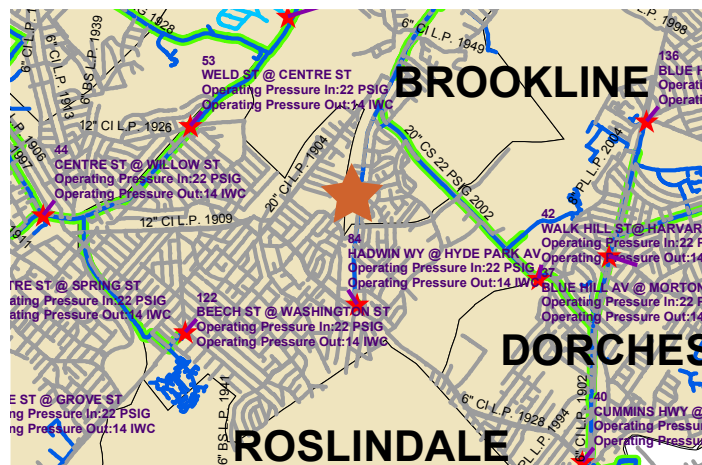


Figure 6. Gas pipeline distribution map in a portion of Boston. The star shown in the middle marks the location of the gas main fire that ignited on December 31, 2017 at 340 Hyde Park Avenue, Roslindale. Note that the gas line running north to south (indicated in blue, signifying an intermediate pressure of 22 psi) is not considered to be one of the critical mains, outlined in green. Figure adapted from a National Grid filing with the Massachusetts Department of Public Utilities, DPU Document 10-55 Attachment AG-46-36, since removed from the DPU website.

Because gas must be pressurized to be distributed, properly regulating gas flow is an ongoing safety issue. Gas enters the Commonwealth through just three interstate transmission pipelines, and no clear design solution exists to mitigate the risk of an incident disabling all downstream customers. However, an important criterion for evaluating risk and prioritizing repair versus replacement is to take

into account proximity to the gas transmission pipeline and number of downstream customers affected.



#### RECOMMENDATION

Cities and towns should include large-scale gas system failure risk and response in Municipal Vulnerability Preparedness plans, including special consideration of both overpressurization and underpressurization, as well as seasonal impacts.

#### GAS COMBUSTION

Gas is combustible in a confined space when it reaches a “gas in air” mixture of 4–15%. Below 4%, the mixture is too lean to ignite, while above 15% the mixture is too rich to ignite.

Gas leaks can cause explosions in multiple scenarios. Gas can build up in manholes, causing the covers to fly off and fires to start. Leaky service lines can lead to gas building up near foundations, a situation that creates a Grade 1 or potentially explosive leak. Leaks can originate indoors from interior gas lines, furnaces, and stoves. Even leaks that start outside homes at gas mains or service lines can migrate into buildings through foundation cracks or other pathways such as water lines, sewer lines, electric duct lines, telephone duct lines, and so on.

Leak grade classifications are mentioned frequently throughout the remainder of this report. The following table of leak grades lists current classification standards as defined by DPU<sup>29</sup> and recommendations for enhanced classification of Grade 1 and Grade 2 leaks. Rather than relying on interpretations of broad terms, these standards require spatial measurements, quantified levels of gas, or specific descriptions.

Currently, each gas company in Massachusetts can use wide discretion in classifying gas leaks with undefined terms such as “existing hazard” or “probable future hazard.” A more detailed, standardized approach to measuring, grading, and evaluating gas leaks used by all distribution companies would strengthen public safety by enabling clearer oversight and greater public understanding.

CURRENT DEFINITION	RECOMMENDED DEFINITION
<b>GRADE 1 CLASSIFICATION</b>	
<p>Any leak “that represents an existing or probable hazard to persons or property.”</p> <p>DPU requires repair or continuous action until the hazardous condition no longer exists.</p>	<p>Any leak that a person qualified by the Department of Transportation determines is an existing hazard to persons or property.</p> <p>Any leak deemed by the local fire department to be of sufficient magnitude to be a public nuisance.</p> <p>Any gas reading that is:</p> <ul style="list-style-type: none"> <li>• Inside a building</li> <li>• Within 15 feet of any outside building wall</li> <li>• Of one percent or greater in any manhole or confined space</li> </ul>
<b>GRADE 2 CLASSIFICATION</b>	
<p>Any leak “that is recognized as nonhazardous to persons or property at the time of detection, but justifies scheduled repair based on probable future hazard.”</p> <p>Current actions vary among gas companies. Most adhere to repair within 15 months and monitoring every six months.</p>	<p>Any leak that is nonhazardous to people or property at the time of detection, but represents a potential future hazard.</p> <p>Any leak deemed by the local fire department to be of sufficient magnitude to justify scheduled repair.</p> <p>Any leak within 40 feet of any outside building wall.</p> <p>Any leak that migrates to:</p> <ul style="list-style-type: none"> <li>• An area of 500 square feet or more</li> <li>• Private property</li> <li>• The root zone of any tree</li> </ul> <p>Weekly monitoring not to exceed 14 days</p>
<b>GRADE 3 CLASSIFICATION</b>	
<p>Any leak “that is recognized as nonhazardous to persons or property at the time of detection and can be reasonably expected to remain nonhazardous.”</p> <p>Monitored annually</p>	<p>No additional recommendations for safety, with the exception of Grade 3 significant environmental impact leaks.</p>

Figure 7. Table describing current leak grade classifications and definitions along with recommendations to improve safety.

29 220 CMR 114.00: Uniform natural gas leaks classification, April 19, 2019, <https://www.mass.gov/regulations/220-CMR-11400-uniform-natural-gas-leaks-classification>, August 2, 2019.

# Analysis of Gas Incidents in Massachusetts

The Merrimack Valley incident focused public attention on gas safety. In addition to investigating events in the Merrimack Valley, analyzing significant, recent gas incidents in Massachusetts portrays a broader view of how gas incidents occur. Understanding the causes, not just the impacts of gas incidents, is the more direct path to safety improvements.

## GAS INCIDENT REPORTING

Since 2000, PHMSA has reported 36 gas incidents in Massachusetts. Of these, the DPU Pipeline Engineering and Safety Division has completed 24 investigations with reports that provide detailed information on the incidents and are currently available on the DPU website:<sup>30</sup>

The criteria for any gas event to be designated as a significant incident include at least one of the following: a death, overnight hospitalization, property damages exceeding \$50,000, or another result that is significant in the judgment of the gas company.

An investigation is also required when there is an unintentional gas release estimated at three million cubic feet or more, or an emergency shutdown of a liquefied natural gas or underground gas storage facility. Although these types of incidents have not triggered an investigation in Massachusetts over the past 18 years, they remain safety concerns.

These investigations provide valuable descriptions of the vulnerabilities of the gas distribution system. While PHMSA and DPU reports describe both the cause and the impact of gas incidents, this report examines the causes to reveal patterns in the vulnerabilities of the distribution

system and provide insights into how to better safeguard homes and communities.



## RECOMMENDATIONS

PHMSA and DPU reports should summarize incident causes in tables, presented in the same way as impacts are currently shared, so that both sets of information are prioritized and accessible.

PHMSA and DPU should lower the threshold for incidents that require investigations and reports, and should include outage incidents with potential to incur \$50,000 worth of economic damage.

DPU should conduct investigations and produce incident reports within two years rather than two years or more, as is the current practice.

## GAS PRESSURE

Gas distribution systems are typically sourced from transmission pipelines that have pressures greater than 100 pounds per square inch (psi). Regulator stations reduce pressure to suit the distribution system that is being fed.

Pressure varies throughout our gas distribution system. Any community can have low pressure (less than 1 psi), intermediate pressure (up to 100 psi) and high pressure (over 100 psi) pipes running down the same street. Some homes and businesses in Massachusetts are served by high pressure gas lines that have up to 300psi coming right up to the buildings.

In a confined space, methane is explosive when it reaches concentrations between five and 15 percent. These conditions may occur in utility access holes or basements fed by gas leaks. Whether a space reaches explosive levels depends on the rate of the leak and the time the leak builds up. There is thus no inherently safe leak; even a small leak, if gas concentrations are allowed to increase over time, can reach explosive levels.

<sup>30</sup> Mass.gov., Pipeline Safety Division, "Pipeline incident reports," <https://www.mass.gov/info-details/pipeline-incident-reports>, accessed August 11, 2019.

## HOW GAS ACCUMULATES AND EXPLODES

Gas is much more difficult to contain than a liquid. It can disperse through soil, air, or water, and it can build up to combustible levels in confined spaces.

### CASE STUDY

#### THE MERRIMACK VALLEY GAS DISASTER

Event timeline: September 13, 2018–December 2018

Fires and explosions across Andover, Lawrence, and North Andover

Cause: Overpressurization

Key statistics:

- One fatality, Leonel Rondon
- 21 injuries requiring hospitalization
- Five houses destroyed, 131 structures damaged
- 8,517 addresses without gas for up to 3 months
- 900 businesses affected. 30% still closed ten months later.

Key lessons learned

- Develop proactive heat restoration strategies for responding to large scale gas failures.
- Incorporate inventory of household electric heating capacity into Municipal Vulnerability Assessments and develop plan to begin upgrades.

There are often few or no warning signs before a gas fire or explosion. Mercaptan, a class of sulfuric compounds that smells like rotten eggs, is added to gas to create a detectable odor. However, gas incidents can occur before any smell of gas is present. For example, witnesses in the 2005 Lexington incident say they did not smell gas, but instead heard loud hissing.<sup>31</sup>

## ACCUMULATED GAS IN A CONFINED SPACE

Gas leaks can originate from gas mains under streets and service lines leading to buildings, then accumulate in a

maintenance hole or utility trench. Gas can also migrate through the soil or along other utility pipes into the basement of a building. In buildings gas lines can leak, and the gas can accumulate in a basement or crawlspace.

## IGNITION OF ACCUMULATED GAS

When gas accumulates in a confined space, it can become explosive and easily ignited by the pilot of a furnace or water heater. In addition, the arc of an electric filament from simple actions such as a light switching on or off, a doorbell ringing, unplugging an appliance, using a cell phone, or even static electricity can also trigger a fire or explosion.

First responders are trained to control these sources of ignition in a potentially explosive area, but the general public is largely uninformed and untrained in taking life-saving precautions when a gas odor is detected.



## RECOMMENDATIONS

DPU should report data on significant incidents by the cause of the leak, the location, and the source of ignition.

DPU should require utilities to more fully educate and inform customers on procedures for gas leak detection and response.

## CLASSIFICATION OF GAS INCIDENTS BY CAUSE

Gas incidents occur due to three main causes: pressurization issues, mechanical damage, and aging infrastructure. While many gas explosions and fires begin with mechanical damage to pipes during excavation, repairs, or winter

<sup>31</sup> Personal communication from Lexington Selectman Mark Sandeen, based on his knowledge of the 2005 Lexington gas explosion.

weather, incidents are also commonly caused by gas leaking from corroded pipes or failed joints.

## Pressurization Incidents

**Overpressurization** The Merrimack Valley explosions revealed the vulnerability of the gas distribution system to a single-point failure in pressure regulation. Routine replacement work on a gas main caused the collapse of the gas distribution system in Lawrence, Andover, and North Andover, triggering explosions and fires that damaged 121 structures and destroyed five homes, resulting in 21 injuries and one death.

According to the NTSB, the Columbia Gas work package failed to include a description for transferring the regulator pressure sensor from the old piping to the new, so the Columbia Gas employee omitted this critical step.<sup>32</sup>

As a result, when the old pipe was depressurized, the regulator sensed zero pressure on the low-pressure side and opened completely, feeding the full pressure of the main pipeline into the local distribution network. In response, automatic shutoff valves are now being installed in these communities to help protect against future pressurization issues.

While the Merrimack Valley explosions are attributed to overpressurization, many small failures contributed to the problem including clerical, procedural, and structural errors. The overpressurization began with a clerical error in that a known, necessary procedure was not included in the utility operations manual and work package. The error was procedural in that there were no redundant checks in

the protocol to verify pressure and catch errors. The error was structural in that an available safety feature, the automatic shutoff valve, had not been installed in pipes in these communities.

While the Merrimack Valley incident highlighted the risks of pressurizing explosive gas, overpressurization is an ongoing issue. Shortly after this incident, Columbia Gas was fined \$75,000 for another overpressurization incident that occurred two-and-a-half years earlier in Taunton on February 4, 2016.<sup>33</sup> In addition, four other incidents of overpressurization by Columbia Gas occurred between 2011 and 2016, but the locations and details of these incidents were redacted from the DPU reports.

Other utilities also have overpressurization incidents that have merited official reports. Most notably, National Grid was responsible for an overpressurization incident in Lexington in 2005<sup>34</sup> when utility workers connected pipes of different pressures. In this case, inaccuracies in the utility maps did not indicate the presence of the two different sizes and pressures of pipes on the street—a 60 psi pipe and a 2 psi pipe. Although a worker had identified the two pressure systems a few months before, the updated information had not yet been recorded on available maps. This incident affected 1,634 customers in Lexington for six days, caused an explosion that destroyed a home, and resulted in gas leak damage in 11 other homes.

The error in this case was clerical, as updated information about the pressure of pipes had not been added to the information system. It was also procedural, as there was no safety check in place to determine actual pressure in the new service line.

