The Benefits of using Monitoring for Natural Gas Leak Detectors

A white paper to assist municipalities as they consider implementation of National Fire Prevention Association NFPA 715, Standard for the Installation of Fuel Gases Detection and Warning Equipment, Compliant with UL Standard UL-1484

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Executive Summary

While not common, natural gas explosions can be devastating for residents and first responders. With the development of advanced, 10-year battery powered technologies to sense natural gas leaks without false positives, the National Fire Prevention Association has now created a standard for these natural gas detectors.

As Municipalities consider how best to implement this new standard, they must assess two critical issues for themselves: Must the devices be hardwired to power? Should the devices be monitored? The requirement for devices to be hardwired generally prevents existing housing to be part of the mandate and increases costs. As hardwired devices can still be offline because of power issues without anyone knowing the issue, they still account for 6% of fire deaths per year.[1] Monitored devices provide timely notification if a device goes offline for any reason; and during a gas leak they provide precise notifications to first responders of location and concentration of gas leaks allowing for safe, quick, and efficient remediation of gas leaks. They notify first responders within seconds, even if residents aren't home, and by giving the concentration of the gas within a residence, give fire fighters and utilities workers critical information about the chance the building is about to explode. Municipalities will need to balance these advantages against the cost.

With the technological advances to make small detectors capable of sensing natural gas leaks at early stages, are advances in cost efficient, wireless, monitored technologies, saving millions compared to traditional wired sensors.

This paper briefly explores the history of detectors, the advance of wireless technology and specifically, LoRaWAN technology, the benefits of monitored detection, the move of states towards allowing wireless technology and the move in New York State towards making all gas detectors monitored.

By permitting wireless technologies for mandated regulations, municipalities are easing the transition to smart building technologies, such as water leak detection and mechanical monitoring. These then help address other building issues such as mold, a leading cause for Asthma, improving indoor air quality, and monitoring a building's mechanical equipment. The relative low cost of these devices combined with the

[1] Smoke Alarms in US Home Fires, Supporting tables (nfpa.org)

savings due to early detection of common building issues, lead to lower repair and maintenance costs, lower insurance costs, and an increase in building values.

The History of Monitoring Alarms

The first fire alarm system[2] invented by Channing and Farmer in 1852 required a person to notice the fire, insert a key into a special fire alarm box and crank a handle. This would send a coded telegraphic message to a nearby alarm station which would then take the message to a nearby fire department.

In 1902, George Andrew Darby patented the first heat and smoke detector in Birmingham England [3]. His device used technology to sense what had previously required human eyes and noses.

Technology serves humankind by providing an always vigilant machine to watch for dangers and alert help. Because of the sensitivity of machines and swiftness of telecommunication response, dangerous conditions can often be nipped in the bud before the problems become more difficult to contain.

If Not Monitoring, at Least Hard Wiring or Long-Life Batteries

Balanced against the desire for rapid response is the cost of the implementation of technology. Though monitored fire alarm systems have existed since 1852, according to a 2004-2005 Consumer Products Safety Commission Report, only 12% of homes have smoke alarms connected to a home security service.[4]

Monitored systems have clear benefits for residents, property owners, and first responders, but the cost of running wires through existing apartment buildings is too great. New York City's last update to the smoke and carbon monoxide code, Local Law 157 of 2016[5], recognized this issue. While it required monitored smoke and carbon monoxide sensors for new buildings, except when covered by an automatic fire sprinkler system that notifies the fire department on activation[6], it does not require monitored systems in existing housing stock.

