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Quantifying Emissions of Natural Gas Storage Tanks in the Greater Los Angeles Metropolitan Area

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A Research Report from the National Center for Sustainable Transportation

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16. Abstract

Natural gas provides an alternative to petroleum-based fuels as an energy source that is being more widely adopted across multiple sectors in California. The viability of natural gas depends on its total life cycle emissions, specifically of those of methane. This paper addresses the possibility of and reason for fugitive emissions of methane from the transportation sector by surveying and quantifying methane plumes from compressed natural gas (CNG) and liquified natural gas (LNG) storage tanks at vehicle fueling facilities in the greater Los Angeles metropolitan area. This project used methane plume images provided by airborne imaging spectroscopy, collected by NASA's AVIRIS-NG mission, to identify large methane point sources originating from CNG and LNG infrastructure. The periodic methane plume observations were converted into emission rates to provide an estimate for potential methane emissions from NG storage facilities across California. For the population of facilities that were analyzed, four had natural gas storage tanks with emission rates that are higher than the maximum rate specified by the tank manufacturers. The significant disparity between the expected emission rate and the actual emission rate can be explained by tank malfunction, as the number of observed plume events are far higher than what would be expected for a fully operational tank. If the tank malfunction rates found in the group that was analyzed were applied to the entire population of California CNG and LNG facilities, total emissions may be up to 1300 kg CH_4 per hour, suggesting a need for leak monitoring and repair to prevent excessive methane emissions from this sector.

17. Key Words
Natural gas, methane emissions, compressed natural gas (CNG), liquified natural gas (LNG), greenhouse gas emissions

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Disclaimer

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Quantifying Emissions of Natural Gas Storage Tanks in the Greater Los Angeles Metropolitan Area

A National Center for Sustainable Transportation Research Report

January 2025

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TABLE OF CONTENTS

List of Figures

Quantifying Emissions of Natural Gas Storage Tanks in the Greater Los Angeles Metropolitan Area

Introduction

Over recent decades, natural gas production has been increasing in the United States as a result of technological advances in the methods and materials required for shale gas extraction [1]. Natural gas has a high methane (CH_4) content, ranging between 90% and 95% [2], so leakage of natural gas to the atmosphere is an environmental concern due to its climate and air quality impact. CH_4 has a global warming potential (GWP) greater than that of carbon dioxide over the short term [3], and reducing CH_4 emissions is considered to be an important near-term action to reduce climate warming, as exemplified in policies such as the 2021 Global Methane Pledge. However, most greenhouse gas reduction policies in the transportation sector focus on CO_2 emissions.

Transportation is the largest single source of California's greenhouse gas emissions, accounting for 55% of statewide CO_2 emissions in 2021 [4]. Natural gas fueled vehicles emit 30% fewer CO_2 emissions than those fueled by petroleum-based liquids (e.g., gasoline, diesel) in internal combustion engines [5]. The higher efficiency with respect to CO_2 emissions, as well as the falling price of natural gas, have increased the use of natural gas as fuel for heavy duty trucks and buses. More recently, biogas supplies have also been used as a low carbon vehicle fuel in California. However, CH_4 has a high global warming potential, so the risk of leakage of CH_4 in vehicle use of natural gas must also be assessed to fully account for the effect of this fuel switch on emissions of greenhouse gas and criteria air pollutants. In order to quantify the total emissions of CH_4 in the natural gas supply chain for vehicles, emissions at the liquefaction, storage, loading/unloading, regasification, and end use stages need to be understood. The focus of this paper is on CH_4 emissions from storage of natural gas fuels in storage tanks in the greater Los Angeles area of Southern California.

Background

Urban areas, such as the greater Los Angeles megacity, have been at the forefront of policies and practices to reduce air pollutant emissions due to longstanding air quality issues. One of these strategies has been to encourage the use of natural gas as a vehicle fuel, given that it emits less criteria pollutants than diesel or gasoline powered vehicles [6]. While natural gas has increased in popularity as a vehicle fuel due to climate and air quality concerns, this increase has been concentrated amongst municipal vehicle fleets for which natural gas fuels can be provided in corporation yards and is not limited by a paucity of natural gas fueling stations. For example, the use of natural gas for transit buses has increased in recent decades in the United States; from 2007 and 2019, there was an increase from 15 to 30% of all transit buses fueled by natural gas [7]. In California, a move towards low carbon fuels, including natural gas, by governmental entities has encouraged this increase. In addition to transit vehicles, there has been increasing use of natural gas powered vehicles in waste collection municipal truck fleets

[8]. Similar to transit buses, waste collection trucks are good candidates for natural gas fuels, as they are heavy duty vehicles housed in municipal yards where natural gas fuels may be easily available in contrast to heavy duty vehicles traveling long distances. As of 2021, there were roughly 14,000 natural gas powered heavy duty trucks in California [9].