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32 National Transportation Safety Board, *Safety Recommendation Report, Natural Gas Distribution System Project Development and Review* (Urgent), November 15, 2019, <https://www.nts.gov/investigations/AccidentReports/Reports/PSR1802.pdf>, accessed August 22, 2019.

33 Ally Jarmanning, "Columbia Gas Fined \$75,000 For 2016 Pipeline Pressure Spike Only After Recent Explosions," February 4, 2019, <https://www.wbur.org/bostonmix/2019/02/04/columbia-gas-merrimack-valley-explosions>, accessed September 1, 2019. And Department of Public Utilities Consent Order 18-PL-03, November 30 2018, <https://www.documentcloud.org/documents/5700564-Columbia-Gas-Signed-Consent-Order.html>, accessed September 1, 2019.

34 Mass DPU, Pipeline Engineering and Safety Division, "Incident Report, 3 Hancock Ave., Lexington, November 9, 2005," June 2007, <https://www.mass.gov/files/documents/2018/07/31/11-9-05-lexington.pdf>, accessed August 11, 2019.



## RECOMMENDATION

Utilities should introduce redundant protocols to crosscheck critical decisions with at least two sources of verification.

**Underpressurization** Underpressurization of the distribution system can cause the pilot lights in appliances to go out, creating the risk of unburned gas accumulating in basements. When underpressurization occurs, the gas company must go door-to-door to turn off the service, then return to all customers to make sure their systems are re-ignited when the gas is turned on.

There are no official records of underpressurization incidents in Massachusetts, however, underpressurization caused a state of emergency in Newport, Rhode Island in January 2019<sup>35</sup> after National Grid suspended service to 7,100 customers due to pressurization concerns that originated in Massachusetts.



## RECOMMENDATION

DPU should require investigation and incident reports for underpressurization as well as overpressurization events.

## Mechanical Damage

Based on DPU reports, a main cause of gas incidents is mechanical impact to the gas lines—from errors during gas utility maintenance and repairs as well as from third-party hits during excavation for water and sewer repairs or other construction.

### **Gas Utility Damage and Accidents, Puncture of the Gas**

**Line** Some incidents caused by gas utilities are due to errors in identifying the location of their own gas line during repair.

Responding to an odor call in Springfield on November 23, 2012,<sup>36</sup> a gas company employee—after obtaining a zero-level reading inside the building—began to investigate outside using the bar hole method to detect gas in the soil. The probe struck and punctured the one-and-a-half inch plastic service line that was inserted inside an older two-inch bare steel pipe, causing gas to enter the building. The resulting explosion and fire levelled the building.

Another puncture occurred in Groton in 2007<sup>37</sup> when a leak-survey technician punctured the gas line while using the bar hole method to measure leak extent. The bar hole procedure is defined differently in different states, but it essentially involves drilling a narrow hole as close to the pipe in questions as possible.<sup>38</sup> As the leak survey technician used a probe bar to create a hole in the ground to investigate a Grade 3 leak, he hit the plastic service line. The gas migrated into a nearby basement, creating an explosion that destroyed the home.

35 Rachel Nunes, The Patch, “Newport Gas Outage Second-Largest After Hurricane Sandy,” January 23, 2019, <https://patch.com/rhode-island/newport/gas-outage-restoration-efforts-continue-6-600-still-affected>, August 12, 2019.

36 Mass DPU, Pipeline Engineering and Safety Division, “Incident Report, 453 Worthington St., Springfield, November 23, 2012,” September 19, 2014, [https://www.mass.gov/files/9-18-14-springfield\\_pipeline\\_incident\\_report\\_redacted.pdf](https://www.mass.gov/files/9-18-14-springfield_pipeline_incident_report_redacted.pdf), accessed August 11, 2019.

37 Mass DPU, Pipeline Engineering and Safety Division, “Incident Report, 44 Willowdale Rd., Groton, December 11, 2007,” September 1, 2009, <https://www.mass.gov/files/documents/2018/07/31/12-11-07-groton.pdf>, accessed August 11, 2019.

38 Jerry Watkins, Black Hills Energy, “Basic Leak Investigation,” October 20, 2015, [https://kcc.ks.gov/images/PDFs/pipeline/2015-seminar/basic\\_leak\\_investigation.pdf](https://kcc.ks.gov/images/PDFs/pipeline/2015-seminar/basic_leak_investigation.pdf), accessed August 22, 2019.



### **Gas Utility Damage and Accidents, Movement of the Service Line**

In Framingham in 2002,<sup>39</sup> a gas utility contractor excavating with a backhoe struck and pulled on a one-inch steel gas line, causing a break in the line at the service regulator in the basement wall. Gas migrated into the basement. The three residents had already moved outside when the explosion destroyed the home and threw a utility worker from inside the house into the front yard.

in Easton in 2007,<sup>40</sup> gas utility workers digging a trench to repair a one-inch steel gas service line inadvertently caused a hazardous leak inside the home. The excavator moved a rock that pushed against the service line, creating enough movement to open a leak in the isolation joint inside the home. There was no detectable gas odor outside before the house exploded.

### **Gas Utility Damage and Accidents, Valve Not Properly Closed During Repair**

In Waltham in 2010,<sup>41</sup> a utility employee failed to turn off the gas valve during a routine meter replacement, resulting in gas leaking into the basement that triggered an explosion and fire.

In Boston in 2005,<sup>42</sup> a utility crew inadvertently left open the valve on a service relay and went to lunch. Another crew activated the main not knowing the valve was in the open position, causing an explosion and fire at a Northeastern University dormitory while 110 to 130 students were having lunch. Seven people were taken to the hospital.

### **Gas Utility Damage and Accidents, Human Error and Insufficient Training**

In Needham in 2006,<sup>43</sup> a utility worker was hospitalized with serious injuries sustained while repairing a Grade 2 leak in the street. The worker had done the same repair at least a dozen times, but the investigation concluded that proper procedure had not been followed for the repair. The utility agreed to update the written procedure and retrain all workers.

In Dracut in 2009,<sup>44</sup> two utility workers were hospitalized with serious injuries after the cover blew off a primary valve during repair to a gas main at 60 psi pressure. The incident was attributed to human error—as the workers had not followed the written procedure—illustrating the need for redundant safety protocols to reduce the chance of errors and injury.



### **RECOMMENDATION**

Utilities should introduce redundant protocols to better anticipate human error and prevent accidents. See “Augment Utility Reviews and Protocols” on page 53.

### **Construction or Other Utility Damage and Accidents, Dig Safe and Marking Gas Lines**

Gas-related accidents also occur during general construction, either because Dig Safe<sup>45</sup> is not contacted before excavation or because markings are incorrect.

39 Mass DPU, Pipeline Engineering and Safety Division, “Incident Report, 9 Bonito Dr., Framingham, May 24, 2002,” [no publication date], <https://www.mass.gov/files/documents/2018/07/31/5-24-02-framingham.pdf>, accessed August 11, 2019.

40 Mass DPU, Pipeline Engineering and Safety Division, “Incident Report, 39 Jenny Lind St., Easton, September 10, 2007,” July 15, 2019, <https://www.mass.gov/files/documents/2018/07/31/9-10-07-easton.pdf>, accessed August 11, 2019.

41 Mass DPU, Pipeline Engineering and Safety Division, “Incident Report, 47 Chestnut St., Waltham, January 15, 2010,” April 20, 2012, <https://www.mass.gov/files/documents/2018/07/31/1-15-10-waltham.pdf>, accessed August 11, 2019.

42 Mass DPU, Pipeline Engineering and Safety Division, “Incident Report, 96 The Fenway, Boston, April 6, 2005,” September, 2008, <https://www.mass.gov/files/documents/2018/07/31/4-6-05-fen-boston.pdf>, accessed August 11, 2019.

43 Mass DPU, Pipeline Engineering and Safety Division, “Incident Report, Webster St., Needham, April 28, 2006,” <https://www.mass.gov/files/documents/2018/07/31/4-28-06-needham.pdf>, accessed August 11, 2019.

44 Mass DPU, Pipeline Engineering and Safety Division, “Incident Report, Hildreth St., Dracut, April 16, 2009,” April 14, 2011, <https://www.mass.gov/files/documents/2018/07/31/4-16-09-dracut.pdf>, accessed August 11, 2019.

45 Dig Safe is “a not-for-profit clearinghouse that notifies participating utility companies plans to dig. In turn, these utilities (or their contract locating companies) respond to mark out the location of their underground facilities. Dig Safe is a free service, funded entirely by its member utility companies.” <http://www.digsafe.com/>, accessed August 27, 2019.

In Hyde Park in November 2010,<sup>46</sup> a contractor failed to consult Dig Safe before excavating a water main. The excavator ruptured a one-inch steel gas service line. Gas migrated into the basement of an adjacent house, resulting in an explosion and fire fifteen minutes later.

In Chatham in 2002,<sup>47</sup> a contractor failed to call Dig Safe to locate pipes. While drilling piers for a walkway over a marshy area, the contractor punctured the conduit and a one-inch plastic gas service line to a home. Two days later, the homeowner smelled gas in the basement. A fire started when a maintenance person turned off the basement light switch.

In Weston in 2005,<sup>48</sup> Dig Safe incorrectly marked the location of the gas line. The contractor struck the one-inch plastic gas line and immediately called 911. The gas migrated into the basement through an open basement window. The home exploded before the gas company arrived.

**Construction or Other Utility Damage and Accidents, Accidental Damage to Outside Meter** DPU records include two reports of vehicles damaging an outside gas meter.

The original PHMSA Report for an incident in Attleboro in 2013<sup>47</sup> suggested that a vehicle or plow likely damaged the exterior gas meter to a residence, creating a leak in the gas line that ignited, causing extensive damage to the

house. However, the DPU report of December 2015<sup>49</sup> that cited \$85,000 in damages found the evidence inconclusive.

In Seekonk in 2012,<sup>50</sup> a tractor-trailer rolled over and struck an exterior meter, causing extensive fire damage to a restaurant.

**Construction or Other Utility Damage and Accidents, Heat Damage to Plastic Pipes** Currently, gas companies are replacing leak-prone cast iron and bare steel pipes with plastic that is supposed to last for decades. Yet plastic pipes are also vulnerable to failure from impact, heat, and errors. Two reported incidents illustrate the vulnerability of plastic gas lines to electrical fires and heat sources.

In Maynard in 2008,<sup>51</sup> an electrical malfunction caused a small fire that then melted a plastic gas service line. The leak migrated into the basement, resulting in a fire that destroyed the home.

In West Barnstable in 2009,<sup>52</sup> a residence was severely damaged when a plastic gas line was melted by a kerosene heater, causing an explosion and fire with significant damage to the home and nearby residences.

In March 2014, PHMSA updated incident report guidelines to require reports only when gas *caused* the incident.

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46 Mass DPU, Pipeline Engineering and Safety Division, "Incident Report, 17 Danny Rd., Hyde Park, November 3, 2010, December 4, 2014, <https://www.mass.gov/files/documents/2018/07/31/12-03-2014dannyroadreport.pdf>, accessed August 11, 2019.

47 Mass DPU, Pipeline Engineering and Safety Division, "Incident Report, 82 Marsh View Rd, Chatham, October 30, 2002," [no publication date], <https://www.mass.gov/files/documents/2018/07/31/10-30-02-chatham.pdf>, accessed August 11, 2019.

48 Mass DPU, Pipeline Engineering and Safety Division, "Incident Report, 225 North Ave., Weston, September 12, 2005," March, 2007, <https://www.mass.gov/files/documents/2018/07/31/9-12-05-weston.pdf>, accessed August 11, 2019.

49 Mass DPU, Pipeline Engineering and Safety Division, "Incident Report, 71 Such Dr., Attleboro, February 9, 2013," December 9, 2015, [https://www.mass.gov/files/71\\_such\\_drive\\_attleboro\\_february\\_9\\_2013.pdf](https://www.mass.gov/files/71_such_drive_attleboro_february_9_2013.pdf), accessed August 11, 2019.

50 Mass DPU, Pipeline Engineering and Safety Division, "Incident Report, 390 Fall River Ave., Seekonk, June 24, 2012," March 25, 2014, [https://www.mass.gov/files/6-24-12-seekonk\\_redacted.pdf](https://www.mass.gov/files/6-24-12-seekonk_redacted.pdf), accessed August 11, 2019.

51 Mass DPU, Pipeline Engineering and Safety Division, "Incident Report, 88 Waltham St., Maynard, January 3, 2008," May 12, 2010, <https://www.mass.gov/files/documents/2018/07/31/1-3-08-maynard.pdf>, accessed August 11, 2019.

52 Mass DPU, Pipeline Engineering and Safety Division, "Incident Report, 1415 Osterville Rd., W Barnstable, March 9, 2009," July 14, 2010, <https://www.mass.gov/files/documents/2018/07/31/3-9-09-w-barnstable.pdf>, accessed August 11, 2019.



## RECOMMENDATIONS

- DPU should investigate Dig Safe errors and oversee improvements in mapping and marking gas lines.
- DPU should investigate ways to mitigate damage to outside meters.
- DPU and PHMSA reports should include electrical failures that melt plastic pipes.

### Weather Conditions

The effect of winter weather on gas infrastructure is a significant concern. Frost heaves can damage underground pipes, and falling ice or snow can damage outside gas meters. Either condition can start a gas leak.

