

Innovative Kitchen Management Application Test and Learn Project

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ABSTRACT

“California has committed to a goal of reducing carbon pollution to 1990 levels by 2030 which is equivalent to taking 5.6 million cars off the road every year and reducing annual emissions from 14 tons to 10 tons per person” (2020 Energy Upgrade California). In support of this endeavor, SoCalGas has proposed a test and learn project concentrated on proactive energy efficiency engagement with food service customers. The project approach encourages, enables, and motivates these customers to manage energy use while expanding their knowledge of kitchen equipment efficiencies and or inefficiencies. Participants are offered novel digital technologies and extensive analytical methodologies that provide SoCalGas an opportunity to engage with them and recommend solutions that aim at the elimination of ambient methane emissions. Ambient methane detection sensors and Advanced Meter Usage Data in conjunction with propensity modeling are some of the innovative methods utilized. Through these innovative methodologies, this program identifies fugitive methane leaks, assists in fixing or replacing fatigued transport mediums and outdated or inefficient equipment and or parts. It will also promote behavioral change, workforce education, training, and outreach. The program design and technologies continues to leverage existing, and promotes new energy efficiency program offerings (i.e. equipment rebates, on-bill 0% financing, behavioral engagement, technical assistance, etc.) while addressing faulty equipment and improved safety.

Background on Methane Emission Detection Efforts in the US

In the Pipeline & Gas Journal January 2022 issue, D. Moores described Duke Energy’s efforts to achieve a net-zero carbon emissions goal by 2030 for its’ natural gas business. The company joined ONE Future, a group of natural gas/utility companies aimed at reducing methane emissions value chain to 1% or less. Duke’s efforts focused on a drone program and later transitioned to a satellite format. Satellites would capture images of a pipeline system monthly and analyze the data to detect leaks. Along with satellite technology for leak detection, Duke also eliminated flaring during maintenance activities.

D. Moores (2022) described CenterPoint Energy’s efforts together with PG&E where the Picarro Surveyor was used. Picarro Surveyor is a vehicle-mounted leak detection technology that enables earlier detection of leaks- before they can be detected by traditional leak survey methods.

In 2017, Con Edison of New York launched their residential methane detection pilot program to determine the best technology to quickly detect fugitive methane gas entering buildings. Together with the Gas Technology Institute (GTI), Con Edison fielded the study in lower Manhattan and several Westchester County communities. The study utilized 9,000 New Cosmos USA methane detectors with ITron’s Milli 5 battery-optimized communication module through its’ existing IOT network. “If methane is detected, the device sounds both an alarm and a voice warning and can only be silenced by the utility. It also alerts the operators at Con Edison’s

Gas Emergency Response Center, who notify the local fire department” (D.Moores, 2022. Pipeline & Gas Journal).

While there are several efforts to detect and limit ambient fugitive methane emissions in the US, there are no known proactive energy efficiency efforts having been implemented to reach the commercial foodservice sector. SoCalGas’ approach of utilizing innovative technologies and modeling strategies to limit methane emissions while driving energy savings is the first of its’ kind. This innovation was inspired by the company’s solemn mission to offer a suite of energy efficiency solutions that:

- Incorporate the best available technologies and services
- Contribute to the achievement of California’s energy efficiency goals, and
- Align with the State’s energy efficiency policies—including doubling of energy efficiency in California by 2030.

Introduction

A paper from the American Lung Association described methane as a major contributor to climate change. “...according to the UN Environment Program, methane has accounted for roughly 30% of climate change since pre-industrial times” (2022 The American Lung Association). The United States Environmental Protection Agency (EPA) findings stated, “In 2020, methane accounted for about 11% of all U.S. greenhouse gas emissions from human activities. Human activities emitting methane include leaks from natural gas systems...” (2022 The United States Environmental Protection).

M. Somma published an article on sciencing.com describing the dangerous effects of methane leaks. Somma stated that exposure to methane for an extended period may cause health issues. Aside from adverse health effects, methane emissions pose a danger to the environment. “Methane is one of the several greenhouse gases that contribute to the greenhouse effect that causes global warming and climate change... Methane is the second prevalent greenhouse gas, after carbon dioxide. Approximately 80% of greenhouse gases come from carbon dioxide emissions, 10% from methane and the remaining 10% from various other sources” Somma. M (2021).