Despite the purported climate and air quality benefits of a switch to natural gas fueled vehicles, there is a risk that a switch to natural gas may perversely increase radiative forcing because fugitive CH_4 emissions may outweigh reductions coming from tailpipe CO_2 production [6]. CH_4 is a powerful radiative forcing agent, with a global warming potential ~80 times greater than CO_2 per molecule of carbon over a 20 year timescale. In addition, CH_4 contributes to air pollution as a precursor to the formation of ground level ozone, which is a criteria air pollutant with significant positive radiative forcing. Mitigation of methane is considered a key driver for near-term climate change, and due to its relatively short atmospheric lifetime, and has been targeted for reductions in California and globally. Recent efforts toward identifying large CH4 leaks as targets for mitigation have been used to justify the technical feasibility of CH_4 mitigation [10]. Many of these large CH_4 leaks have been identified to be fugitive emissions from natural gas production and transportation. In fact, fugitive CH_4 emissions are thought to constitute >90% of CH_4 emissions from the natural gas powered vehicle life cycle [6]. Much work has been done to understand CH_4 emissions in oil and gas production; however, less is known about emissions during storage and transfer to the end user. Natural gas is stored and dispensed either as compressed natural gas (CNG) or liquified natural gas (LNG), both of which require tank storage at the site of a fueling station. For compressed natural gas (CNG), gas must be compressed, then stored under pressure in a fuel tank, then dispensed. For liquified natural gas (LNG), which is 660 times less dense than its gaseous form [11], gas must be liquified and maintained at cryogenic temperatures for long periods of time. When LNG is heated past its boiling point at atmospheric pressure by conductive heat transfer through the storage tank wall, boil-off gases are produced. These boil off gases increase tank pressure, which must be managed to maintain tank integrity. Different storage tank designs implement different methods of managing the boil-off gases. In the case of tanks built to International Organization for Standardization (ISO) standards, boil-off gases are vented to the atmosphere. The amount of time that a tank can hold cryogenic liquid before requiring venting is known as the holding time. For standard 40-foot ISO tanks, rated holding times can be as high as 60 days in the case of Taylor-Wharton and HTAW [12] with a maximum evaporation rate of less than 1%/day. Trans World Equipment Corps manufactures a 40-foot ISO standard LNG tank with a rated boil-off rate (BOR) of 0.17%/day, and a rated hold time of 50 days at 90%. These tanks are designed to vent excess pressure under certain conditions; however, it is also possible that they can malfunction and leak excessively. Some sources of emissions from LNG segments of the natural gas supply chain are wear and tear on the equipment [13], expected venting designed as part of a process, or venting to prevent overpressure. Previous observations of leaks at CNG fueling stations from ground and airborne surveys suggest that there are very likely to be significant fugitive CH_4 emissions from storage tanks [6, 10]. Determining the existence of large fugitive CH_4 emissions from natural gas storage tanks is critical for maximizing the benefit of municipal natural gas fleets for climate and air quality purposes, particularly given that most lifecycle assessments of well-to-wheels emissions from natural gas powered vehicles neglect emissions from storage tanks [6].

New advances in airborne imaging spectroscopy provide a new opportunity to assess the actual leak rate of natural gas storage tanks in practice. NASA's Airborne Visible/InfraRed Imaging Spectrometer-Next Generation, abbreviated AVIRIS-NG [10, 14], is an airborne platform that has been flown extensively over the past decade in the greater Los Angeles region, and can image individual CH_4 plumes down to scales of ~1 m. These observations enable attribution of CH_4 plumes to emitting infrastructure, such as storage tanks, and quantification of instantaneous CH_4 emissions from large point sources with addition of estimated wind speed. Assuming most natural gas storage for vehicle usage takes place at natural gas fueling stations, this leads to a finite number of targets for survey. According to the Vista-LA methane infrastructure inventory [15], there are 109 CNG and 27 LNG fueling stations in the greater Los Angeles region.

Previous observations of methane plumes from LNG tanks by airborne imaging spectrometers suggest that natural gas leaks from storage tanks may be emitting methane at a higher rate than estimated using tank specifications provided by manufacturers. Due to the similarity between the design of storage tanks and the ISO tanks used for transportation of LNG, any differences between the rated emissions and actual emissions in storage tanks may have implications for transportation tanks as well. In this section, we investigate the occurrence of methane plumes from CNG and LNG facilities in Southern California by analyzing AVIRIS-NG observations and modeling expected emissions derived from the characteristics of LNG storage tanks. We hypothesize that the frequency of methane plume detections in airborne observations exceeds the anticipated rate from properly functioning tanks, leading to higher-than-expected greenhouse gas emissions from the use of natural gas as a vehicle fuel. Our goal is to understand the frequency of large fugitive CH4 emissions from natural gas fueling stations, and to identify methods for rapid detection and leak repair that can be helpful for municipalities and other entities in charge of natural gas fueling to reduce emissions.

Methods

Methane Emissions Data from Airborne Plume Imaging

We obtained methane plume observations from NASA's Airborne Visible-InfraRed Imaging Spectrometer-Next Generation (AVIRIS-NG) for 2016-2018. In brief, AVIRIS-NG was flown aboard aircraft extensively over California, and clutter matched filter retrievals were performed on hyperspectral spectroscopic data to detect methane plumes in the environment [14]. These methane plume images were combined with reanalysis wind products to estimate an instantaneous source emission rate given in units of kg CH_4 hr^{-1} [10]. Based on previous work, the rated detection limit of this instrument is ~10 kg CH_4 hr^{-1} [10]. Methane plume observations and estimated emissions were downloaded from the Carbon Mapper data portal (https://carbonmapper.org/data).

The domain of our study included the greater Los Angeles region, encompassing the urban portions of Los Angeles, Riverside, Orange, San Bernardino, and Ventura counties. First, we obtained all flight lines flown within our domain, including plume observations and non-detects. We defined plume observations and non-detects from NG infrastructure by intersecting the AVIRIS-NG flight lines with the NG layer from the Vista-LA infrastructure dataset. Vista-LA is a methane source location database sorted into the energy, agriculture, and waste sectors, containing over 33,000 potential methane emission sources [15]. The NG layer includes geolocated polygons representing the extent of all CNG and LNG fueling stations in the domain. Methane plumes detected by AVIRIS-NG that fall within the boundary of a fueling station polygon were attributed to that station. Overflights over NG station polygons where no plumes were observed were considered to be non-detects, or emissions equal to 0, with insignificant methane emissions detected. The frequency of emissions from an individual fueling station was defined as the number of overflights over a given station with plume observations divided by the total number of overflights.