**Frost Heaves** Recent DPU reports attribute three gas incidents to frost heaves that damaged underground pipes.

In Reading in 2010,<sup>53</sup> frost heaves cracked a six-inch cast iron main originally installed in 1930. The gas leak migrated to the basement of a nearby house through the soil, sewer lines, and cracks in the basement floor, resulting in an explosion and fire. National Grid had not yet started routine winter patrols to identify gas leaks that occur frequently when freezing and thawing cycles can break pipes.

### CASE STUDY

#### GLOUCESTER HOUSE EXPLOSION:

Event timeline: January 25, 2009

Cause: Broken 6" cast iron gas main migrating into house.

Key statistics: House destroyed, occupant Wayne Sargent critically injured, pet dog killed.

Key lesson learned: Gas odor complaints (reported for weeks prior to explosion) should be taken seriously and acted upon.

In Hyde Park on New Year's Eve in 2017,<sup>54</sup> a number of leaks were reported in this Boston neighborhood. During utility repair, a fire broke out in the hole, sending two workers to the hospital. The circumferential crack in the gas main that led to the fire was attributed to freezing.

In Fitchburg in 2013,<sup>55</sup> frost heaves cracked a four-inch cast iron gas main. The leaking gas migrated and accumulated in a nearby auto parts store, causing an explosion and fire.

**Falling Ice or Snow** In the winter of 2015, falling snow and ice damaged outside meters at five different locations, resulting in explosions and fires with significant impact to buildings in Westford,<sup>56</sup> Marshfield,<sup>57</sup> Duxbury,<sup>58</sup> and Tewksbury.<sup>59</sup> In Canton that year,<sup>60</sup> the owner was shoveling snow off the roof when the incident occurred.

53 Mass DPU, Pipeline Engineering and Safety Division, "Incident Report, 22 Manning St., Reading, January 25, 2010," November 26, 2012, <https://www.mass.gov/files/documents/2018/07/31/1-25-10-reading.pdf>, accessed August 11, 2019.

54 Brian Dowling, Boston Herald, "Gas pipe rerouted as flames shut down street, January 2, 2018, <https://www.bostonherald.com/2018/01/02/gas-pipe-rerouted-as-flames-shut-down-street/>, accessed August 12, 2019.

55 Mass DPU, Pipeline Engineering and Safety Division, "Incident Report, 214 Lunenburg St., Fitchburg, February 5, 2013," May 7, 2015, [http://www.mass.gov/files/2-05-2014lunenburgstreetreport\\_redacted.pdf](http://www.mass.gov/files/2-05-2014lunenburgstreetreport_redacted.pdf), accessed August 11, 2019.

56 Jason Claffey, Westford Patch, "Gas-Fed Fire on Bandon Circle in Westford," February 11, 2015, <https://patch.com/massachusetts/westford/gas-fed-fire-erupts-bandon-circle-westford-0>, accessed September 2, 2019.

57 Jessica Trufanthe, Patriot Ledger, "Trapped gas ignites; Marshfield building ruled uninhabitable", February 17, 2015. <https://www.patriotledger.com/article/20150217/NEWS/150217062>, accessed September 1, 2019.

58 NECN, "Ice Buildup Blamed for 2-Alarm Fire at Alzheimer's Care Center" Feb. 19, 2015. <https://www.nbcboston.com/news/local/2-Alarm-Fire-at-Assisted-Living-Facility-292655641.html> accessed September 1, 2019.

59 Robert Mills and Lauren Peterson, Lowell Sun, "Falling ice suspected in Tewksbury blaze", March 10, 2015. <https://www.lowellsun.com/2015/03/10/falling-ice-suspected-in-tewksbury-blaze/>, accessed September 1, 2019.

60 Kim Tunnicliffe, CBSlocal, "Snow-Covered Gas Meter Causes Explosion, Fire In Canton" February 22, 2015. <https://boston.cbslocal.com/2015/02/22/snow-covered-gas-meter-causes-explosion-fire-in-canton/>, accessed September 1, 2019.



## RECOMMENDATIONS

Utilities should start winter patrols earlier in the season and extend the patrol season.

DPU should enforce and conduct oversight for the frequency and effectiveness of patrols.

### Aging Infrastructure

**Outside Gas Leaks** Gas leaks from aging cast iron and bare steel pipes can migrate from a street leak into a building before the leak has been identified.

In Gloucester in 2009,<sup>61</sup> a six-inch cast iron low-pressure gas main that was installed in the street in 1922 had a circumferential crack at the connection to the one-and-a-quarter-inch bare steel service line. The leaking gas migrated into the basement of a nearby home where it accumulated, though no odor was detected in the street by winter patrols ten days before. The owner arrived home to see black smoke coming from the chimney. He looked in the basement, then called the oil company for service. When he returned to the top of the basement stairs, an explosion caused the house to collapse into the foundation. Debris blew into the street and adjoining properties. The owner was hospitalized, and property damage was estimated to be \$400,000.

In Somerset in 2009,<sup>62</sup> the leak that caused an explosion was attributed to damage to the protective yellow coating on the two-inch coated-steel gas main during sewer line work in 1974—35 years before—that had exposed the pipe to corrosion. Although the gas company detected 100

percent gas on the street, none was detected at the foundation of the home. It was unclear how the gas migrated to the basement a distance away, although there were cracks in the foundation. The home was levelled by an explosion after the gas had been shut off. The resident died in the explosion, despite fire department efforts to alert anyone inside. Property loss was estimated at \$1,100,000, and three other homes sustained serious damage.

In Winthrop in 2012,<sup>63</sup> a leak at a connection between a gas main and a service line resulted in the migration of gas from the street along the service line that had been fitted with a one-inch plastic pipe inserted inside the old cast iron pipe in 1986. The owner smelled gas in the home and basement and reported the odor at 7:54 AM. Four minutes later, the fire department called the gas company to report an incident. The resulting explosion and fire caused \$500,000 in damage, but no one was injured.

**Indoor Gas Leaks** DPU incident reports illustrate that gas leaks within a building can occur if service lines are not tested periodically. In some cases, leaking gas can accumulate and become explosive, often with little to no warning.

Currently, when gas meters in homes and businesses are replaced every seven years, the gas company assesses the condition of indoor pipes and appliances, checking for corrosion, leaks, and pipe supports as well as manually bleeding appliances of air. Inspectors can reveal dangerous conditions, document them, and make them safe. These inspections are likely the only time indoor gas lines are evaluated for safety and are not frequent enough to prevent incidents.

61 Mass DPU, Pipeline Engineering and Safety Division, "Incident Report, 76 Eastern Ave., Gloucester, January 24, 2008," August 2, 2010, <https://www.mass.gov/files/documents/2018/07/31/1-25-09-gloucester.pdf>, accessed August 11, 2019.

62 Mass DPU, Pipeline Engineering and Safety Division, "Incident Report, 93 New York Ave., Somerset, February 9, 2009," December 30, 2010, <https://www.mass.gov/files/documents/2018/07/31/2-19-09-somerset.pdf>, accessed August 11, 2019.

63 Mass DPU, Pipeline Engineering and Safety Division, "Incident Report, 627 Pleasant St, Winthrop, February 23, 2012," May 23, 2014, [http://www.mass.gov/files/5-23-14-winthrop\\_pipeline\\_incident\\_report\\_redacted.pdf](http://www.mass.gov/files/5-23-14-winthrop_pipeline_incident_report_redacted.pdf), accessed August 11, 2019.

In Hopkinton in 2002,<sup>64</sup> a multifamily home was leveled by a gas explosion in the early morning. Awakened by a loud rumbling sound, 11 people were able to escape. Tragically, however, two young sisters died. The investigation determined that the indoor service line had not been tested for five years, as required at the time.

In Sudbury in 2004,<sup>65</sup> a hazardous gas leak developed from a crack in a universal joint nylon gasket located above the service line shutoff valve. Leaking gas was drawn into the furnace flue and ignited by the pilot, causing an explosion and fire.

### A Note on Sources of Ignition

In most cases, the source of ignition cannot be identified, but there are many possibilities in a basement, including a pilot light for a furnace or water heater. Electrical systems can also trigger an explosion, such as the incident in Chatham in 2002<sup>66</sup> when an explosion destroyed a home after a repairman switched off the basement light as he was leaving.



#### RECOMMENDATIONS

Utilities should continue meter replacement programs—the only time when interior pipes and appliances are inspected for leaks—at seven-year intervals or consider shortening rather than extending the timeframe.

See “[Recommendations: Triage and Transition](#)” on page 51 for ways to address safety issues originating from both outdoor and indoor gas leaks.

## HOW GAS INCIDENT REPORTS ENHANCE SAFETY

A review of reported gas incidents in Massachusetts reveals patterns in how these incidents occur. The causes not only highlight the vulnerability of the infrastructure to hazardous pressure changes, impacts, and leaks, but also show that some inevitable human and procedural errors can be mitigated with redundant protocols and fail-safe shutoff systems.

### Redundant Protocols

In other high-risk environments—such as surgery or flying a plane—redundant protocols and checklists are essential safeguards against accidents and inevitable human errors.<sup>67</sup> A redundant system uses more than one measure to verify critical decisions and prevent errors. Given that there will always be human error, gas distribution companies need a standard, redundant system with checklists to help workers verify critical information and reliably cross-check decisions before taking action.



#### RECOMMENDATION

Utilities should use best management practices to establish checklists and redundant safety protocols as appropriate

### Fail-Safe Technology

To improve safety, the gas distribution system should include automatic devices to shut down supply when a failure is detected. In the Merrimack Valley, Columbia Gas is installing overpressurization and underpressurization

64 Mass DPU, Pipeline Engineering and Safety Division, “Incident Report, 65 Main St., Hopkinton, July 24, 2002,” November 6, 2003, <https://www.mass.gov/files/documents/2018/07/31/116inrep.pdf>, accessed August 11, 2019.

65 Mass DPU, Pipeline Engineering and Safety Division, “Incident Report, 72 Austin Rd., Sudbury, January 13, 2004,” November, 2008, <https://www.mass.gov/files/documents/2018/07/31/1-13-04-sudbury.pdf>, accessed August 11, 2019.

66 Mass DPU, Pipeline Engineering and Safety Division, “Incident Report, 82 Marsh View Rd., Chatham, October 30, 2002,” July, 2018, <https://www.mass.gov/files/documents/2018/07/31/10-30-02-chatham.pdf>, accessed August 11, 2019.

67 Gawande, Atul. *The Checklist Manifesto: How to Get Things Right*. New York: Metropolitan Books, 2010.

sensors that trigger automatic shutoff.<sup>68</sup> Investing in fail-safe technology that contains incident scope is critical to enhancing public safety.



#### RECOMMENDATION

Utilities should install automatic sensors to shut down supply automatically when necessary.

#### Publicly Available Data

The public is accustomed to receiving information about the risks of many products, such as Surgeon General messages on cigarettes and alcohol, choking hazard labels on small objects, and strangulation warnings for cords on window blinds. There are also detailed warnings of possible side effects in commercials for prescription drugs. This information helps the public make informed decisions and protect themselves from dangers that may not be obvious.

Gas companies publish information to call Dig Safe before excavating, but should do more to inform the public about the risk of migrating leaks, frost heaves, meter damage, and ignition risk when a gas odor is detected. The public would benefit from information about what to do about a gas odor indoors and actions to avoid as well as the importance of ventilating when cooking with gas. All three investor-owned utilities have safety information on their websites describing approaches that meet different standards and take different attitudes toward the reader.<sup>69</sup>



#### RECOMMENDATION

DPU should standardize publicly available safety protocols that utilities must meet.

DPU should require periodic outreach, appropriate for each customer class, explaining relevant safety information.

## Utility Management Practices and DPU Oversight

Gas company management practices compound gas distribution system safety issues. For example, the Merrimack Valley incident also involved management and human resource issues such as inadequate staffing, training, and protocols, along with fail-safe infrastructure. In any system, accidents and human error are inevitable. Recognizing that people make mistakes is essential to enhancing the safety of the gas distribution system.

This report asserts that state agencies should improve oversight of gas utilities and increase sanctions and incentives to motivate compliance.

### INSPECTORS AND ENGINEERS

At the time of the Merrimack Valley incident in September 2018, the DPU employed two active field inspectors with responsibility for oversight of more than 21,000 miles of

68 Kristin LaFratta, MassLive, "Columbia Gas announces \$80 million settlement with Lawrence, Andover, North Andover on gas disaster costs," May 7, 2019, <https://www.masslive.com/news/2019/05/columbia-gas-announces-80-million-settlement-with-lawrence-andover-north-andover-on-gas-disaster-costs.html>, accessed August 12, 2019.

69 Columbia Gas, Massachusetts Gas Safety Website: <https://www.columbiagas.com/safety/stay-safe/>; Eversource, Massachusetts Gas Safety Website: <https://www.eversource.com/content/ema-c/residential/safety/natural-gas-safety/gas-pipeline-safety/>; National Grid, Massachusetts Gas Safety Website: <https://www.nationalgridus.com/MA-Gas-Home/Natural-Gas-Safety/>, accessed August 26, 2019.

gas distribution pipes. As recently as 2016, Massachusetts had 12.5 inspectors.<sup>70</sup>

Currently, the number of trained engineers working for the utilities is also limited. During the repair work that triggered the Merrimack Valley incident, Columbia Gas did not have a professionally certified engineer onsite to oversee and approve the work. Additionally, the company had downsized its gas pressure monitoring staff from four to one.<sup>71</sup>



## RECOMMENDATION

DPU should increase the number of active DPU field inspectors to at least 10.