New York is not alone in compelling fire alarm systems in new construction, recognizing the dangers of fire in large buildings; but many states require smoke detectors to have a constant power source, [7]i.e., "hard wired" rather than relying on replaceable batteries which may go dead. To deal with this issue for battery powered alarms, states are requiring the batteries to be non-replaceable and have a 10-year life. However, states are recognizing the benefits of "low-power radio frequency wireless communications devices" as these devices will also notify the alarm monitoring company of a device going offline

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[2] https://www.lifesafetycom.com/the-history-of-fire-alarms/#:~:text=The%20first%20fire%20alarm%20system%20ever%20was%20invented%20way%20back,telegraphic%20key%20and%20a%20handle.
[3] https://www.mysmokealarm.org/smoke-alarm-history/#:~:text=Smoke%20detectors%20have%20been%20around,poison%20gas%2C%20but%20was%20failing.
[4] http://www.nfpa.org//-/media/Files/News-and-Research/Fire-statistics-and-reports/Detection-and-signaling/ossmokealarmstables.pdf
[5] ll157of2016.pdf (nyc.gov)
[6] CHAPTER 9 - 2008CC_BC_Chapter_9_Fire_Protection_Systems.pdf (nyc.gov)
[7] https://www.firstalert.com/us/en/legislation/#smoke

because of a dead battery or other issue. States are allowing these low-power wireless devices to be exempt of the 10-year battery. [8]

Is Now the Time to Consider Wireless Monitoring?

As New York City prepares to implement the code for natural gas detection devices as mandated by Local Law 157, a consideration should be made whether devices in new construction must be constantly powered via hardwire, or can these devices take advantage of the cost savings of wireless connectivity while being continuously monitored by a central monitoring station? Should New York city's existing stock continue to be battery powered, or is it time to begin to connect emergency warning devices directly to first responders, using new low-powered radio frequency wireless communications devices?

Connecting New York's housing stock to first responders will provide dramatic benefits in saving time and lives during emergencies; and is now much more fiscally possible as wireless technology has driven down the costs for installation and monitoring.

Low-powered Radio Frequency Wireless Communications Devices

Wi-Fi technology sends large amounts of data, such as video and audio, for short distances using considerable energy over free radio spectrum. Cellular technology sends large amounts of data such as video and audio longer distances but uses even more energy over a licensed radio spectrum (except CBRS spectrum local networks).

For the "Internet of Things" (IOT), it was necessary to establish a protocol to send much smaller packets of information in a way that was both energy and cost efficient. In 2009, two friends in France, Nicolas Sornin and Olivier Seller, began working on a technology using Chirp Spread Spectrum (CSS) modulation technology. This technology was used in sonar in the maritime industry and radar in aviation. Bats and dolphins also use it to detect insects and fish. Convinced of the long range and lower power capabilities of the protocol, Semtech, a technology manufacturer acquired their company, Cycleo, in 2012, and developed the use. In 2015, Semtech founded the non-profit LoRa Alliance, and the networking protocol was renamed LoRaWAN, standing for Long Range Wide Area Network.[9]

Unlike a mesh network, where individual end nodes may forward the information of other nodes before traveling to a signal booster and then back to a router to expand range, LoRaWAN end nodes communicate directly to multiple gateways. The gateways then communicate to a network server to process the information and remove duplicates. This simplifies the power requirements for the individual end nodes as power is only used to transmit or receive information specifically for that device. Device battery lives are now easily reaching 10 years utilizing the LoRaWAN protocol, and where a Wi-Fi enabled device may require a wireless router and a few boosters within a medium size apartment, LoRaWAN devices would typically require only one gateway every 3-5 floors, in a typical apartment building, with no need for signal boosters. This reduction in equipment, paired with a ten-year battery life, creates vital economies that make the Internet of Things possible.

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[8] https://www.firstalert.com/us/en/legislation/#power-source

[9] https://www.daviteq.com/blog/en/lorawan-technology-the-new-era-of-iot/

Because the typical LoRaWAN application sends packets of data a tenth the size of a text message and cannot transmit video or audio (alleviating privacy concerns), the technological demands are much simpler. While cell service and Wi-Fi have technology upgrades approximately every two years with advancements moving respectively from 1G to 5G[10] and from 802.11 to 802.11af[11], LoRaWAN's simple protocol has no expectation for a technology upgrade for 20 years.