The ONE Future Coalition, a group of more than 50 natural gas companies, including SoCalGas holding company Sempra, voluntarily agreed to work together and “reduce methane emissions across the natural gas value chain to 1% (or less) by 2025” (2022 Our Nation’s Energy Future). As SoCalGas’ moves forward on its’ climate commitment and sustainability strategy, a particular focus on behind the meter fugitive methane emissions is necessary. By identifying source of leaks, understanding leak volume and frequency trends, and addressing these emissions at onset can help reduce not just potential health and safety hazards but also contribute to California’s goal of reducing methane emissions.

In 2020 the California Energy Commission issued a report on the Characterization of Fugitive Methane Emissions from Commercial Buildings in California. The report concluded that more than 50 percent of current fugitive methane emissions derive from only three percent of customers. Johnston, Bluestein, et al (2020) reported:

“Off the 499 gas appliances measured, the top 3 percent of highest emitting sources accounted for more than 50 percent of total fugitive emissions. For piping components, the same observation was made; the highest 3 percent of pipe joints emitting fugitive methane accounted for more than 50 percent of fugitive methane from pipe joints observed. This suggests it may be possible to greatly reduce fugitive methane emissions from the commercial sector by identifying and repairing a relatively small number of problem areas. By identifying where these problem areas are most likely to be and understanding what may be driving their poor performance, relatively quick and limited adjustments could be made to yield sizable savings.” (page 46, para. 4)

In 2021, SoCalGas launched the Innovative Kitchen Management Application Test and Learn Project (K-MA). This project focused on energy efficiency engagement within commercial food service customers through proactive escaped methane sensing technologies, and data analytics to further study the issue. Commercial food service customer’s natural gas usage data were analyzed in August of 2021. Results provided a method with which to determine which food service customers had the highest propensity for fugitive methane emissions associated with natural gas equipment. In October 2021, those customers were invited to participate in the test and learn project. By December 31, 2021, there were 84 commercial food service customers enrolled (the project requires 100 commercial food service customers to enroll in order to obtain an ample amount of data). Of those enrolled, 9 customers were visited by a SoCalGas technicians, diagnosed natural gas equipment specifically searching for leaks and usage data. 19 leaks were repaired by end of January 2022. The repairs included 11 burner valves, 7 connectors, and 1 line valve. Service technician diagnosis will continue until 50 of the highest propensity food service customers to manifest an appliance leak have been visited and emission issues addressed.

By March 2022, 9 food service customers participating in the program each received 2 appliance-level usage meters and 3 methane detectors. Installation of these devices will provide clues to ambient methane emissions. The project aims to install these devices in all 100 enrolled food service customers by September 2022.

By March 2022, 50 of the enrolled commercial food service customers received low-cost energy efficiency measures through SoCalGas’ existing energy efficiency programs. These included 100 feet of pipe insulation, 32 pre-rinse spray valves, and 101 faucet aerators. This effort resulted to an estimated 1,800 therm savings. The various interaction with food service customers allows the gathering of extensive appliance level usage data to be used in the analyzation of trends providing a pathway to solutions. Through proactive equipment diagnosis and smart ambient methane sensing devices, SoCalGas will minimize if not eliminate ambient emissions while providing customers cleaner, safer, and more affordable energy.

The Innovative Kitchen Management Test and Learn project is at its’ infancy but has realized early success in identifying and repairing fugitive methane leaks, offering measures that can drive energy savings, creating awareness and engagement of customers with gas usage. To further demonstrate the positive impact of this project, it will need 100 commercial food service

restaurants enrolled. Current enrollment is at 84%. K-MA is a 2-year project that commenced in August of 2021 and will end in August 2023. Details of the various phases is described infra.

This project embodies SoCalGas climate commitment, associated sustainability strategy, and its mission to be the cleanest, safest, and most innovative energy company in America.