Utilities should have at least one experienced professional engineer onsite during pipe replacement work.

## WORKFORCE

On the day of the incident, the qualified union workforce available to respond to the Merrimack Valley explosion was noticeably understaffed. As the NTSB reported: “Columbia Gas shut down the regulator at issue by about 4:30 p.m. The critical valves of the involved natural gas distribution system were closed by 7:24 p.m. Beginning about midnight, crews consisting of two Columbia Gas technicians escorted by two emergency response personnel began shutting off the meters at each house to isolate the homes from the

natural gas distribution system. All meters were shut off by the following morning.”<sup>72</sup>

Having only two technicians and two emergency response personnel per crew to respond to a disaster of that scale highlights the issue of inadequate staffing. The workers needed several hours to ensure that each house was protected from potential explosion.

The public has limited access to information about gas company staffing and training. The differing ratios of gas worker per miles of pipe, however, suggest a need for more standardization and oversight. For example, National Grid has one worker for every eight miles of gas main, and one worker for every 552 service lines.<sup>73</sup> In comparison, Eversource has one worker for every 13 miles of gas main and one worker for every 807 service lines.<sup>74</sup> The significant difference in these ratios of workers to miles of pipe shows a lack of industry standards and a lack of oversight that can impact public safety.

To properly maintain the gas system and respond to incidents, gas companies need a standard metric for numbers of qualified union workers based on each company’s miles of pipe and number of service lines. While the Merrimack Valley incident dramatically revealed the lack of qualified workers to respond to a gas disaster, it highlights the need for gas companies to increase staffing to be able to respond effectively to future incidents.

70 Mike Deehan, WGBH, “Feds Praised Mass. Gas Pipe Line Inspectors Before Lawrence Explosions, But Questioned Staffing Levels,” September 24, 2018, <https://www.wgbh.org/news/politics/2018/09/24/feds-praised-mass-gas-pipe-line-inspectors-before-lawrence-explosions-but-questioned-staffing-levels>, accessed August 12, 2019.

71 Dave Copeland, Patch, “Columbia Gas Cut Pressure-Monitoring Staff: Whistle Blower,” December 17, 2018, <https://patch.com/massachusetts/north-andover/s/gkrxt/columbia-gas-cut-pressure-monitoring-staff-whistle-blower>, accessed August 11, 2019.

72 National Transportation Safety Board, Executive summary, “Preliminary Report Pipeline: Overpressure of a Columbia Gas of Massachusetts Low-pressure Natural Gas Distribution System,” October 11, 2018, <https://www.nts.gov/investigations/AccidentReports/Pages/PLD18MR003-preliminary-report.aspx>, accessed August 12, 2019.

73 National Grid has 1,379 union workers available to monitor 11,130 miles of gas mains and 761,382 service lines. Rough estimates provided by New England Gas Workers Alliance.

74 Eversource has 3,292 miles of gas mains and 204,947 service lines, with 254 workers. Estimates provided by New England Gas Workers Alliance.



## RECOMMENDATIONS

DPU should require a standard metric for workforce numbers based on each company's miles of pipe, age of pipe, and number of service lines.

DPU should require utilities to show that they have a sufficient number of qualified union workers to respond to incidents and properly maintain the gas system.

### EQUIPMENT

Cavity ringdown spectroscopy (CRDS) technology detects, precisely measures, and digitally documents methane in the atmosphere in parts per billion per second as well as identifies each methane reading with a global position tag and timestamp.<sup>75</sup> CRDS equipment is mounted in a vehicle, enabling efficient surveys at high speed, two to three times faster than industry standard flame ionization detectors. This data allows for rapid methane mapping and identification of new gas leaks.

CRDS equipment can also be used in emergency situations to quickly assess the condition of the gas distribution system. A driving survey covering many miles of pipe can be made after a natural disaster or terrorist event in order to identify where resources are most needed.

While CRDS technology enhances standard leak detection equipment, it cannot replace it. Portable flame ionization detectors and combustible gas indicators are necessary to pinpoint leak sources, identify the extent of leak migration, quantify atmospheric gas concentration, and aid in classifying a gas leak. Hendrick et al. (2016)<sup>76</sup> found that driving surveys, even with high precision instrumentation, can miss

small but hazardous Grade 1 leaks. Moreover, the discovery of those hazardous leaks indicates that business-as-usual walking surveys are not finding them. Thus, increased frequency and rigor in walking surveys is needed.



## RECOMMENDATIONS

DPU should require equipment that can detect gas in parts per billions, such as CRDS technology, as standard utility equipment for performing leak surveys or assessing resources required in emergencies.

As a leak detection control, DPU should commission a performance measurement survey with independent experts using CRDS equipment for comparison to utility findings.

Utilities should increase frequency and rigor in walking surveys that complement driving surveys and uniquely pinpoint subsurface leaks and provide data for assessing leak grade.

### INFORMATION AND PLANNING

In the Merrimack Valley, faulty work plans and insufficient information about the local distribution pipelines abetted the disaster. The incident was caused in part by lack of knowledge of the local distribution pipelines, as reflected in plans drafted by Columbia Gas personnel who did not review engineering drawings specifying where pressure sensors were located. As a result, the plans did not show that the pressure regulator on the decommissioned pipeline should have been relocated.<sup>77</sup>

75 Wikipedia. "Cavity Ringdown Spectroscopy," April 6, 2019, [https://en.wikipedia.org/wiki/Cavity\\_ring-down\\_spectroscopy](https://en.wikipedia.org/wiki/Cavity_ring-down_spectroscopy), accessed August 12, 2019.

76 Margaret F. Hendrick, et al., *Journal of Environmental Pollution*, "Fugitive methane emissions from leak-prone natural gas distribution infrastructure in urban environments," January 2016, <http://dx.doi.org/10.1016/j.envpol.2016.01.094>, accessed August 27, 2019.

77 Hendrick MF, Ackley R, Sanaie-Movahed B, Tang X, Phillips NG, Fugitive Methane Emissions from Leak-prone Natural Gas Distribution Infrastructure in Urban Environments. *Environ Pollut.* 2016, accessed August 27, 2019.

76 National National Transportation Safety Board, Executive Summary, "Pipeline: Over-pressure of a Columbia Gas of Massachusetts Low-pressure Natural Gas Distribution System," October 11, 2018, <https://www.nts.gov/investigations/AccidentReports/Pages/PLD18MR003-preliminary-report.aspx>, accessed August 11, 2019.





## RECOMMENDATIONS

Utilities should conduct internal reviews of all work plans and develop a checklist of required steps to use during work plan development.

Utilities should conduct internal reviews of infrastructure engineering drawings.

## DATA COLLECTION AND REPORTING

Tracking gas leak information made available annually to the public raises questions about gas company practices for collecting and sharing accurate data. It also reveals gaps in the kinds of data that should be publicly available, and the standards required for a gas incident to merit an investigation and report.

### Missing Leaks

Every year, a number of previously reported leaks are dropped from gas company reports without an explanation or record of repair. Because gas utilities remove leaks from the rolls, the number of reported active leaks at the beginning of a new year is usually lower than the reported number of active leaks at the end of the previous year.<sup>78</sup> See [Gas Leaks Allies](#) analysis of leak data.

Since annual leak reporting began in 2014, the fraction of leaks that disappear has varied widely from four to 40 percent. While National Grid has steadily reduced the number of leaks that go missing from its records, Ever-source and Columbia Gas continue to drop approximately 25 percent of leaks from their records each year.<sup>79</sup>

Some leaks may be removed from gas company records and not reported to DPU due to nearby repairs or pipe replacement. However, in March 2019, this report audited 27 missing leaks in National Grid service territory to investigate whether these leaks were still active. Findings include that ten missing leaks—37 percent of our sample—were still leaking, including a Grade 1 leak at 180 Needham Street in Newton.<sup>80</sup>



## RECOMMENDATION

DPU should publish and maintain a live leak map, with required real-time leak data. An example of this kind of map is available from ConEdison.<sup>81</sup>

DPU should audit gas company leak records including controls on fixed leaks.

Utilities should track the active leaks that were deleted and reconcile the balance of active leaks at the beginning of a new year to the balance of active leaks at the end of the previous year.

### Incident Data

This report's review of state and federal records reveals 60 investigated gas safety incidents in Massachusetts since 2002. These incidents have resulted in five fatalities from four separate events, 84 injuries, and \$14.5 million in property damage.<sup>82</sup>

Fourteen of the 60 incidents were not reported to the DPU because the DPU has lower standards for reporting than the federal standard. Federal reporting requirements

78 Michael Webber, MIT website, Lost Leaks, 2014-2015 data, <http://lostleaks.csail.mit.edu>, accessed August 14, 2019.

79 See Gas Leak Scorecard data on [gasleaksallies.org](http://gasleaksallies.org).

80 Bob Ackley and Nathan Phillips, "NGRID Missing Leak Survey 2019," <https://docs.google.com/spreadsheets/d/1X-xPDEqeGaG8pMrvNapahFIVEH-rCcs2cRSvyFBN75E/edit?usp=sharing>.

81 Con Edison, "Reported Gas Leaks," <https://www.coned.com/en/safety/safety/gas-safety/reported-gas-leaks>.

82 Gas Leaks Allies, Incidents Table, 2019, <https://docs.google.com/spreadsheets/d/1Uj-RTNAJmJ25dND2BcZN6A5rtQKpMZYUeOo6uw9Qnr8/edit?usp=sharing>, accessed August 11, 2019.

include at least \$50,000 in damages or three million cubic feet of gas released.

Because there is no comprehensive list of incidents resulting from gas leaks, it is not possible to rigorously quantify risk from various causes or in diverse situations. Without risk analysis of the full range of incidents, an important tool for prioritizing repair work is missing.



## RECOMMENDATION

Gas system operators should report any incident involving property damage exceeding \$10,000 or 100,000 cubic feet of gas released to the DPU, using a standardized record. These reports should be publicly available for inspection and analysis.<sup>83,84,85</sup>

## COORDINATION AND COMMUNICATION

Insufficient coordination and communication between utilities and municipalities can create safety risks.

In a clear example of the need for greater coordination and communication, 20 municipalities in National Grid territory recently formed a consortium to share challenges and devise solutions for working with the gas company. See [gasleaksallies.org](http://gasleaksallies.org) for the consortium's January 30, 2019 Letter to National Grid listing their ongoing common problems.

Mayors and administrators of these municipalities have all signed on to “seek to initiate a regional dialogue with National Grid to establish a consistent and productive forum

for discussing shared concerns and for driving collaborative solutions.” Cities and towns are asking for better communication, coordination, and data sharing so they can do their part to monitor the gas distribution system and keep the public safe. Together, they hope to be more effective in getting the gas company to address gas leak repair as well as safety issues, especially since the Merrimack Valley and other incidents of the past year, including National Grid's lockout of union workers, have elevated concerns.

Among the many benefits of regular, effective communication is the opportunity for municipalities to coordinate with utilities on street work. For example, street crews frequently pave over gas shutoff valves, impeding timely response in a gas emergency.<sup>86</sup> In a recent example, responses to a gas leak triggering an explosion and fire in San Francisco<sup>87</sup> were delayed when shutoff valves could not be located. Increasing visibility and accessibility of shutoff valves means that a gas incident can be contained or even prevented.

83 Operators may compute gas released using existing meters or, in the case of meter failure, estimated from the volume of depressurized pipe. 100,000 cubic feet of gas is a substantial loss of gas, equal to the daily gas use of over 500 average US homes and over 1,000 residents.

84 Teco Peoples Gas, Average US daily natural gas usage = 168 cubic feet, <https://www.peoplesgas.com/company/ournaturalgassystem/naturalgas-factslinks/>, accessed August 27, 2019.

85 Average us household size is 2.6, <https://www.arcgis.com/home/item.html?id=ede1a9cebbf74c11bd1556db9618715a>, accessed August 27, 2019.

86 Anonymous, Berkshire Eagle, “Report: many emergency gas shutoff valves inaccessible,” October 28, 2006, <https://www.berkshireeagle.com/stories/report-many-emergency-gas-shutoff-valves-inaccessible,488228>, accessed August 11, 2019.

87 J.D Morris, San Francisco Chronicle, “San Francisco pipeline blast puts spotlight on PG&E shutoff abilities,” February 8, 2019, <https://www.sfchronicle.com/business/article/San-Francisco-pipeline-blast-puts-spotlight-on-13598976.php>, accessed August 11, 2019.



## RECOMMENDATIONS

DPU should enforce existing Massachusetts law and regulation with stronger fines to ensure that shutoff valves are accessible and maintained.<sup>88</sup>

DPU should require utilities in one calendar year to locate, repair, and install where missing all critical valves: shutoff valves, gate boxes, and gate valves.

Utilities and municipalities should improve communication and coordination to perform repairs cost-effectively and with minimal disruption, thus speeding up needed safety changes.

### Emergency Preparedness

The Merrimack Valley disaster and other large gas system failures discussed in this report demonstrate a lack of emergency preparedness and response planning by utilities, state and federal agencies, and municipalities.