First, each California LNG source was checked for overlap with any flight lines using the ArcGIS spatial search tool. The polygons that define each LNG source are from the Vista CA spatial layer provided by Hopkins et al [16]. Each flightline that overlapped a source was checked in the list of plumes provided in Thorpe et al. [17]. If the flightline name appears in the plume list, and the plume's latitude and longitude fall within the polygon of the NG station, that plume is attributed to the NG source and recorded as a plume. If the flightline does not appear in the plume data, or the plume coordinates fall outside the source boundary, the source does not have any plumes attributed to it from the flightline. The total percentage of flights where a plume was observed is then calculated for each flown source. This is necessary to determine how many of the tanks have observable plumes out of the entire set of storage tanks in the greater Los Angeles area. In order to aggregate all emissions and scale to the full LNG tank population, a scalar must be determined using the ratio of total number of LNG sites to the total number of flown LNG sites [15]. Finding the scaling factor using this method is only valid for normally distributed data, however.

Estimating leakage rate from LNG storage tanks

We estimated the expected boil off methane emissions from standard LNG tanks in the same units as given above using the dimensions of LNG tanks with the methane content of LNG. We assume an LNG methane content of 100% and calculated the volume of the tank to estimate the daily boil off rate using the 1% maximum evaporation loss per day and converting to kg of methane per hour assuming constant emission in time. This estimation method does not yield the exact boil off rate for each tank, but should be comparable to atmospheric emissions observations if the rated daily evaporation loss is accurate. The remainder of the analysis compares these calculated boil-off rates with the methane plume observations from airborne imaging.

Estimated Holding Time of LNG Tanks

In order to understand whether the observed methane plumes from NG tanks described previously may be due to normal tank venting behavior, we calculated the probability of a plume observation given different possible holding times. The real holding time of an LNG tank must be determined in order to compare the value to the rated holding time listed by the manufacturer. To estimate the real holding time, the probability of observing k venting events given a holding time of N_h must be calculated, then compared to the actual number of observed venting events. For a tank that experiences a number of venting events each lasting for a length of time N_t [18], measurements are taken over a period of time N_m, with N_s representing the number of samples taken over the measurement period. The time period N_m is divided by N_t to give N_w, the number of time steps of length N_t in the measurement period. N_{ht} is defined as the number of time steps of length N_t in the holding time N_h, found by calculating N_h/N_t. N_w is then rounded to the nearest multiple of $N_{ht}+1$. The number of venting events, N_p, is determined by $N_w/(N_{ht}+1)$.

The probability of observing k number of venting events is found as $P_{k,s}= N_{pk}/N_{pt}$, where N_{pk} is the number of possible ways of observing k venting events and N_{pt} is the number of possible ways of observing all numbers of venting events. $P_{k,s}$ is a function of N_w, N_h, N_s, and k. The possible ways to observe k = 1 venting events is calculated by

$$N_{pk} = C_k^{N_p} \times C_{N_s-k}^{N_w-N_p} \qquad \text{Eq. 1}$$

And N_{pt} is calculated by

$$N_{pt} = \sum_{k=0}^{k_{max}} C_k^{N_p} \times C_{N_s-k}^{N_w-N_p} \qquad \text{Eq. 2}$$

If a source has an n number of tanks on site, $n \times N_p$ is used instead of N_p.

Results

Tank Leaks Observed from Airborne Methane Plume Imaging

118 NG stations were flown, and 5 had methane plumes measured by AVIRIS-NG at least 1 time (Table 1). Emissions from individual plumes ranged from 51 to 972 kg of methane per hour. Plume emissions had a highly skewed distribution, with a few very large plumes (e.g., three plumes > 400 kg methane per hour).

Frequency of plume occurrence ranged from 0%, with the vast majority of flights having no plumes even in the case of multiple overflights, to 33% for the site observed to be emitting most frequently (Figure 1). Most of the NG station overflights, for 113 stations, had no observable methane plumes at all. Even for the 5 stations that had measurable methane plumes, most flights did not have observable methane emissions using this technique; for 56 overflights over these 5 stations, only 10 flights revealed measurable (i.e., > 10 kg methane per hour) methane emissions by this technique. These non-detects were considered as zero emissions, and when included in the average emissions for these 5 sites, estimated average emissions ranged from 52-75 kg methane per hour (Table 1).

Table 1. Airborne methane plume surveys and observations from AVIRIS-NG 2016-8

Source number	**Site**	**Latitude, longitude**	**$N_{flights}$**	**N_{days}**	**N_{plumes}**	**Max. emissions (error)** kg CH_4 h^{-1}	**Mean emissions (std. dev.)** kg CH_4 h^{-1}
S00686	Clean Energy Port of Long Beach	33.7832ºN, 118.2219ºW	22	12	5	488 (167)	52 (140)
S00645	Harbor Division LNG	33.7969ºN, 118.2491ºW	13	9	1	972 (632)	75 (270)
S00647	LAX LNG	33.9401ºN, 118.4253ºW	15	7	2	625 (145)	53 (165)
S00295	Clean Energy Whittier	34.0235ºN, 118.0344ºW	4	3	1	257 (62)	64 (129)
S00102	Clean Energy	33.9950ºN, 118.1521ºW	2	1	1	139 (37)	70 (98)

Probability of tank emissions given normal operations, considering rated holding times

For the five sites where plumes were observed, tank dimensions were estimated from high resolution satellite imagery from Google Earth or ground photos from Google Street view (Figure 2 through Figure 5). Using manufacturer's specifications and observed tank shape and sizes, we estimated the volume of each tank. Assuming methane is 100% of the contents, we also assumed the methane content of each tank in kg.

We then calculated the probability of a plume observation given different possible holding times. Assuming each venting event lasts for 15 minutes, for holding times of 0.5, 1, 7, and 14 days, by far the most probable outcome, given proper tank operation, was that there would be no plume observation (Figure 2b through Figure 5b). The probability of observing one venting event was below 20% for all sources only for very low holding times of 0.5 and 1 day. Given that the average rated holding time for the ISO tanks is 50 days, there is very low probability of a leak observation occurring due to regular boil off gas maintenance as expected. This contrasts greatly with the observation of two venting events in one day for one source (Figure 2).

We then compared the observed emission rate over time by averaging plume values for each station multiplied by the source's plume frequency, to account for non-detects (Table 1), with a continuous estimated 1% loss of methane from each tank given the tank's methane content as inferred from imagery. In 4 out of 5 sites with observed plumes, the averaged observed emissions greatly exceeded the possible emissions from a 1% leakage of gas (Figure 6).