As a result, LoRa devices running on LoRaWAN networks are being used to provide energy management, natural resource reduction, pollution control, infrastructure efficiency, and disaster prevention. Devices are being used in hundreds of uses cases for smart cities, homes and buildings, communities, metering, supply chain and logistics, agriculture, and more. Hundreds of millions of devices are connected to networks in more than 100 countries.

Natural Gas Detectors: Un-Monitored vs. Monitored

The National Fire Prevention Association (NFPA) created the national standard for gas detection devices: NFPA 715,[12] which refers to Underwriters Laboratory UL 1484 Standard for Safety Residential Gas Detectors[13]. Together the standards describe two types of gas detectors-- un-monitored and monitored. Un-monitored detectors simply sound an alert when the device detects a concentration of gas at 10% of the Lowest Explosion Limit (LEL). Monitored detectors sound a local alert as well, but also notify a Central Monitoring Facility upon reaching the concentration limit. In addition, the monitored version provides its location (for example, the kitchen in Apartment 21J at 230 Frederick Lewis Boulevard, New York), but also provides continuous updates on the gas concentration, as first responders move towards the emergency. Finally, the monitored version provides trouble signals when a device goes offline, or low battery, as well as providing a permanent record of gas leaks for governmental record keeping, research, and action.

The un-monitored device does not contact first responders but relies on residents or visitors to hear the alarm and notify the proper authorities.

As an example, Con Edison of New York has mounted a substantial public relations campaign to remind people to "Smell gas, act fast" and to evacuate and call 911.[14] Too often the smell of gas triggers people to investigate the smell themselves, call their building super, or assume others have reported it and do nothing. While the Fire Department's policy is to discover the cause of the gas leak, address the leak locally, and turn off gas service to the building only as a last resort, building managers have substantial concerns that if 911 and the utility are called for a gas leak, they may shut down the building's main gas service. While this concern may be unfounded, many building managers will report a reluctance to call 911 or the utility in the event of a gas leak for this reason.

In the case of an unmonitored smoke detector, which are common throughout the United States, when the fire department arrives, the location of the fire is often self-evident from smoke exiting the building. In the case of unmonitored carbon monoxide detectors, while the location can't be determined, the

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[10] https://www.cengn.ca/information-centre/innovation/timeline-from-1g-to-5g-a-brief-history-on-cell-phones/
[11] https://www.cablefree.net/wireless-technology/history-of-wifi-technology/
[12] https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=715
[13] UL Standard | UL 1484 (shopulstandards.com)
[14] Gas Safety | Con Edison

greatest risk of a CO leak is to any sleeping inhabitants in the apartment, and the local alarm should wake them.

However, in the case of gas leaks, particularly when the resident with the leak is not home, it can be difficult to hear the alarm and locate it. Currently, when notified of a gas leak, the fire department and the Utility must slowly walk through the floors with gas detection devices to locate the gas leak. As they search for the leak, the leak concentration can be building towards the 100% of the Lowest Explosion Limit, when entry into the apartment or switching on a light switch could cause an explosion.

With monitored gas detectors, the location of the alarming device is communicated to the resident, the building's management team, and the fire department so that action can be taken swiftly. Rather than searching for the apartment with the leak and hesitating before breaking through a door, all parties have the concrete knowledge of the location of the device sensing a leak and it's current, updated percentage of LEL. First responders arriving at a site can respond confidently, knowing the device in the kitchen in apartment 21J is reporting a leak, and with a 22% of the LEL, they can safely enter to turn off the gas and open the window.

While missing, disconnected or dead batteries were responsible for 79% of deaths from failed, unmonitored smoke detectors,[15] monitored gas detectors alert the central station, resident, and maintenance team of a loss of power or any other failure which breaks the communication chain.

Con Edison of New York's Natural Gas Detector Program[16]

After two catastrophic natural gas explosions causing multiple fatalities and numerous injuries in the New York City neighborhoods of East Harlem in 2014 and the East Village in 2015, Con Edison of New York sought natural gas detector technology that could be integrated with its Advanced Meter Infrastructure (AMI) communication system to provide continuous natural gas leak monitoring and early warning of potentially hazardous conditions. The program started as a pilot in 2018 and has since progressed to full scale deployment across Con Edison's service territory.