First, distribution of temporary electric heating appliances such as space heaters or cooktops was conducted without prior knowledge of or an inventory of household electric service. Without consideration of household electric circuit capacity or fire hazards, about 7,000 hot plates and space heaters were procured and delivered to Merrimack Valley households. Similar missteps were made after the Academy Homes outage in Roxbury<sup>89</sup> and the Aquidneck Island gas outage in Rhode Island.<sup>90</sup> This knowledge gap is solvable if municipalities work in cooperation with utilities and state

agencies to develop easily accessible municipal databases of building electric capacity.

Second, the plan to restore permanent heating systems appeared to consider only one option—the complete replacement of the gas system—when complementary or alternative options existed. Electrification of heating systems in at least some outlying streets could have provided permanent, cost-effective solutions earlier to residents on streets that were among the last to have their gas service restored. This all-or-nothing decision to replace the gas system in its entirety created an unprecedented shortage of skilled labor. Instead, a hybrid approach could have leveraged diversely skilled work forces that include electricians, plumbers, and HVAC and insulation professionals. Long-term recognition of energy supply, especially in the winter months, must include identifying alternative energy sources and skilled labor pools in the event of a gas failure.

#### CASE STUDY

#### AQUIDNECK ISLAND–WEYMOUTH GAS OUTAGE

Event timeline: January 2018

Cause: Valve failure at Enbridge regulator station in Weymouth, Massachusetts.

Key statistic: 7,100 addresses, 10,000 people, without gas for a week in winter weather.

Key lesson learned: Space heaters distributed as in the Merrimack Valley three months prior were mismatched with customer electric service.

88 Chapter 164, §116B, <https://malegislature.gov/laws/generallaws/parti/titlexxii/chapter164>, August 11, 2019: Whenever the Commonwealth or a city or town undertakes the repair of streets, roads or sidewalks the appropriate gas company shall provide for the maintenance and improvements of its gate boxes located in the streets, roads or sidewalks to be repaired, so that the gate boxes are more easily and immediately accessible.

And 220 CMR 101: 101.06 (14), <https://www.mass.gov/regulations/220-CMR-10100-massachusetts-natural-gas-pipeline-safety-code>, August 11, 2019: Service Lines Location of Valves. (§192.365 MFS Standards.) whenever gas is supplied to a theatre, church, school, factory, or other buildings where large numbers of persons assemble, an outside shutoff in such case will be required regardless of the size of the service or of the service pressure. All underground curb shutoffs shall be readily identifiable and available for easy access by gas company personnel.

89 Andres Picon, Boston Globe, “Still without gas Academy Homes residents bundle up over a cold Christmas,” December 26, 2018, <https://www.bostonglobe.com/metro/2018/12/26/still-without-gas-academy-homes-residents-bundle-over-cold-christmas/wmEeZncmR7omVH7CCuOdzO/story.html>, accessed September 2, 2019.

90 Alex Kuffner, Providence Journal, “In vast gas network, single valve suspected,” January 22, 2019, <https://www.providencejournal.com/news/20190122/in-vast-gas-network-single-valve-suspected>, accessed September 2, 2019.



## RECOMMENDATIONS

Municipalities should include an inventory of household electric service indicating ability to take on temporary electric heating in Municipal Vulnerability Preparedness plans. This inventory should be mandatory for all municipalities that are substantially dependent on gas if they apply for state funding through the Massachusetts Department of Environmental Protection's Municipal Vulnerability Preparedness program.

Utilities should have detailed disaster preparedness plans and training overseen by experts, and such plans should be routinely updated.

DPU should commission an economic and feasibility assessment of alternatives to replacing gas mains, including options for district or household heat pump HVAC systems.

DPU and MassSave should develop community programs to double the energy efficiency of homes, perhaps using on-bill financing for weatherization. These programs would improve resilience in the event of future catastrophes and enable transition to heat pumps.<sup>91</sup>

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<sup>91</sup> One of the primary impediments to the goal of moving off gas and transitioning to heat pumps is the poor energy efficiency of the existing housing stock. Old, underinsulated housing stock is using two to four times the Btu per square foot for heating of average New England homes.

GAS INCIDENTS REPORTS IN MASSACHUSETTS 2000–2018										
CAUSE	TOTAL INCIDENTS	DPU PIPELINE SAFETY REPORT	FIRE	EXPLOSION	INJURIES OR HOSPITALIZATION	FATALITIES	PROPERTY DAMAGE COST	GAS EMITTED FINE	DESCRIPTION	
PRESSURIZATION										
OVERPRESSURIZED	3	1	2	1	2		2	1	LEXINGTON-2005, WEST SPRINGFIELD-2011, TAUNTON-2016*75K-FINE	
UNDERPRESSURIZED	1								NEWPORT, RHODE ISLAND- 2019	
MECHANICAL										
GAS UTILITY	11	9	10	7	6 (35)		9		FRAMINGHAM-2002,BOSTON-FENWAY-2005, NEEDHAM-2006, DRACUT-2009, EASTON-2007, GROTON-2007, WALTHAM-2010, SPRINGFIELD-2012, WINTHROP-2012, BEDFORD-2013, SHREWSBURY-2013	
THIRD PARTY	13	6	8	3	2	1	10		CHATHAM-2002, WESTON-2005, HYDE PARK-2010, SEEKONK-2012, FITCHBURG-2012, LITTLETON-2012, ATTLEBORO-2013, ANDOVER-2014, LAKEVILLE-2015, NEWBURYPORT-2016, REVERE-2016, TAUNTON-2018	
MELTED PLASTIC LINE	2	2	2	2			2		MAYNARD-2008, WEST BARNSTABLE-2009	
WEATHER										
GROUND FREEZE	3	1		2	1		1		READING-2010, FITCHBURG-2013, HYDE PARK-2017	
FALLING ICE OR SNOW	5		5	1			4		WESTFORD-2015, MARSHFIELD-2015, DUXBURY-2015, TEWKSBURY-2015, CANTON-2015	
UNCLEAR CAUSE										
INSIDE BUILDING	5	3	5	4	3	1 (2)	4		HOPKINTON-2002, SUDBURY-2002, PEABODY-2007, MARLBORO-2012, LAWRENCE-JAN2018	
OUTSIDE, ON STREET	2	2	2	2	2 (3)	1	2		GLOUCESTER-2009, SOMERSET-2009	
TOTAL	41	24	35	21	6	3	32	1		
							\$14.5Mil.			
MERRIMACK VALLEY	1		80+	3	21	1	\$1.1billion.		MERRIMACK VALLEY- 9-13-2018	

Figure 8. Table summarizing gas incident reports. Numbers in parentheses indicate number of incidents.



# LONGER-TERM SAFETY CONCERNS



A complete assessment of gas system safety must include additional considerations of long-term risks to public health, gas workers, oil and gas drilling workers,<sup>92</sup> families living near drilling rigs, the environment and trees, economic stability, homeland security, and climate. While less dramatic than a sudden explosion or fire, these risks may ultimately cause more harm than any collection of gas incidents.

## Public Health

When introduced as a fuel in the nineteenth century, gas was a byproduct of petroleum production or gathered from natural underground reservoirs. In 2005, an amendment to the Safe Drinking Water Act exempted the gas industry from disclosing the chemicals used in hydraulic fracturing, or fracking, by allowing the chemicals to be considered proprietary.<sup>93</sup> Fracking injects millions of gallons of water combined with sand and chemicals, some toxic, into the

underground shale formations to release the gas.<sup>94,95</sup> The FracFocus<sup>96</sup> database, managed by the Ground Water Protection Council and the Interstate Oil and Gas Compact Commission, is a voluntary national hydraulic fracturing chemical registry that catalogs chemicals currently in gas. Chemicals that are considered proprietary, are not reported. As a result, the public has no knowledge of the

92 Roxanna Z. Witter, et al., "Occupational Exposures in the Oil and Gas Extraction Industry: State of the Science and Research Recommendations,"- March 14, 2014, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4469339/>, accessed August 22, 2019. According to the CDC, the oil and gas industry had a two-and-a-half times higher fatality rate than construction industry and seven times higher fatality rate than average jobs.

93 Energy Policy Act of 2005, 42 U.S.C. § 300h, August 8, 2005, <https://www.energy.gov/sites/prod/files/2014/03/f14/EPAof2005.pdf>, accessed September 1, 2019.

94 Wikipedia, "Natural gas", last updated July 23, 2019, [https://en.wikipedia.org/wiki/Natural\\_gas](https://en.wikipedia.org/wiki/Natural_gas), accessed July 30, 2019.

95 Interview with Thomas W. Griffith, retired Senior Risk Analyst and Director of Geology, Anadarko Petroleum, July 30, 2019.

96 FracFocus, Chemical Disclosure Registry, <https://fracfocus.org>.

actual composition of the gas that we use to cook, heat our homes, and use in appliances.

In general, fracked gas may contain a number of chemicals and radioactive substances in addition to methane. Some of the dozens of impurities and additives found in gas are benzene, toluene, ethylbenzene, and xylene, which may cause health effects.<sup>97</sup> To simplify a complex process, radioactive radon gas concentrates in gas streams and decays to lead-210, then to bismuth-210, polonium-210, and stabilizes as lead-206. When inhaled, these elements migrate to bone tissue, possibly leading to bone cancers or abnormalities.<sup>98</sup>

Current research raises many questions about the health impacts of both leaked<sup>99</sup> and combusted gas.<sup>100</sup> Moreover, odorants added to gas can cause serious acute<sup>101</sup> and chronic<sup>102</sup> health problems.

Preliminary research shows that trace indoor gas leaks, though not potentially explosive, are common in Massachusetts homes and indoor public spaces. Yet with minimal research published to date, health risks from indoor gas leaks remain an open question. Outdoors, methane leaks are a precursor to ground level ozone formation and a

source of formaldehyde,<sup>103</sup> both of which are damaging to human health.

Cooking with gas releases particulate matter and nitrogen oxides,<sup>104</sup> and exposure in kitchens is heightened with poor ventilation. Although a range of pollutants are emitted from cooking with any source of heat, cooking with gas has been found to produce “much higher emissions overall.”<sup>105</sup> As with leaked gas, exposure and health risks of cooking with gas are open questions that require more research. See additional research and a bibliography of primary and secondary sources on this subject on [gasleaksallies.org](http://gasleaksallies.org).

With outstanding questions about the impacts of leaking gas on human health, an adequate assessment of the safety of the gas distribution system would require more information about the chemical components of gas and risks from exposure.



## RECOMMENDATION

The Massachusetts Department of Environmental Protection (DEP) and Department of Public Health should support studies of gas composition and population exposure to hazardous compounds associated with indoor and

97 Environmental Health Center-Dallas, “Natural Gas,” <https://www.ehcd.com/natural-gas/>, accessed August 27, 2019.

98 Wikipedia, “Naturally Occurring Radioactive Material,” July 17, 2019, [https://en.wikipedia.org/wiki/Naturally\\_occurring\\_radioactive\\_material](https://en.wikipedia.org/wiki/Naturally_occurring_radioactive_material), accessed August 27, 2019.

99 Robert F. Swarthout and Rachel S. Russo, et al., ACS Publications, “Impact of Marcellus Shale Natural Gas Development in Southwest Pennsylvania on Volatile Organic Compound Emissions and Regional Air Quality,” January 16, 2015, <https://pubs.acs.org/doi/abs/10.1021/es504315f>, accessed August 11, 2019.

100 Brett C. Singer, ScienceDirect, “Pollutant concentrations and emission rates from natural gas cooking burners without and with range hood exhaust in nine California homes,” September 2017, <https://www.sciencedirect.com/science/article/abs/pii/S036013231730255X>, accessed August 11, 2019.

101 Ca.gov, OEHHA, “Aliso Canyon Underground Storage Field, Los Angeles County,” May 22, 2018, <https://oehha.ca.gov/air/general-info/aliso-canyon-underground-storage-field-los-angeles-county>, accessed August 11, 2019.

102 Ivan Penn, Los Angeles Times, “‘We cannot breathe’: A poor Alabama town has lived with the rotten egg stench of gas for 8 years,” October 15, 2016, <https://www.latimes.com/projects/la-fi-eight-mile-leak/>, accessed August 11, 2019.

103 J. Jason West and Arlene M. Fiore, et al., “Global health benefits of mitigating ozone pollution with methane emission controls,” March 14, 2006, <https://www.pnas.org/content/103/11/3988>, accessed August 11, 2019.

104 Brett C. Singer and Rebecca Zarin Pass, et al., Elsevier, “Pollutant concentrations and emission rates from natural gas cooking burners without and with range hood exhaust in nine California homes,” September, 2017, <https://www.sciencedirect.com/science/article/pii/S036013231730255X>, accessed August 11, 2019.

105 Nicola Twilley, The New Yorker, “The Hidden Air Pollution in Our Homes,” April 1, 2019, <https://www.newyorker.com/magazine/2019/04/08/the-hidden-air-pollution-in-our-homes>, accessed August 11, 2019.



outdoor gas leaks.<sup>106</sup> These studies should focus on vulnerable populations, including those with existing lung disease.

DEP should conduct public education and awareness campaign of the dangers of particulate matter and other air pollution created by cooking with gas.

## Gas Workers

Gas workers regularly risk their safety. They are vulnerable due to their daily proximity to leaking and venting gas. They are also often in contained spaces where gas can reach explosive levels, and they are frequently the victims of burns, injury, or death from explosions and fires related to gas.