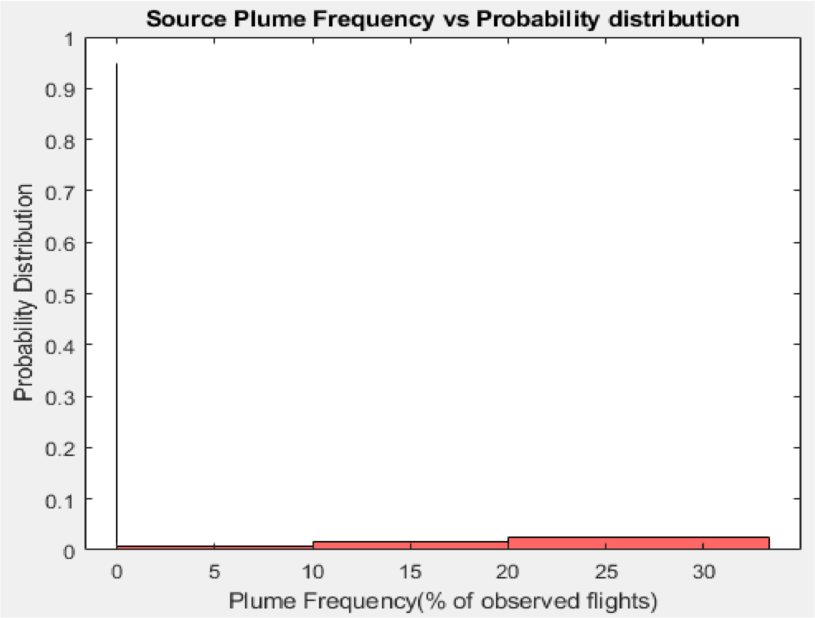

Figure 1. Probability distribution of Plume Frequency, which is the percent of flights where a plume was observed

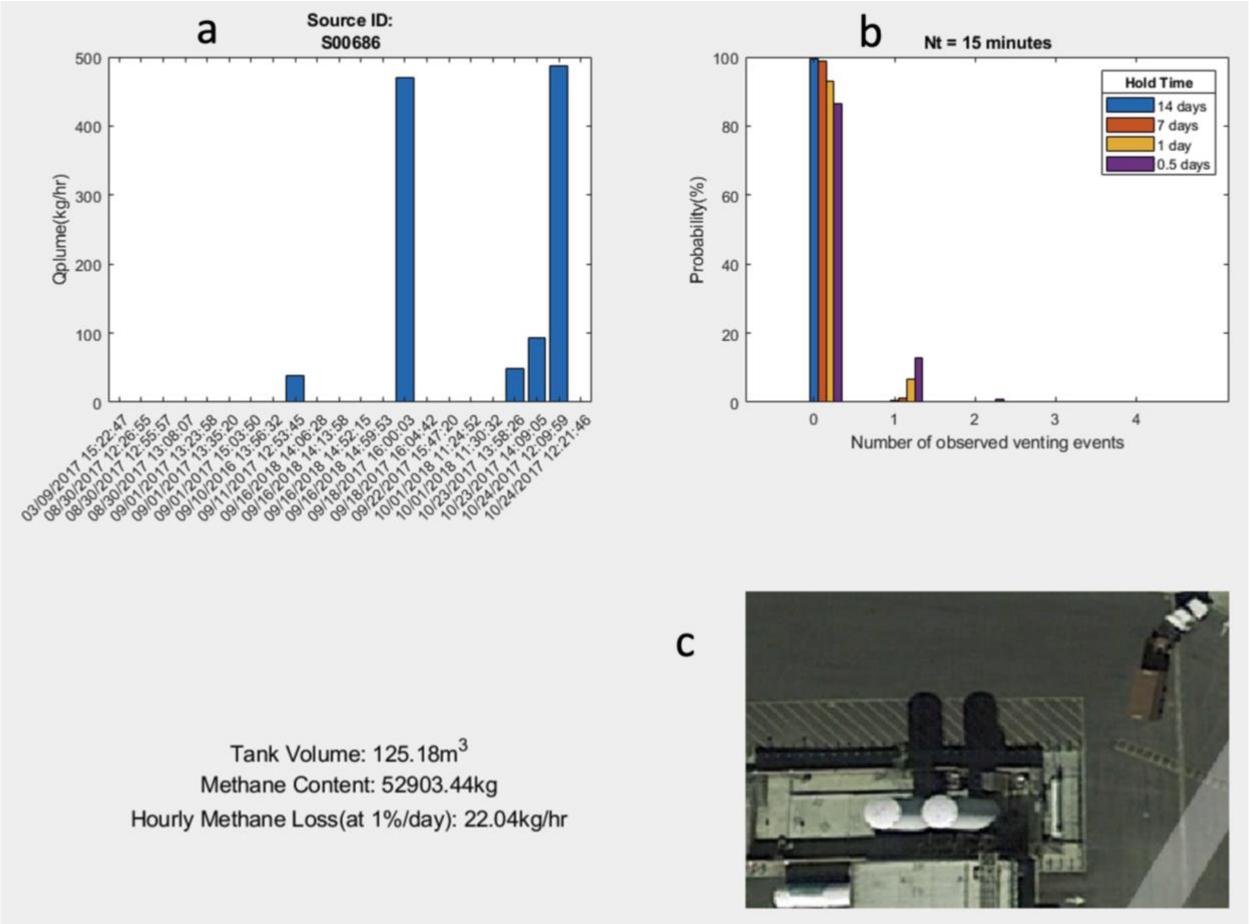

Figure 2. Long Beach Clean Energy CNG fueling station. (a) Dates of overflights and methane plume observations by emission amount. Empty spaces on the horizontal axis denotes a flight over the source where no plume was observed. (b) Probability of observable venting event given different estimated holding times. (c) Google Earth image of NG storage tanks at this site.