Con Edison's Natural Gas Detector (NGD) program prioritizes installation of NGD's near the gas service point-of-entry (POE) in basements, as opposed to dwelling living spaces, to guard against migration of outside gas leaks into basements through gas, electric, telephone, sewer and water POEs which could accumulate unnoticed and create a hazardous condition.

To date, over 160,000 NGDs have been incorporated into a monitoring network that covers parts of New York City and Westchester County. These NGDs have already identified more than 1,500 natural gas leaks, of which 18% originated from gas infrastructure outside the building. Con Edison's full deployment plan calls for the installation of a NGD at every gas service POE, or approximately 375,000 by the end of 2025.

Con Edison has stated "Gas leak alarm results have been accurate and reliable, initiating prompt response from our first responders and fire department personnel to mitigate potentially dangerous conditions."

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[15] Smoke Alarms in US Home Fires, Supporting tables (nfpa.org)

[16] In-Home Methane Leak Detection: A Case Study presented at Pipeline Safety Trust Conference, December 1 & 2, 2022. Hotel Monteleone, New Orleans, LA

This industry leading initiative has clearly demonstrated under real world conditions the public safety value of monitored gas detector technology.

The Fire Department

Calls for natural gas leaks are common. During these calls, fire fighter crews must slowly move through the hallways carrying handheld sensors to detect gas.[17] Because of imperfect sealing between apartments, gas may appear a distance from where the leak is, creating uncertainty.

The average fire department response times is 5 to 7 minutes[18] while the Utilities generally respond to the leak within 20-30 minutes when responsibility for the gas leak investigation is transferred to the Utility. Time spent by fire department crews attempting to locate the source of a gas leak when monitored gas detectors could provide apartment room level locational information is a distraction from being available for other calls, wasting resources and focus. If the cause of the gas leak is not identified, it leaves residents with the feeling that there is a gas leak, and the Utility and fire department did nothing.

Having solid, actionable evidence allows the fire department to respond swiftly and safely to the emergency, resolve it, and because of the permanent record keeping and ability to report to state agencies, an audit trail of the issue and the resolution of the issue.

States Recognize the Effectiveness of Monitored Low-Power Wireless Systems

Because missing batteries or battery failure account for 79% of deaths for failed smoke detectors[19], states are beginning to require detectors with 10-year, non-removable batteries. However, states with this battery requirement, [20] including New York, are allowing an exemption for low-power wireless communicating alarms, recognizing the effectiveness of low battery or failure alerts on wireless monitored systems such as home security systems. In addition, 6% of deaths for failed smoke detectors are attributed to hardwired power failure[21] and so some states, notably California and Florida, are allowing wireless detectors instead of hardwired powered detectors.

- Florida allows wirelessly interconnected and multi-sensor alarms to be exempt from the requirement for 10-year battery devices to replace hardwired alarms in Level 1 renovations and as battery operated solely smoke alarms.
- California requires all smoke alarms to either be hardwired, powered by a 10-year non-removable battery, or be wireless.

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[17] https://firefighternow.com/will-the-fire-department-check-for-gas-leaks/#:~:text=Yes%2C%20most%20fire%20departments%20will,by%20discussing%20gas%20leak%20risks.
[18] https://www.nyc.gov/site/911reporting/reports/end-to-end-repsonse-time.page

[19] Smoke Alarms in US Home Fires, Supporting tables (nfpa.org)
[20] https://www.firstalert.com/us/en/legislation/#power-source
[21] Smoke Alarms in US Home Fires, Supporting tables (nfpa.org)