As more homes, businesses, and communities turn to renewable energy sources, gas workers face layoffs with no plans in place for transitioning to good careers in related businesses, retraining, or ensuring that unions have any power or role. Gas workers face on-the-job safety risks as well as long-term health impacts and negative job pros-

pects. Valuing the role of gas workers is part of a comprehensive assessment.



### RECOMMENDATIONS

Massachusetts Occupational Health Surveillance Program should assess and monitor gas worker health and safety.

Massachusetts Department of Career Services should promote gas worker career development to help ensure a just transition to renewable energy and energy efficiency jobs.

## Environment and Trees

Street trees provide multiple benefits such as oxygen production, cooling shade, lowering heat island effect, reducing pollution, mitigating ozone, revealing beauty, lowering blood pressure, improving emotional and psychological health, and increasing real estate values. One estimate claims each tree provides over \$90,000 in economic value in these services provided.<sup>107</sup>

Leaking methane takes the place of oxygen in the soil, suffocating organisms that feed root systems and killing trees. In addition to the loss of value, trees falling on the

street can harm people and damage vehicles, buildings, and streetscape infrastructure.

For example, in 2019 two mature trees toppled on the sidewalk in front of the main entrance to the Hurley School in Boston, a K–8 public school, where students had been walking an hour earlier. Documented gas leaks had permeated the root zones and killed the trees. Methane concentrations in the air in front of the school exceeded six times the ambient concentration, while methane levels in the root zones exceeded 90 percent. See “Figure 9. Gas leak plume

106 Concerned Health Professional of New York and Physicians for Social Responsibility, “Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking (Unconventional Gas and Oil Extraction),” June 2019, <https://www.psr.org/wp-content/uploads/2019/06/compendium-6.pdf>, accessed August 27, 2019.

107 Dan Burden, Glatting Jackson and Walkable Communities, Inc., “Urban Street Trees: 22 Benefits,” Summer 2006, [http://www.walkable.org/download/22\\_benefits.pdf](http://www.walkable.org/download/22_benefits.pdf), accessed August 22, 2019



Figure 9. Gas leak plume measured in front of the Hurley School in Boston and subsequent tree fall. Plume was measured months prior to subsequent downed trees.

measured in front of the Hurley School in Boston and subsequent tree fall.” on the following page.

Tree loss due to leaking gas is a complex issue. It affects property values and aesthetics but, perhaps more importantly, carries a carbon cost. Protecting trees from gas leak damage and death, particularly in urban areas, is an important safety measure as well as a pathway to carbon absorption and climate mitigation.<sup>108</sup>



## RECOMMENDATIONS

DPU should consider gas leaks that damage trees to be environmentally significant and graded as Grade 3 Significant Environmental Impact (G3SEI) leaks.

DPU should enhance gas leaks classification with safety issues involving trees.

## Economic Stability

Massachusetts ratepayers are currently committed to spend \$9.3 billion to replace about one-quarter of the gas system, or 5,408 miles, by 2033 through the Massachusetts Gas System Enhancement Plan (GSEP).<sup>109</sup> Unprotected steel,

cast iron, and wrought iron pipes can be replaced with plastic pipes that depreciate over 50 to 60 years.<sup>110</sup> By the time the plan is complete—in light of the achievement of emissions-reduction goals and mandates of the Global

<sup>108</sup> Jean-Francois Bastin, et al., Science Magazine, “The Global Tree Restoration Potential,” July 5, 2019, <https://science.sciencemag.org/content/365/6448/76>, accessed July 30, 2019.

<sup>109</sup> Commonwealth of Massachusetts, “GSEPs Pursuant to 2014 Gas Leaks Act,” <https://www.mass.gov/lists/gseps-pursuant-to-2014-gas-leaks-act>, accessed August 27, 2019.

<sup>110</sup> Mass.gov, “GSEPs Pursuant to 2014 Gas Leaks Act,” summary of G.L. c. 164, § 145, <https://www.mass.gov/lists/gseps-pursuant-to-2014-gas-leaks-act>, accessed August 13, 2019.

Warming Solutions Act<sup>111</sup> and Boston Climate Action Plan<sup>112</sup>—the gas system will have been replaced by a carbon-neutral system, potentially leaving these pipes abandoned in the ground, while ratepayers continue to pay for them as a form of stranded asset.

Instead of investing ratepayer dollars blindly, alternatives are available to begin transitioning gas company business models and shifting financial investments in a thoughtful way. Costs of renewable energy and energy storage technologies continue to fall.<sup>113</sup> Proven systems for thermal heating with fuel other than gas are currently available. Geothermal district heating is feasible for Massachusetts and would enable gas utilities to deliver safe, efficient thermal energy without explosive gas.<sup>114</sup> Massachusetts has a robust energy innovation sector that can and should focus on thermal energy alternatives to combustion of gas.<sup>115</sup>

As investment in the gas distribution system carries a large price tag, any comprehensive assessment and accompanying recommendations must include financial consid-

erations. GSEP, meant to enhance the safety of the gas distribution system, is financially risky for ratepayers and shareholders alike. Funding should be used responsibly to address the most hazardous safety issues while transitioning away from gas to safe, cost-effective solutions.

## RECOMMENDATIONS

Utilities should provide incentives for thermal heating alternatives to gas. State legislation should enable pilot projects to assess the benefits and costs of thermal energy heating system alternatives to gas pipeline replacement projects currently eligible under the GSEP.

DPU and utilities should consider alternatives to using GSEP funds for gas pipeline replacement.

DPU and utilities should choose the most cost-effective strategy of providing heat to ratepayers.



Figure 10. Plastic pipe replacement in Brookline, Massachusetts.

111 Mass.gov, “Global Warming Solutions Act Background,” <https://www.mass.gov/service-details/global-warming-solutions-act-background>, accessed July 30, 2019.

112 City of Boston, “Boston Climate Action,” July 2, 2019, <https://www.boston.gov/departments/environment/climate-action-plan>, accessed July 30, 2019.

113 Catherine Morehouse, Utility Dive, “Los Angeles solicits record solar + storage deal at 1.997/1.3-cents kWh,” July 2, 2019, <https://www.utilitydive.com/news/los-angeles-solicits-record-solar-storage-deal-at-199713-cents-kwh/558018/>, accessed August 27, 2019.

114 HEET, “GeoMicroDistrict Feasibility Study,” July 1, 2019, <https://heetma.org/energy-shift/geomicrodistrict-feasibility-study/>, accessed July 30, 2019.

115 Mass.gov, “Clean Energy Rankings/Progress,” <https://www.mass.gov/service-details/clean-energy-rankingsprogress>, accessed August 13, 2019.

# Homeland Security

Internationally, gas pipelines are subject to both physical attack and cyberattack. A March 2019 report<sup>116</sup> from the US Congressional Research Service cites several federal reports describing “the possibility of multiple, coordinated attacks with explosives” in addition to cybersecurity breaches. Among the risk characteristics listed are the stationary, dispersed infrastructure and the volatility of gas itself.

Liquefied natural gas (LNG) tanks, tankers, and trucks that transport gas into, around, and out of the state are susceptible to sabotage. Gas distribution pipes are also physically exposed in some locations, including at metering and regulating stations, along bridges and overpasses, and at building meters for public schools, libraries, and municipal buildings.

In Massachusetts, the gas distribution system is vulnerable, especially with the increased automation enabled by sensors.<sup>117</sup> Initial responses to the Merrimack Valley disaster included speculation that the explosions and fires could have been caused by a software incursion.<sup>118</sup> Programmable logic controllers (PLCs) and supervisory control and data acquisition (SCADA) software and hardware are used in the gas system in every metering and regulating station that directs gas to local distribution pipes. Targeting a critical node could lead to system collapse.

As previously described in this report’s section on system design the design of the gas distribution system creates the potential for mass disruption and casualties. Gas compa-

nies themselves are aware of and cautious about system safety risks. For example, National Grid has memoranda of understanding (MOU) with municipalities in Massachusetts stating that the company will share pipeline data with local officials only if they do not share it with the public. These MOUs state that the data is exempt from public record “because they relate to security measures, emergency preparedness, threat or vulnerability assessments, and to the security of persons, buildings, structures, facilities, utilities, transportation, and infrastructure located in the Commonwealth, the disclosure of which is likely to jeopardize public safety.”<sup>119</sup>

Measures to enhance physical security and cybersecurity must be included in any gas safety planning, but cannot prevent hacking or guarantee public safety.



## RECOMMENDATION

Massachusetts should conduct a security threat assessment of the gas distribution system, including both physical threats and cyberthreats, while recognizing that there is no reason to keep information from the public about underground infrastructure.

116 Paul W. Parfomak, Federation of American Scientists, “Pipeline Security: Homeland Security Issues in the 116th Congress,” March 1, 2019, <https://fas.org/sgp/crs/homesec/IN11060.pdf>, August 1, 2019.

117 Paul Roberts, RSA, “Sleepless in Security: Sensor-y Overload,” January 3, 2019, <https://www.rsa.com/en-us/blog/2019-01/sleepless-in-security-sensor-y-overload>, accessed August 13, 2019.

118 Jennifer Levitz and Russell Gold, Wall Street Journal, “Pipe Pressure Eyed in Gas Blasts,” September 14, 2018, <https://www.wsj.com/articles/officials-probe-fires-explosions-that-damaged-dozens-of-homes-near-boston-1536933528>, accessed August 27, 2019.

119 Letter from Stacey M. Donnelly, National Grid Counsel, to Mark D. Marini, Secretary, Department of Public Utilities, October 29, 2010, <https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/9275704>, accessed August 1, 2019.

# Emissions and Climate

Global warming is the most consequential risk to gas infrastructure. Flooding from sea level rise and increasingly severe storm events put pressure on the integrity of the gas distribution system.

As the climate warms, water expands in volume and polar ice caps melt, both raising sea level. Simultaneously, even modest warming of the atmosphere increases storage capacity of water vapor exponentially, resulting in the potential for above average rainfall and freshwater flooding.<sup>120</sup> New flood zones appear as these changes occur, and built infrastructure that was formerly on dry land could be subject to submersion.

Climate change, driven in part by methane leaks across the oil and gas supply chain,<sup>121</sup> threatens buried gas infrastructure through inundation and extreme weather events. Unprecedented recent gas pipe water inundations in low-lying neighborhoods in Saugus<sup>122</sup> and Gloucester<sup>123</sup>

are a bellwether of climate-driven risks to our gas distribution system. The LNG tanks in Everett are vulnerable to sea level rise and storm surge, in which case nearby low-income neighborhoods could be exposed to significant levels of leaking gas. These events will increase with the same certainty as sea level rise.

In addition to the physical risks to gas infrastructure from a warming climate, an increasingly unstable climate could also compound other safety and health issues associated with gas as well as accompanying costs. These risks should figure into utility planning.



## RECOMMENDATIONS

DEP should conduct a study of gas pipeline and related infrastructure (LNG facilities, compressor stations, and metering and regulating stations) vulnerability to sea level rise in coastal communities, and develop a response plan.

DEP should rigorously measure methane emissions from gas infrastructure and include the emissions in the Massachusetts Greenhouse Gas Emissions Inventory.

### CASE STUDY

#### SAUGUS–GLOUCESTER TIDAL GAS INUNDATION

Event timeline: Fall-winter, 2018

Cause: Groundwater leaking into gas pipelines and blocking home gas meters. Unclear how much inundation is due to tidal influence versus freshwater.

Key statistic: Dozen or more homes without gas

Key lessons learned: Shoreline communities are becoming more vulnerable to impacts of extreme weather and sea level rise.

<sup>120</sup> Union of Concerned Scientists, “Climate Change, Extreme Precipitation, and Flooding: The Latest Science,” June 2018, <https://www.ucsusa.org/sites/default/files/attach/2018/07/gw-fact-sheet-epif.pdf>, accessed May 14, 2019.

<sup>121</sup> John R. Worden, et al., Nature Communications, “Reduced biomass burning emissions reconcile conflicting estimates of the post-2006 atmospheric methane budget,” December 20, 2017, <https://www.nature.com/articles/s41467-017-02246-0>, accessed May 16, 2019. Also, Robert W. Howarth, Biogeosciences, “Ideas and perspectives: is shale gas a major driver of recent increase in global atmospheric methane?” August 14, 2019, <https://www.biogeosciences.net/16/3033/2019/bg-16-3033-2019.pdf>, accessed August 27, 2019.

<sup>122</sup> Mike Gaffney, Wicked Local Saugus, “Water Floods Gas Main on Beechview Avenue, Belair Street in Saugus,” November 20, 2018, <https://saugus.wickedlocal.com/news/20181120/water-floods-gas-main-on-beechview-avenue-belair-street-in-saugus>, accessed August 13, 2019.

<sup>123</sup> Ray Lamont, Gloucester Times, “Gas service disrupted to homes due to water leak,” November 8, 2018, [https://www.gloucestertimes.com/news/local\\_news/gas-service-disrupted-to-homes-due-to-water-leak/article\\_28390dea-3f06-54e4-b948-c9f4f84373ff.htm](https://www.gloucestertimes.com/news/local_news/gas-service-disrupted-to-homes-due-to-water-leak/article_28390dea-3f06-54e4-b948-c9f4f84373ff.htm), accessed August 13, 2019.