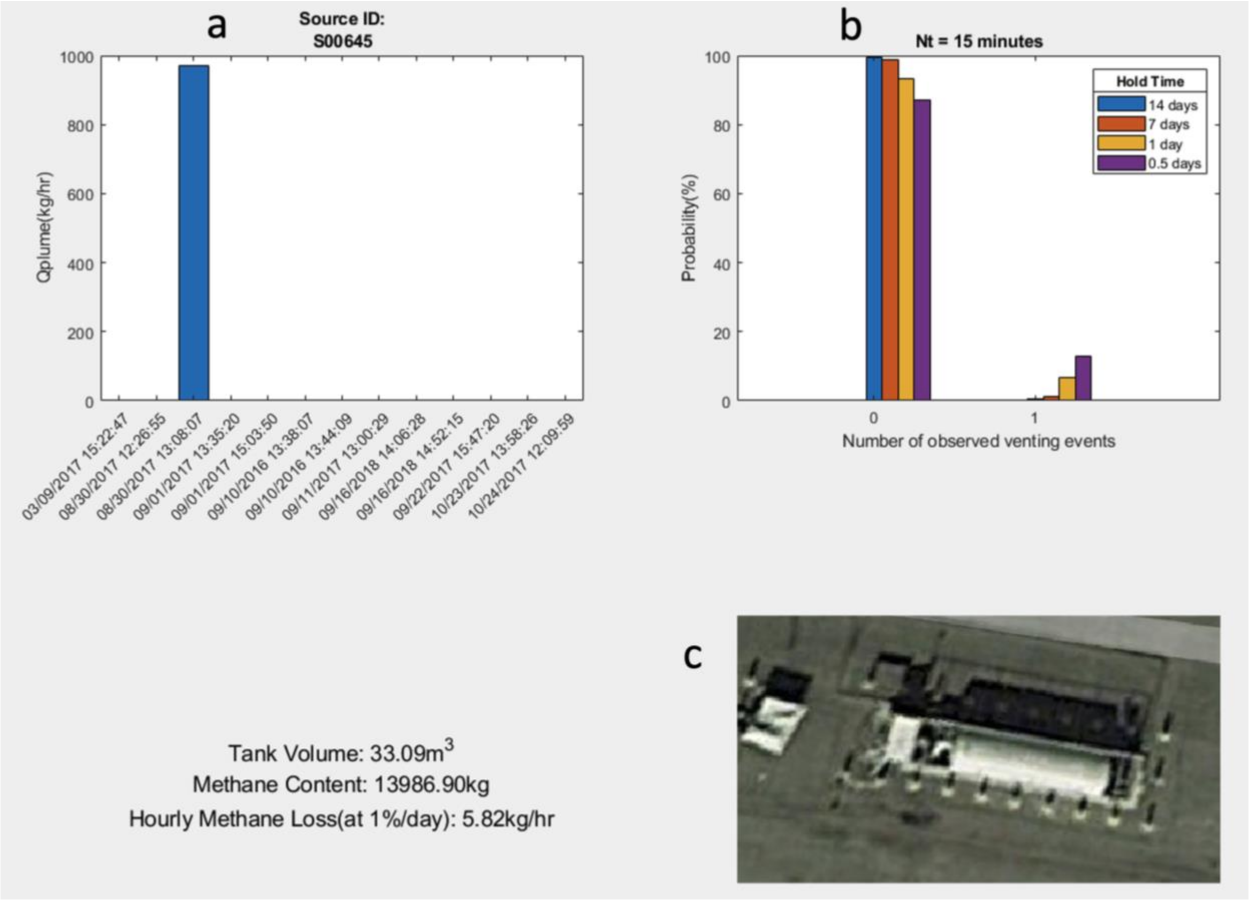

Figure 3. Harbor Division LNG Tank. (a) Dates of overflights and methane plume observations by emission amount. Empty spaces on the horizontal axis denotes a flight over the source where no plume was observed. (b) Probability of observable venting event given different estimated holding times. (c) Google Earth image of NG storage tanks at this site.