- Florida allows battery powered devices to replace hard wired devices, if the batteries have a 10-year battery, but allow wirelessly interconnected alarms to be exempt for the 10-year requirement.
- Illinois requires hard wired smoke alarms for new construction, allows battery powered devices with a 10-year battery, but allows low-power radio frequency wireless communication signals, Wi-Fi or other Wireless Local Ara Networking Capability to be exempt from 10-year requirement.
- Indiana Indianapolis-Marion County requires hardwired alarms in all new construction. When a device is battery powered in existing building and the device uses low-power wireless communication, it is exempt from the 10-year minimum on battery life.
- Massachusetts requires hard-wired smoke alarms for all new construction and requires 10-year battery life for battery powered devices, except for low-power radio frequency wireless communication signals, Wi-Fi or other Wireless Local Area Networking capability.
- New York requires hardwired smoke alarms in all new construction. Battery powered smoke alarms must have a 10-year battery, unless the devices use low-power radio frequency wireless, in which case they are exempt.

LoRaWAN Networks for Gas Detection Sets Stage for Other Benefits

Contemporary office buildings and high-rise residential buildings are frequently managed using Building Management Systems (BMS). These hard-wired systems of sensors provide information regarding boiler and elevator function, water usage, gas usage, power usage, HVAC, and other mechanical operations. The systems are generally composed of hard-wired sensors with a computer server somewhere in the building, monitored by a trained operator. While the benefits are substantial, this system is employed in some recently constructed buildings but the expense to hardwire a building, install a local server, and provide a trained person to monitor the system is generally considered too expensive.

The technological advances of the Internet of Things, made possible by low-power wireless communication through LoRaWAN, allows low-cost sensors to be installed wirelessly throughout a building, connecting to Gateways every three to five floors. These systems are controlled by cloud-based software and by providing simple texts and voice mail alerts to serious conditions, remove the requirement for trained personnel on site. The benefits of these systems can easily outweigh the costs.

By installing the initial LoRaWAN gateways to serve monitored gas leak detectors, the infrastructure is in place to add whatever additional monitors a building might need including water leaks at sinks, toilets, laundry and air conditioning equipment; monitors for temperature, humidity, air quality, the presence of cigarette and THC smoke, monitors for boiler, exhaust fan and elevator operation as well as monitored mouse and rat traps. Door position monitors can increase security by notifying building management when entrance doors have been propped open and can increase fire safety by notifying building management when fire doors have failed to close.

These sensors can cost-effectively transform existing housing stock to “smart” buildings decreasing damage due to water leaks. In the United States the average damage sustained from a leak is $11,098[22]

[22] https://ipropertymanagement.com/research/water-damage-statistics

and in New York's luxury market the average is $55,000.[23] Early water leak detection reduces mold. Mold is the source of 21% of all Asthma cases.[24] Rooftop exhaust fan failures also contribute to high humidity levels in bathrooms, leading to mold. The federal government seeks to monitor mold, heat, elevator operation, and rodent infestations in public housing with clear record keeping. Low-power wireless networks allow sensors for all these issues and the record keeping that aids in accountability and action.

Early notification of water leaks catches the first drip from a corroding pipe, rather than a collapsed ceiling a floor below, days later. Monitored rodent traps allow for the extermination of rodent families over a period of hours, rather than the ineffectual trapping of a single rat when the exterminator arrives. These advances improve resident satisfaction, improve the reputation of buildings, and provides solid economic return for the building owners, whether landlords are commercial or residential owners.

Value is Improved by Transition to being a "Smart Building"

A building's value is a simple calculation of its Net Operating Income (NOI) divided by its Cap Rate.[25] The Net Operating Income is the amount of rent collected less the cost to operate the building, including its mortgage cost. The Cap Rate depends on the market value of the property with the Cap Rate going down as the property is perceived as being more valuable.

Adding a sensor network to a building cost effectively will improve the market value of the property by decreasing maintenance & repair costs, while also decreasing insurance premiums to improve the NOI of the building while potentially improving the Cap Rate by decreasing the "riskiness" of the investment and increasing its desirability among residents to have a well-managed building.

Environmentally, natural gas leaks from stoves and driers account for as much global warming as 500,000 cars[26]. Monitored natural gas detectors will naturally alert maintenance staff of leaks and reduce this negative environmental impact.