# BEYOND STATE BOUNDARIES



Restricting a safety assessment to one part of the gas system constitutes a safety problem in itself by artificially excluding safety issues that involve the interaction among parts of a complex, connected system. For example, the Massachusetts transmission valve failure leading to the gas outage on Aquidneck Island<sup>124</sup> illustrates the interaction between transmission infrastructure and distribution pipes. Moreover, there has been no official investigation of whether the Merrimack Valley incident involved high pressure transmission pipeline alarms or other high-pressure gas sources.<sup>125</sup>

## Interstate Gas Systems

Any assessment of safety issues in Massachusetts must also examine the connection between the pipes under streets and the interstate infrastructure that brings gas to homes and businesses, as well as through the state for export.

Recently disclosed<sup>126</sup> overpressurization incidents by Columbia Gas include one in July, 2016 involving an error by a Tennessee Gas Pipeline worker. Though pressure spiked to almost 12 percent over safe levels, the DPU did not investigate this event because it falls under federal jurisdic-

<sup>124</sup> Gavin Blade, Utility Dive, "Gas outages hit 10K in Rhode Island after issue on Algonquin pipeline," January 22, 2019, <https://www.utilitydive.com/news/gas-outages-hit-10k-in-rhode-island-after-issue-on-algonquin-pipeline/546556/>, accessed August 13, 2019.

<sup>125</sup> William Huston, Terra Vigilate, "The Black Swan at Merrimack Valley: Analysis of NTSB Preliminary Report, and introducing the 'Tube-Trailer Pressure-Booster' Theory," December 9, 2018, [TinyURL.com/BlackSwanMerrimackValleyPDF2](https://www.tinyurl.com/BlackSwanMerrimackValleyPDF2), accessed August 11, 2019.

<sup>126</sup> Ally Jarmanning, WBUR, "Columbia Gas Fined \$75,000 For 2016 Pipeline Pressure Spike Only After Recent Explosions," <https://www.wbur.org/bostonmix/2019/02/04/columbia-gas-merrimack-valley-explosions>, accessed Sept 1, 2019.

tion. Furthermore, the location of the incident was withheld from the public for homeland security reasons.<sup>127</sup>

These incidents in Massachusetts show that safety here is tied to events all along the network of interstate pipelines and other gas infrastructure that feed the state distribution system. Public awareness of gas safety issues is limited by the discrepancy between state and federal oversight.

This lack of preparedness and consideration of safety carries over to high pressure transmission pipelines and related infrastructure projects in Massachusetts. New gas infrastructure projects or expansions are being proposed or have been built in dense neighborhoods, including a compressor station in Weymouth and the 750 psi West Roxbury Lateral Pipeline. In the case of the proposed Weymouth

facility, there is ample reason for public safety concern, given two recent valve failures at an existing regulator station, one of which led to the extended gas outage affecting 7,100 customers on Aquidneck Island, Rhode Island.<sup>128</sup> Regarding the compressor station, Greater Boston Physicians for Social Responsibility has published a complete report on safety issues related to the project that concludes that “public safety officials could and should recommend against building the compressor.”<sup>129</sup>

The venting of gas from interstate pipelines that has recently occurred in Wellesley<sup>130</sup> and Needham<sup>131</sup> is an additional concern. These events illustrate that pipeline companies can decide to vent massive amounts of explosive, polluting, climate-damaging gas with almost no public notice and without local approval.

## A Broader View of Safety

Rolling the dice in Massachusetts, from gas distribution pipes to interstate infrastructure, also endangers the safety of others beyond state borders. With much of the gas delivered in Massachusetts supplied by hydraulic fracturing, most likely from the Marcellus shale, an understanding of gas safety must take into account the safety and health issues of fracking. Fracking jobs carry the highest safety and

health risks to workers of any energy industry.<sup>132</sup> Pipeline and other gas infrastructure explosions are widespread and well-documented.<sup>133</sup> Seventeen million people live within a mile of an active oil or gas well,<sup>134</sup> which, despite the different processes and products, both emit roughly the same air pollutants. People living within a mile of fracked gas drilling sites have 27 percent higher chance of suffering

127 Ally Jarmanning, WBUR, “Columbia Gas Fined \$75,000 For 2016 Pipeline Pressure Spike Only After Recent Explosions,” <https://www.wbur.org/bostonomix/2019/02/04/columbia-gas-merrimack-valley-explosions>, accessed Sept 1, 2019.

128 Rachel Nunes, Patch, Governor Declares State of Emergency in Newport For Gas Outage, January 21, 2019, <https://patch.com/rhode-island/newport/national-grid-gas-outage-affects-over-7-000-newport>, accessed August 13, 2019.

129 Baker, Anna et al, “Flammable, High-Pressure Industry in a Populated Coastal Flood Zone? Public Safety and Emergency Response Aspects Of a Proposed Methane Gas Compressor in Weymouth,” May 2019, <https://gbpsr.org/wp-content/uploads/sites/11/2019/05/compressor-public-safety-report.pdf>, accessed August 29, 2019.

130 Swellesley, Another Wellesley gas release to happen on August 27, August 27, 2019, <https://theswellesleyreport.com/2019/08/another-wellesley-gas-release-to-happen-on-august-27/>, accessed August 27, 2019.

131 Irina Costache, Bill Humphrey, 8/16/19: Quinobequin Natural Gas Alert, Needham Road Work, 5000 doors, 3.5 Weeks to Go, August 16, 2019, <https://www.billhumphrey.org/newsletter/2019/8/16/81619-quinobequin-natural-gas-alert-needham-st-road-work-5000-doors-35-weeks-to-go>, accessed August 27, 2019.

132 National Transportation Safety Board, “Pipeline Accident Reports,” <https://www.nts.gov/investigations/AccidentReports/Pages/pipeline.aspx>, accessed August 29, 2019

133 National Transportation Safety Board, “Pipeline Accident Reports,” <https://www.nts.gov/investigations/AccidentReports/Pages/pipeline.aspx>, accessed August 29, 2019.

134 PSE Healthy Energy, Phys.org, “17.6 million Americans live close to active oil or gas wells,” August 23, 2017, <https://phys.org/news/2017-08-million-americans-oil-gas-wells.html>, accessed August 23, 2019.



from severe heart disease, cancer, neurological disease, and birth defects.<sup>135</sup>

While safety and health issues tied to the gas industry as a whole are beyond the scope of this report, a truly comprehensive assessment of safety must also take into account the impact that use of gas in Massachusetts has on those who live near extraction sites and along transportation routes.

## THE PUBLIC'S ROLE IN GAS SAFETY

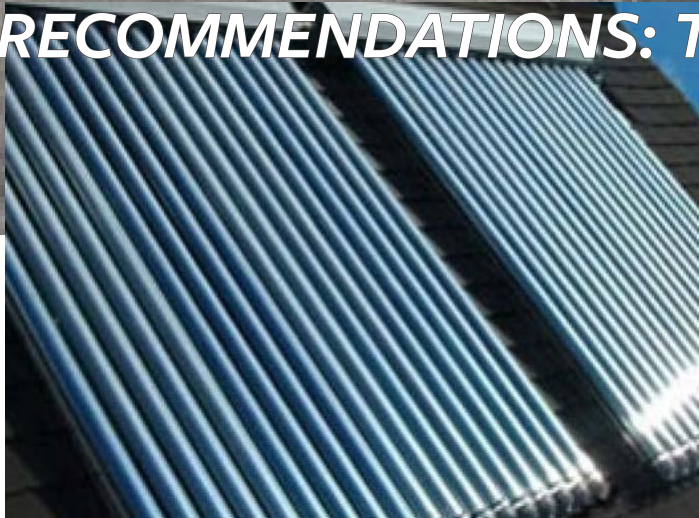
There is a role for all residents of the Commonwealth to act now to improve the safety of the gas system. Through the people and organizations that make up the Gas Leaks Allies, residents can learn about gas leaks and safety risks in their own communities and support efforts of gas workers and first responders to keep their communities safe. Residents can also advocate for specific recommendations in this report and the FUTURE Act with elected municipal and state officials, public safety officials, regulators, gas service providers, and fellow residents. In turn, decision makers in government and industry must respond to a growing chorus of concern and expeditiously pass and implement legislation to preserve public safety and ensure a safer future. Working together, we can all contribute to a healthy, safe, just energy future.

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<sup>135</sup> Julie Fidler, Natural Society, July 26 2015, "People Living Near Fracking Sites Suffer Severe Health Problems," <http://naturalsociety.com/study-people-living-near-fracking-sites-suffer-severe-health-problems/>, accessed August 23, 2019.



# RECOMMENDATIONS: TRIAGE AND TRANSITION



Improving the safety of the Massachusetts gas system in the context of global warming raises the question of whether to continue with the present system or look to alternatives. To stay with the present system and enhance public safety requires increased investment in the integrity of the system. This report asserts that shifting to systems that use renewable energy sources is the most cost-effective, forward-thinking way to improve public safety.

When gas incidents or outages occur, there are usually calls to invest in expanded gas infrastructure<sup>136</sup> instead of considering alternatives. The response to the Merrimack Valley disaster was to invest in new gas infrastructure with some safety enhancements. While household automatic shutoff valves were installed and leak-prone pipe was replaced wholesale, the result was essentially the same system. Columbia Gas acknowledged that electrification at the household level was a viable and permanent heating solution that could have been strategically implemented at a street scale to complement the rebuilding of the pipeline system on other streets and restore heat to portions of the affected area faster. Without a plan in place for a business model

transition for the utility, however, the company could not consider it in the short term.<sup>137</sup>

To meet the mandated Global Warming Solutions Act goal of an 80 percent reduction in emissions below 1990 levels by 2050, Massachusetts government must lead an effort to incorporate gas into a transition roadmap. Improving the safety of the gas distribution system in Massachusetts during this transition requires intelligent rather than accelerated investment in the integrity of the physical infrastructure in order to preserve capital for the transition. This work must be guided by environmental justice principles and must ensure good, unionized jobs for gas workers. It must also incorporate insights from municipalities, first

<sup>136</sup> Providence Journal, "Editorial: When the Heat Gets Turned Off," January 26, 2019, <https://www.providencejournal.com/opinion/20190126/editorial-when-heat-gets-turned-off>, accessed August 13, 2019.

<sup>137</sup> Columbia Gas, "Outline of Claims Handling for Customers Impacted by Loss of Natural Gas," <https://www.columbiagas.com/docs/librariesprovider3/greater-lawrence/claims-handling-for-customers-impacted-by-natural-gas-event.pdf?sfvrsn=2>, accessed August 13, 2019.

responders, public health experts, and other experts and concerned citizens.

## Triage the Current System

Many immediate and near-term improvements can greatly enhance public safety. Gas companies, state agencies, and municipalities can take steps now to prevent gas incidents and better inform the public. Recommendations previously made in the report are grouped below by responsible entity and topic.

### ENHANCE GAS LEAKS CLASSIFICATION

DPU should clarify and standardize gas leak classification, specifically:

- Lower the threshold to one percent gas in a confined space and categorize any detectable gas within 15 feet of a building foundation as a Grade 1 hazardous leak.
- Categorize any detectable gas less than one percent in a confined space as a Grade 2 leak.

See “Figure 7. Table describing current leak grade classifications and definitions along with recommendations to improve safety.” on page 20 for a comparison of current grades and clarified grades.

### IMPROVE DEPARTMENT OF PUBLIC UTILITIES OVERSIGHT

- DPU should report data on significant incidents by the cause of the leak, the location, and the source of ignition.
- DPU and PHMSA reports should include electrical failures that melt plastic pipes.
- DPU should require investigation and incident reports for underpressurization and overpressurization events.
- DPU should investigate Dig Safe errors and oversee improvements in mapping and marking gas lines.

- DPU should investigate ways to mitigate damage to outside meters.
- DPU should require utilities to better educate and inform customers on procedures for gas leak detection and response.
- DPU should require a standard metric for workforce numbers based on each company’s miles of pipe, age of pipe, and number of service lines.
- DPU should require utilities to show that they have a sufficient number of qualified union workers to respond to incidents and properly maintain the gas system.
- DPU and Northeast Gas Association should renegotiate the utility Mutual Aid Program to include situations such as the National Grid lockout of union workers.

### INCREASE TRANSPARENCY

From years of monitoring the gas distribution system as well as the experience of searching for complete and reliable sources of data for this report, the authors have recommendations for standardizing and controlling data collection, reporting, and sharing. Having this data would enable municipalities and citizens to better qualify risk, ensure environmental justice, and act accordingly.

#### Incident Reporting

- PHMSA and DPU reports should summarize incident causes in tables, presented in the same way as impacts are currently shared, so that both sets of information are prioritized and accessible.
- PHMSA and DPU should lower the threshold for incidents that require investigations and reports and should include outage incidents with potential to incur \$50,000 worth of economic damage.

- DPU should conduct investigations and produce incident reports within two years rather than two years or more, as is the current practice.
- DPU should publish and maintain a live leak map, with required real-time leak data. An example of this kind of map is available from ConEdison.<sup>138</sup>
- DPU should audit gas company leak records, including controls on fixed leaks.
- Utilities should track the active leaks that were deleted and reconcile the balance of active leaks at the beginning of a new year to the balance of active leaks at the end of the previous year.
- Gas system operators should report any incident involving property damage exceeding \$10,000 or 100,000 cubic feet of gas released to the DPU using a standardized record.<sup>139</sup> These reports should be publicly available for inspection and analysis.