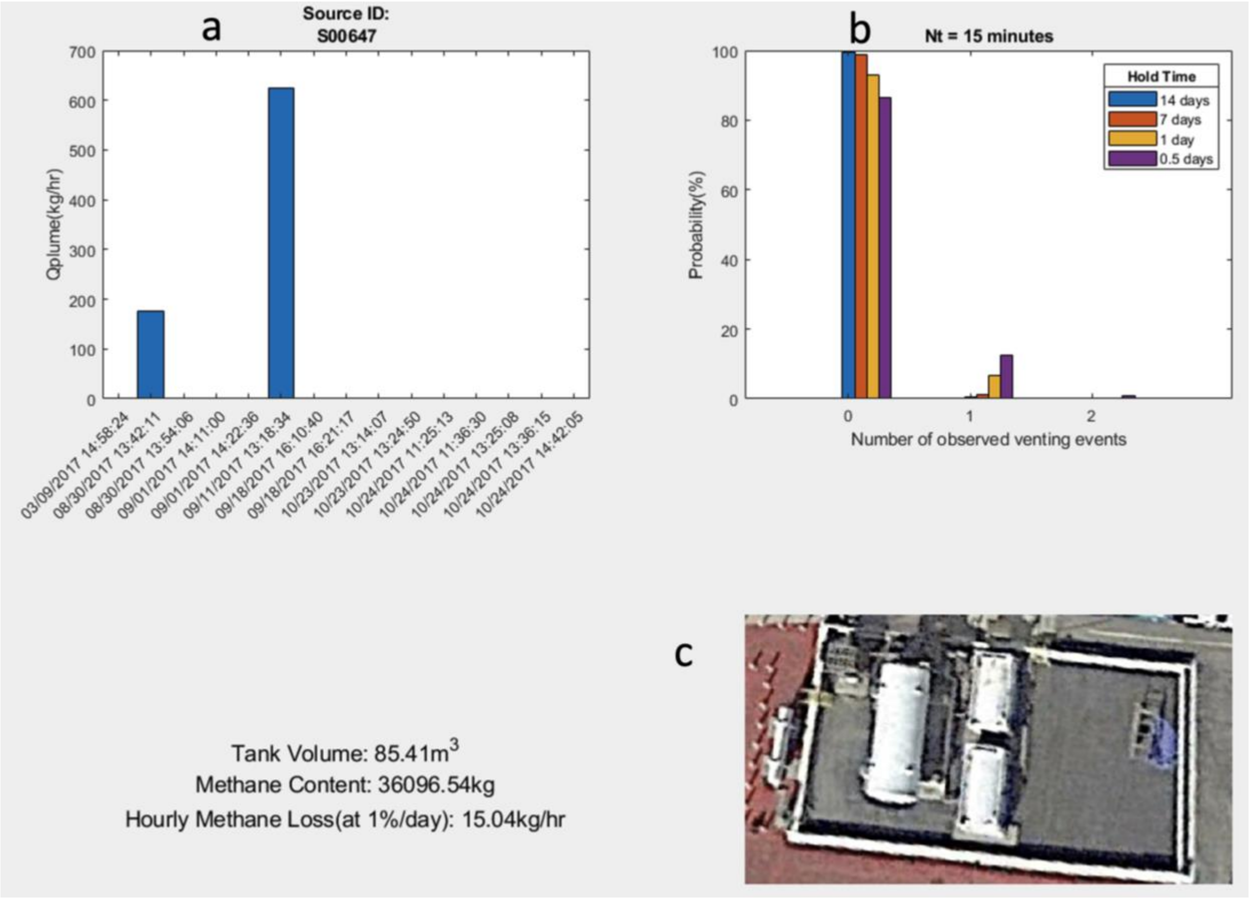

Figure 4. Los Angeles International Airport. (a) Dates of overflights and methane plume observations by emission amount. Empty spaces on the horizontal axis denotes a flight over the source where no plume was observed. (b) Probability of observable venting event given different estimated holding times. (c) Google Earth image of NG storage tanks at this site.

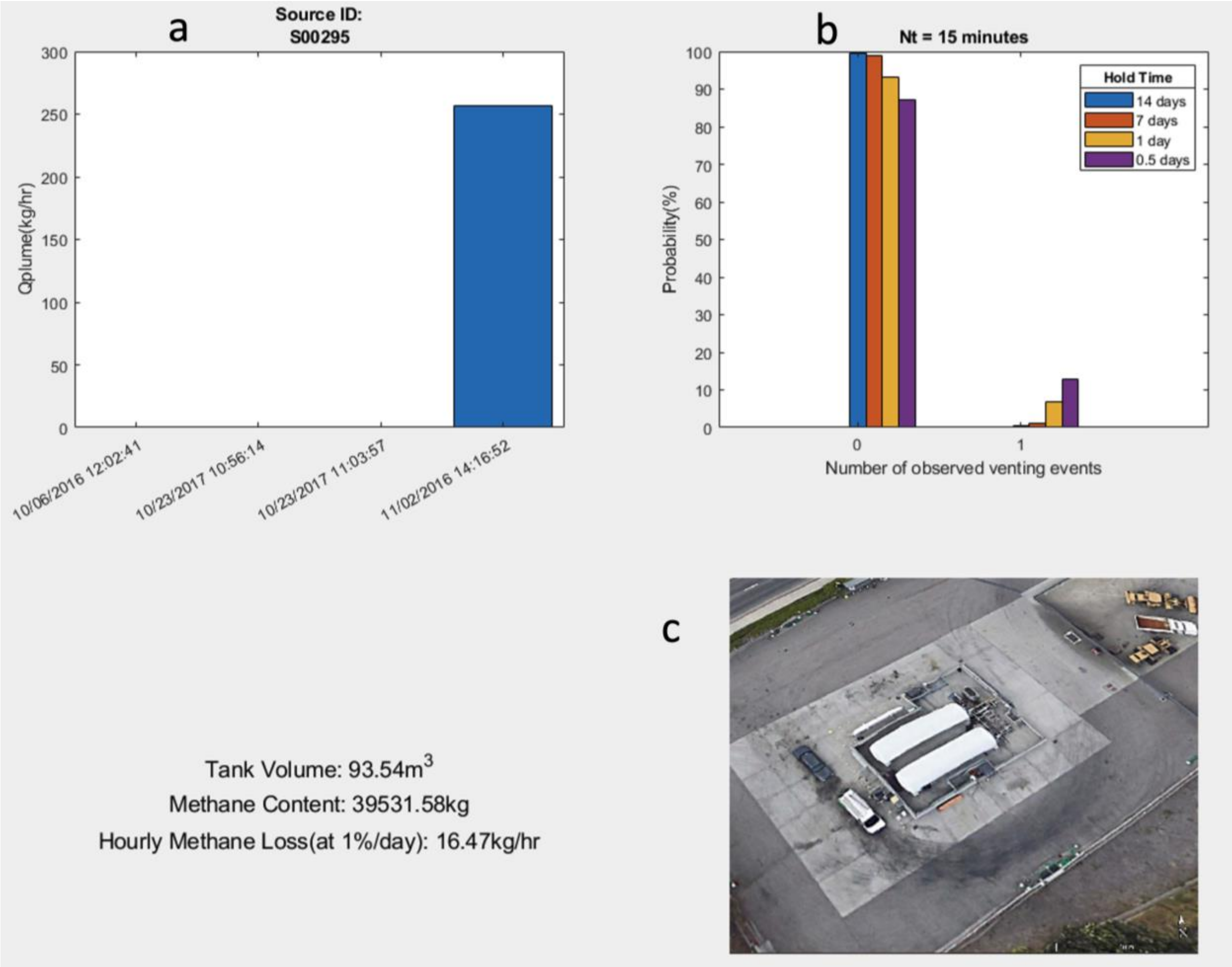

Figure 5. Clean Energy Fuels- Whittier. (a) Dates of overflights and methane plume observations by emission amount. Empty spaces on the horizontal axis denotes a flight over the source where no plume was observed. (b) Probability of observable venting event given different estimated holding times. (c) Google Earth image of NG storage tanks at this site.