Socially, reducing mold occurrences by improving response for water leaks and exhaust fan malfunctions will decrease asthma rates. Asthma disproportionately affects lower income people, largely because many live in undermaintained, aging housing. Monitored sensors increases the ability to cost effectively maintain aging housing, extending its life. Installation of monitoring in buildings creates entry level technology jobs with opportunities for advancement. Gas detection will lead to better indoor air quality for residents and increased safety for residents and first responders when there is a gas leak.

Compliance with Potential Future State Regulation

[23] https://www.chubb.com/us-en/individuals-families/resources/5-questions-to-help-you-prevent-water-damage-in-your-home.html
[24] https://pubmed.ncbi.nlm.nih.gov/19230464/; realtimelab.com
[25] https://www.investopedia.com/terms/t/terminal-capitalization-rate.asp#:~:text=The%20terminal%20capitalization%20rate%2C%20also,to%20get%20the%20terminal%20value.
[26] https://news.stanford.edu/press/view/42487#:~:text=A%20new%20Stanford%2Dled%20study,about%20500%2C000%20gasoline%2Dpowered%20cars.

In 2021, New York State Senator Leroy Comrie, representing the 14th District in Queens and Chairman of Committee on Corporations, Authorities, and Commissions introduced "State Law 3705 Requiring Combustible Gas Detectors in Certain Structures."[27] A feature of the bill was that all gas detectors

> *Shall further be equipped with technology enabling such devices to automatically report the occurrence of each gas leak detected by such devices to the company providing gas to the dwelling in which such device is located.*

And that

> *Standards for the reporting of gas leaks reported via automatic transmission to a gas company by a gas detector by such gas companies. Provided, however, that such standards shall require a gas company to issue an annual report detailing the number of leaks received in a calendar year disaggregated by county.*

It is expected that the law will be reintroduced in the 2023 session with leak reports being transmitted according to Underwriters Laboratory guidelines to resident, building management, and 911 or fire departments who would in turn notify the Utilities.

Conclusion

As municipalities consider the implementation of natural gas detection to stand alongside the innovations of smoke and carbon monoxide detectors, they should also consider including future technological innovations as part of new legislations. The low-cost benefits of using monitored natural gas alarms is significant.

Deploying detectors using a LoRaWAN network, is a non-invasive and cost-effective solution for existing and new housing. Monitored gas detectors increase safety for first responders and residents, reduce natural gas leaks, while providing environmental benefits, and provide for additional safety against battery and equipment failures. By allowing wireless monitored systems, additional benefits are realized, which increase building values and reduce operating costs.

John Rusk is a construction professional and has taught Residential Construction Management at Columbia University's School of Professional Studies for the past 15 years. He is the founder of ProSentry, a building monitoring company using the power of LoRaWAN to cost effectively provide building managers and first responders the tools to manage problems while they are small while increase building value. He is also the founder of Rusk Renovations, a 35-year-old construction firm in New York City and is the founder of Constructive Decisions, a 25-year-old construction dispute resolution firm.

Marc Huestis is a utility industry professional with nearly 40 years of experience, including nuclear and fossil power plant operations as well as project management, construction and operation of electric and natural gas distribution and transmission systems. He served 13 years in executive leadership positions including nearly 7 years as the senior executive of Con Edison of New York's natural gas utility business. He is currently the principal of Huestis Consulting LLC.

[27] https://www.nysenate.gov/legislation/bills/2021/S3705

Ron Lazarus understands the products that keep people and communities safe. Safety alarm leaders New Cosmos USA, Firex, and Universal Security Instruments have relied on Ron for his vast international sales, regulatory and manufacturing operations expertise. Ron currently serves on the Boards of Global Midwest Alliance and previously the U.S.-India Chamber of Commerce – Midwest, demonstrating his dedication to cooperation, growth, and innovation through education on a global scale. After leading several successful businesses throughout the past 35 years in industries ranging from life safety products to cutting-edge drone and IoT technology, Ron now serves as the COO of New Cosmos USA, committed to saving lives by encouraging the utilization of natural gas alarms.