## Leak Reporting

- DPU should require equipment that can detect gas in parts per billion, such as CRDS technology, as standard utility equipment for performing leak surveys or assessing resources required in emergencies.
- As a leak detection control, DPU should conduct a performance measurement survey with independent experts using CRDS equipment for comparison to utility findings.
- Utilities should increase frequency and rigor of walking surveys to complement driving surveys, uniquely pinpoint subsurface leaks, and provide data for assessing leak grade.
- Utilities, who know the location of leak-prone gas infrastructure, should inform property owners about their local service line data, including date of installation, material, and whether it is considered leak-prone.
- Utilities should inform public officials about local age and condition of gas distribution pipes in their cities and towns. With this information, municipalities can work

with the gas utilities to replace infrastructure when other infrastructure is under construction, cutting costs through synergistic scheduling.

## AUGMENT UTILITY REVIEWS AND PROTOCOLS

- Utilities should conduct internal reviews of all work plans and develop a checklist of required steps to use during work plan development.
- Utilities should conduct internal reviews of infrastructure engineering drawings.
- Utilities should introduce redundant protocols to cross-check critical decisions with at least two sources of verification.
- Utilities should introduce redundant protocols to better anticipate human error and prevent accidents. See section below on redundant protocols.
- Utilities should use best management practices to establish checklists and redundant safety protocols as appropriate.

## STRENGTHEN EMERGENCY RESPONSE PLANS

- DPU should standardize publicly available safety protocols that utilities must meet.
- DPU should require periodic outreach, appropriate for each customer class, explaining relevant safety information.
- DPU should increase the number of active DPU field inspectors to at least 10.
- DPU and MassSave should develop community programs to double the energy efficiency of homes, perhaps using on-bill financing for weatherization. This program will improve resilience in the event of future catastrophes and enable transition to heat pumps.<sup>140</sup>
- DPU should require utilities to have detailed disaster preparedness plans and training overseen by experts and require such plans to be routinely updated.

<sup>138</sup> Con Edison, "Reported Gas Leaks," <https://www.coned.com/en/safety/safety/gas-safety/reported-gas-leaks>.

<sup>139</sup> N. B. Operators may compute gas released using existing meters or, in the case of meter failure, estimated from the volume of depressurized pipe. 100,000 cubic feet of gas is a substantial loss of gas, equal to the daily gas use of over 500 average US homes and over 1,000 residents.

<sup>140</sup> One of the primary impediments to the goal of moving off gas and transitioning to heat pumps is the poor energy efficiency of the existing housing stock. Old, underinsulated housing stock is using two to four times the Btu/square foot for heating of average New England homes.

- DPU should commission economic and feasibility assessments of alternatives to gas main replacement and devise a plan to move to heat pump HVAC systems in the event of catastrophic events.
- Massachusetts should conduct a security threat assessment of the gas distribution system, including both physical threats and cyberthreats, while recognizing that there is no reason to keep information from the public about underground infrastructure.
- The Massachusetts Department of Environmental Protection (DEP) should conduct a study of gas pipeline and related infrastructure (LNG facilities, compressor stations, and metering and regulating stations) vulnerability to sea level rise in coastal communities and develop a response plan.
- The Massachusetts DEP should rigorously measure methane emissions from gas infrastructure and include the emissions in the Massachusetts Greenhouse Gas Emissions Inventory.
- Require utilities to have at least one experienced professional engineer onsite during pipe replacement work.
- Municipalities, with support from DPU, should include large-scale gas system failure risk and response in Municipal Vulnerability Preparedness plans, including special consideration of both overpressurization and underpressurization, as well as seasonal impacts.
- Municipalities should include an inventory of household electric service and ability for temporary electric heating in Municipal Vulnerability Preparedness plans. This inventory should be mandatory for all municipalities that are substantially dependent on gas if they apply for funding through the Massachusetts Department of Environmental Protection’s Municipal Vulnerability Preparedness program.

## IMPROVE CURRENT INFRASTRUCTURE

- DPU and utilities should consider alternatives, including ground source district heating, to using GSEP funds for gas pipeline replacement.
- DPU should enforce existing Massachusetts law and regulation with stronger fines to ensure that shutoff valves are accessible and maintained.<sup>141</sup>
- DPU should require the gas companies in one calendar year to locate, repair, and install where missing all critical valves: shutoff valves, gate boxes, and gate valves.
- Utilities should install sensors to shut down supply automatically when necessary.
- Utilities should start winter patrols earlier in the season and extend the patrol season.
- DPU should enforce and conduct oversight for frequency and effectiveness of patrols.
- Utilities should provide incentives for thermal heating alternatives to gas. State legislation should enable pilot projects to assess the benefits and costs of thermal energy heating system alternatives to gas pipeline replacement projects currently eligible under the GSEP.
- Utilities and municipalities should improve communication and coordination to perform repairs cost-effectively and with minimal disruption, thus speeding up needed safety changes.
- Utilities should continue meter replacement programs—likely the only time when interior pipes and appliances are inspected for leaks—at seven-year intervals or consider shortening rather than extending the timeframe.

## ADDRESS PUBLIC HEALTH

- The Massachusetts DEP and Department of Public Health should support studies of gas composition and population exposure to hazardous compounds associated with indoor and outdoor gas leaks.<sup>142</sup> These studies

<sup>141</sup> Chapter 164, §116B, <https://malegislature.gov/laws/generallaws/parti/titlxxii/chapter164>, August 11, 2019: Whenever the Commonwealth or a city or town undertakes the repair of streets, roads or sidewalks the appropriate gas company shall provide for the maintenance and improvements of its gate boxes located in the streets, roads or sidewalks to be repaired, so that the gate boxes are more easily and immediately accessible.

And 220 CMR 101: 101.06 (14), <https://www.mass.gov/regulations/220-CMR-10100-massachusetts-natural-gas-pipeline-safety-code>, August 11, 2019: Service Lines Location of Valves. (§192.365 MFS Standards.) whenever gas is supplied to a theatre, church, school, factory, or other buildings where large numbers of persons assemble, an outside shutoff in such case will be required regardless of the size of the service or of the service pressure. All underground curb shutoffs shall be readily identifiable and available for easy access by gas company personnel.

<sup>142</sup> Concerned Health Professional of New York and Physicians for Social Responsibility, “Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking (Unconventional Gas and Oil Extraction),” June 2019, <https://www.psr.org/wp-content/uploads/2019/06/compendium-6.pdf>, accessed August 27, 2019.

should focus on vulnerable populations, including those with existing lung disease.

- DEP should conduct a public education and awareness campaign of the dangers of particulate matter and other air pollution created by cooking with gas.
- Massachusetts Occupational Health Surveillance Program should assess and monitor gas worker health and safety.
- Massachusetts Department of Career Services should promote gas worker career development to help ensure a

just transition to renewable energy and energy efficiency jobs.

## PROTECT THE TREE CANOPY

- DPU should consider gas leaks that damage trees to be environmentally significant and graded as Grade 3 Significant Environmental Impact leaks.
- DPU should enhance gas leaks classification with safety issues involving trees.

# Transition to a Safe, Clean, Just System

At one time, gas was a welcome advance over coal, whale oil, and kerosene. New technologies, the limited horizon for cost-effective fracking, and the impetus of climate mitigation are already making gas less attractive to the retail energy market. A prudent approach to managing the necessary evolution to renewable energy systems is to triage the current physical infrastructure while launching a managed transition to the future.

## STRATEGY FOR A MANAGED TRANSITION

The cost of the Merrimack Valley disaster now exceeds \$1 billion,<sup>143</sup> with emergency pipeline replacement estimated at \$3.7 million per mile.<sup>144</sup> This example points to the viability as well as urgency of a managed transition away from gas for all of Massachusetts. By triaging the gas system with repair of the most hazardous and climate-damaging leaks rather than aggressively replacing pipe, resources can be reallocated toward distributed heating systems fueled by renewable energy and redoubled energy efficiency efforts.

Increased periodic leak surveys of substandard pipes, weekly cast iron leak patrols during frost conditions, and repairs of the largest leaks are cost-effective approaches compared to pipeline replacement. Leak repair typically costs \$3,000 to \$5,000. For example, in 2018, Columbia Gas estimated a cost of \$3,307 per leak to fix 150 of its largest leaks.<sup>145</sup> In contrast, pipe replacement typically costs \$1.2 million to \$1.8 million per mile.<sup>146</sup> Based on these numbers, the approximately 20,000 leaks in Massachusetts could be repaired for \$60 to \$100 million. Replacing the leak-prone portion of the gas distribution system is currently estimated at \$9.3 billion. These funds could be put to better use transitioning away from gas.

Achieving the significant, rapid emissions reduction targets mandated by the Global Warming Solutions Act requires examination of the utility business model. Ratepayers service the gas company's debt; investors finance utility capital projects through the bond market. For multiple reasons, investments in gas company projects are becoming

143 Milton J. Valencia, Boston Globe, "Merrimack Valley Disasters Toll Passes A Billion," February 20, 2019, <https://www.bostonglobe.com/metro/2019/02/20/merrimack-valley-disasters-toll-passes-billion/kZWuK2lPsZGh6i2uLigJrN/story.html>, accessed August 2, 2019.

144 Milton J. Valencia, Boston Globe, "Lawrence disaster estimated at \$800 million and counting," November 1, 2018, <https://www.bostonglobe.com/metro/2018/11/01/columbia-gas-parent-company-cooperating-with-criminal-investigation/Ewp3FdOmwUuQM80frc7pnO/story.html>, accessed August 2, 2019.

145 D.P.U. "17-GSEP-05," April 30, 2018, <https://www.mass.gov/files/documents/2018/05/01/17-GSEP-05%20Order%20final.pdf>, August 11, 2019.

146 MAPC and HEET, Fixing Our Pipes, 2015, [http://www.mapc.org/wp-content/uploads/2018/06/Fixing-Our-Pipes\\_MAPC-HEET\\_10-2016-FINAL.pdf](http://www.mapc.org/wp-content/uploads/2018/06/Fixing-Our-Pipes_MAPC-HEET_10-2016-FINAL.pdf), page 9, accessed September 1, 2019.

less attractive and risk creating stranded assets. Instead, a new model based on existing, available technologies can help utilities shift away from delivering gas to become companies that deliver thermal energy.<sup>147</sup>

Such transitions are difficult to execute. Old railroad companies did not become air travel leaders; horse-drawn buggy makers did not become big automobile makers; old computer companies did not become dominant Internet and online commerce vendors. The most likely outcome of the push to end the use of fossil fuels in home cooking, heating, and hot water is the demise of retail gas distribution and the gradual abandonment of the gas distribution network. Other existing technologies such as geothermal, thermal solar, heat pumps, and district energy systems tied to the electric grid will supply thermal energy through alternatives to gas.

As thermal gas customers move to renewable and clean energy, fewer and fewer customers will bear the growing costs of the thermal gas system. Aligning the new utility business model with the public interest to avoid a disproportionate impact on low-income and environmental justice communities will require vision, flexibility, and a sense of justice and fairness.

Given the need to accelerate action to meet greenhouse gas reduction targets and timelines at both municipal and state levels, implementing a strategy of triage and transition now will avoid stranded infrastructure assets and ensure an equitable shift to renewable energy.

## LEGISLATIVE MANDATES FOR TRANSITION

This strategy of triage and transition is laid out in state legislation currently under consideration. Aptly named the FUTURE Act (An Act for Utility Transition to Using Renewable Energy) H.2849/S.1940,<sup>148</sup> this bill supports many

of the recommendations listed throughout this report. It allows for gas company reform and provides for a managed transition away from gas to safer thermal energy systems by:

- Creating incentives and opportunities for gas companies to offer renewable energy
- Enabling towns to manage road construction and public safety by working more effectively with gas companies on repair and monitoring of gas leaks
- Strengthening the voice of municipalities at the Department of Public Utilities
- Providing towns with financial recourse for trees killed by gas
- Permitting towns to develop local energy services and infrastructure

This comprehensive look at the Massachusetts legal code for gas distribution enables the Commonwealth to envision a future that is safe and healthy, that protects the environment, and that encourages innovation in the best technologies to serve the public interest and public safety.

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<sup>147</sup> Conversation with Milton Bevington, energy financial analyst, August 13, 2019.

<sup>148</sup> Massachusetts Senate Bill 1940, <https://malegislature.gov/Bills/191/S1940>, accessed August 2, 2019.



# CONCLUSIONS



This report reveals that the underlying assumptions of the gas delivery system are faulty. It provides examples of how pipe materials fail on a regular basis, how the design of the system ensures single-point failures, and how gas can be unintentionally ignited. The report also describes the causes of leaks that trigger these incidents and outlines what can be learned from them, as well as what is lacking in official reports.

For immediate action to preserve and protect public safety, this report offers the Commonwealth—municipalities, utilities, state agencies, and regulators—specific recommendations that relate to current operations and system maintenance.

Longer-term safety, health, and climate protection require an orderly, cost-effective, managed transition from dependence on gas to a safer, cleaner, and more resilient system based on renewable energy, thermal technologies, and

energy efficiency. The report makes a compelling economic case for doing so and points to legislation that provides utilities with policies and incentives to shift how they source and deliver energy.

The stakes could not be higher to consider a triage and transition approach described here, for the current welfare of residents of the Commonwealth, for the health and safety of children as risks of climate change become reality, and for future generations.

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