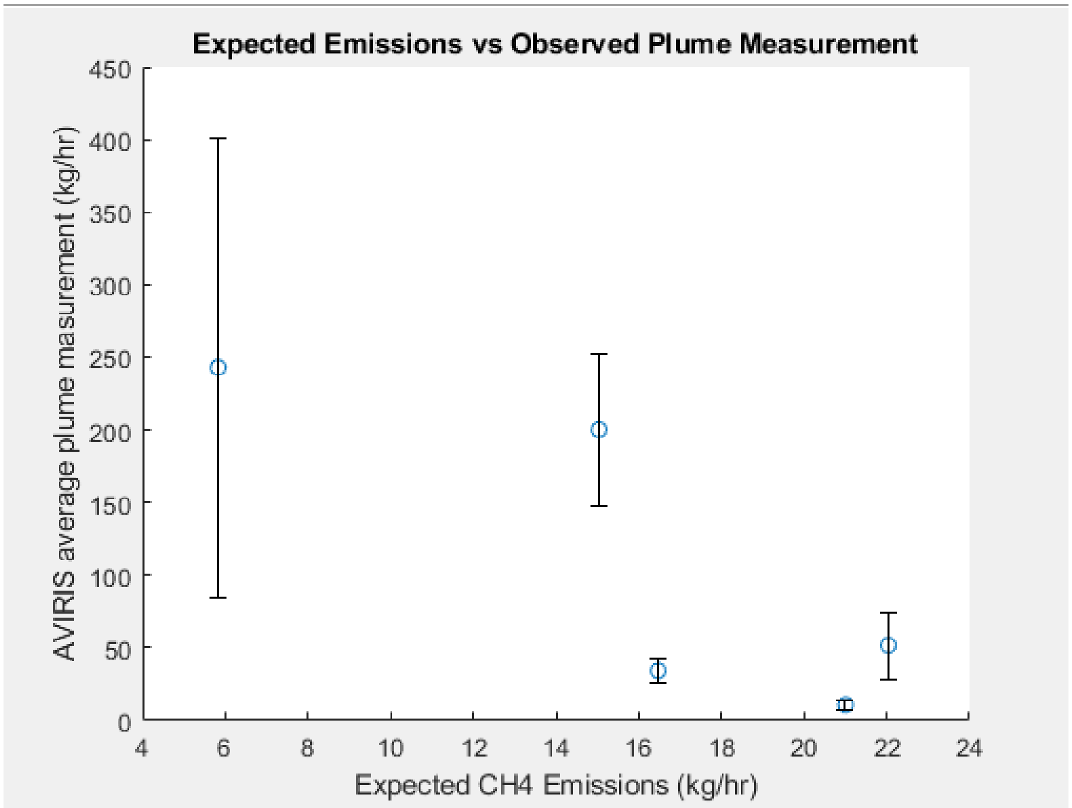

Figure 6. AVIRIS plume data was averaged for each source and multiplied by the plume frequency of that source, giving an equivalent continuous emission rate, plotted against the expected emission rate.

With only 118 fuel stations having been flown over by AVIRIS-NG, there are still 145 NG fueling sites in the Vista-LA database that were not flown and could possibly be emitting methane. Calculating the scaling factor by dividing 263, which is the total number of LNG sites, by 118, which is the total number of sites with one flight or more, results in 2.22. Multiplying each source's average plume measurement by the scalar and summing all average source values results in a total combined emission rate for all LNG sites to be 1,293 kg/hr. Conducting a bootstrap analysis with 10,000 iterations on the average emission data to determine a 95% confidence interval yields a result of between 314 and 2100 kg CH_4 hr^{-1}. The sum of emissions has a standard error of 337 kg CH_4 hr^{-1}.

Discussion and Conclusions

Most observations of LNG tanks on the sites of NG fueling stations did not have observable emission plumes using the method of airborne imaging spectroscopy, which is capable of detecting point source methane emission greater than 10 kg of methane per hour. However, for a minority (~4%) of sites, methane emission plumes were detected at least once, and in two cases, more than once. We investigated the possibility that these leaks could be due to regular venting of boil off gases, but this is highly unlikely unless the tanks have a very short holding time roughly 2 orders of magnitude smaller than the manufacturer specified holding time. Even assuming a constant 1% loss rate from these tanks, observed emissions greatly exceeded expected emissions.

Given that most of the observed LNG tanks had no observed methane plumes, and a minority had large methane plumes, it is likely that the observed emissions for the 5 sites with measured plumes are attributable to the wear of the tanks over time leading to malfunctioning venting systems [19] or other leak in the system. We scaled up the estimated observed tank emissions to the whole region, and estimate that around 1,293 kg of methane is being released each hour from natural gas fuel station sources. Given that these emissions are relatively easy to detect from airborne observations, and possibly from future satellite missions, data such as this should be used to guide leak repair efforts in NG storage tanks, potentially enabling low-cost methane emission reductions. As jurisdictions within California continue to expand the use of natural gas as a vehicle fuel [20], taking advantage of low carbon fuels such as renewable biogas from dairy digesters, rapid detection and leak repair of NG storage tanks is necessary to ensure the success of these programs for climate and air quality goals.

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Data Summary

Products of Research

A list of overflights of CNG and LNG fueling stations, along with data about whether a methane plume was detected, and its size, location, and emissions, is the primary research product. Additional information includes the date and time of the overflight.

Data Format and Content

The data is provided in a Microsoft Excel (.xls) file, and is additionally stored as a comma separated value sheet (.csv). A copy of the data is provided below on this report as Appendix A.

Data Access and Sharing

Original data used for this analysis were downloaded from the ORNL DAAC. Methane plume images, flightlines, and quantifications were from Thorpe, A.K., B.D. Bue, D.R. Thompson, and R.M. Duren. 2019. “Methane Plumes Derived from AVIRIS-NG over Point Sources across California”, 2016-2017. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1727

The VisTa California database provided the locations of the CNG and LNG fueling stations, and was accessed from: Hopkins, F.M., T. Rafiq, and R.M. Duren. 2019. Sources of Methane Emissions (Vista-CA), State of California, USA. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1726

Reuse and Redistribution

The data is freely available for public use.

Appendix A

Table 2. List of overflights of CNG and LNG fueling stations, along with data about whether a methane plume was detected, and its size, location, and emissions

Source ID	Vista GSAAM Facility Vista ID	Qplume__kg	sQplume__k	Year	Month	Day	Time (UTC)	Plume Detected?
S00102	LNG000013	139	37	2016	10	6	18:48:12	Yes
S00102	LNG000013	0	0	2016	11	2	2:55:33	No
S00295	LNG000020	0	0	2016	10	6	19:02:41	No
S00295	LNG000020	257	62	2016	11	2	21:16:52	Yes
S00295	LNG000020	0	0	2017	10	23	17:56:14	No
S00295	LNG000020	0	0	2017	10	23	18:03:57	No
S00645	LNG000047	0	0	2016	9	10	20:38:07	No
S00645	LNG000047	0	0	2016	9	10	20:44:09	No
S00645	LNG000047	0	0	2017	3	9	22:22:47	No
S00645	LNG000047	0	0	2017	8	30	19:26:55	No
S00645	LNG000047	972	632	2017	8	30	20:08:07	Yes
S00645	LNG000047	0	0	2017	9	1	20:35:20	No
S00645	LNG000047	0	0	2017	9	1	22:03:50	No
S00645	LNG000047	0	0	2017	9	11	20:00:29	No
S00645	LNG000047	0	0	2017	9	22	22:47:20	No
S00645	LNG000047	0	0	2017	10	23	20:58:26	No
S00645	LNG000047	0	0	2017	10	24	19:09:59	No
S00645	LNG000047	0	0	2018	9	16	21:06:28	No
S00645	LNG000047	0	0	2018	9	16	21:52:15	No
S00647	LNG000021	0	0	2017	3	9	21:58:24	No
S00647	LNG000021	176	65	2017	8	30	20:42:11	Yes
S00647	LNG000021	0	0	2017	8	30	20:54:06	No
S00647	LNG000021	0	0	2017	9	1	21:11:00	No

Source ID	Vista GSAAM Facility Vista ID	Qplume__kg	sQplume__k	Year	Month	Day	Time (UTC)	Plume Detected?
S00647	LNG000021	0	0	2017	9	1	21:22:36	No
S00647	LNG000021	625	145	2017	9	11	20:18:34	Yes
S00647	LNG000021	0	0	2017	9	18	23:10:40	No
S00647	LNG000021	0	0	2017	9	18	23:21:17	No
S00647	LNG000021	0	0	2017	10	23	20:14:07	No
S00647	LNG000021	0	0	2017	10	23	20:24:50	No
S00647	LNG000021	0	0	2017	10	24	18:25:13	No
S00647	LNG000021	0	0	2017	10	24	18:36:30	No
S00647	LNG000021	0	0	2017	10	24	20:25:08	No
S00647	LNG000021	0	0	2017	10	24	20:36:15	No
S00647	LNG000021	0	0	2017	10	24	21:42:05	No
S00686	CNG000078	0	0	2016	9	10	20:56:32	No
S00686	CNG000078	0	0	2017	3	9	22:22:47	No
S00686	CNG000078	0	0	2017	8	30	19:26:55	No
S00686	CNG000078	0	0	2017	8	30	19:55:57	No
S00686	CNG000078	0	0	2017	8	30	20:08:07	No
S00686	CNG000078	0	0	2017	9	1	20:23:58	No
S00686	CNG000078	0	0	2017	9	1	20:35:20	No
S00686	CNG000078	0	0	2017	9	1	22:03:50	No
S00686	CNG000078	38	15	2017	9	11	19:53:45	Yes
S00686	CNG000078	470	221	2017	9	18	23:00:03	Yes
S00686	CNG000078	0	0	2017	9	18	23:04:42	No
S00686	CNG000078	0	0	2017	9	22	22:47:20	No
S00686	CNG000078	48	27	2017	10	23	20:58:26	Yes
S00686	CNG000078	93	78	2017	10	23	21:09:05	Yes
S00686	CNG000078	488	167	2017	10	24	19:09:59	Yes
S00686	CNG000078	0	0	2017	10	24	19:21:46	No

Source ID	Vista GSAAM Facility Vista ID	Qplume__kg	sQplume__k	Year	Month	Day	Time (UTC)	Plume Detected?
S00686	CNG000078	0	0	2018	9	16	21:06:28	No
S00686	CNG000078	0	0	2018	9	16	21:13:58	No
S00686	CNG000078	0	0	2018	9	16	21:52:15	No
S00686	CNG000078	0	0	2018	9	16	21:59:53	No
S00686	CNG000078	0	0	2018	10	1	18:24:52	No
S00686	CNG000078	0	0	2018	10	1	18:30:32	No
S00947	UNKNOWN	0	0	2016	10	5	19:42:20	No
S00947	UNKNOWN	0	0	2017	9	10	21:22:52	No
S00947	UNKNOWN	0	0	2017	10	5	17:47:00	No
S00947	UNKNOWN	0	0	2017	10	5	17:51:57	No
S00947	UNKNOWN	0	0	2017	10	5	18:02:01	No
S00947	UNKNOWN	51	19	2017	10	5	18:06:14	Yes
S00947	UNKNOWN	0	0	2018	10	9	18:55:41	No
S00947	UNKNOWN	0	0	2018	10	9	19:04:53	No