Methodologies Utilized in the Study

A study on the Characterization of Fugitive Methane Emissions from Commercial Buildings was released in 2020 by the California Energy Commission, infra. The study examined 101 commercial sites including the following sectors: Office, Lodging, Retail, Education, Food Service and Warehouse. 61 of the sites are in Northern California and 40 in Southern California. Johnston, Bluestein, et al (2020) study details are found in Table 1.

Table 1 Sites by Region and Building Sector

Building Sites/Sector	NorCal	SoCal	Total
Office	11	11	22
Lodging	7	7	14
Retail	0	6	6
Education	20	5	25
Food Service	21	8	29
Warehouse	2	3	5
Total	61	40	101

The study concluded that appliance emissions in Southern California that emanated from the lodging sector were due to cooking and those originating within the food service sector from heating. Figure 1 shows Southern California Estimated Appliance Methane Emissions.

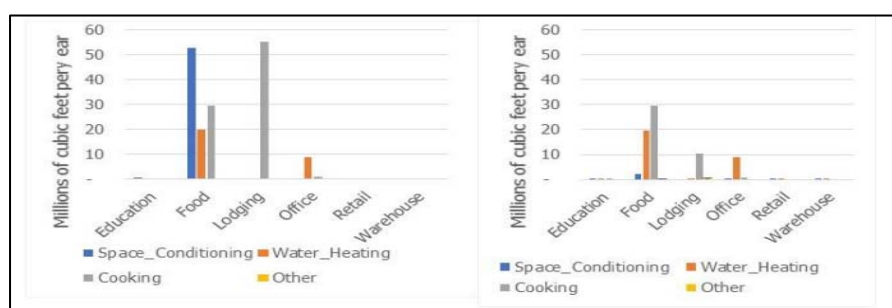


Figure 1 Southern California Estimated Appliance Methane Emissions. As measured (left) and Alternative Estimate (right) (Source: [Characterization of Fugitive Methane Emissions from Commercial Buildings in California](#) page38)

The Characterization of Fugitive Methane Emissions Study paved the way for the exploration of appliance ambient methane emissions from the food service sector in SoCalGas’

service territory. An understanding of ambient methane leaks behind the meter and the implication of proactive customer engagement in mitigating these issues in commercial food facilities, may lead not just to substantial energy savings but will also contribute to SoCalGas' decarbonization goals.

Service Orders Associated with Appliance Leaks in the Food Service Sector

SoCalGas retained Resource Innovations, a consultant, to aid with the investigation of service orders associated with appliance leaks in the food service sector. Service order data analyzed concluded that 77% of SoCalGas appliance methane leak service orders were from the food service sector who make up only 20% of the total non-residential customer base. Figure 2 illustrates the monthly service order trend in relation to appliance leaks from 2014 through 2021.

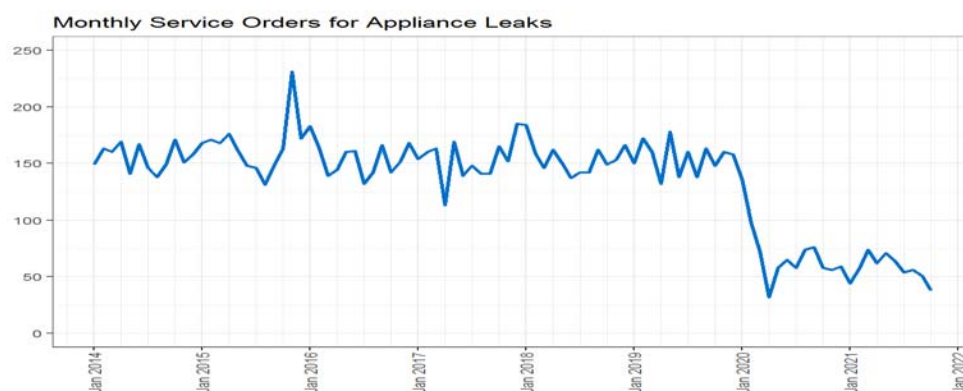


Figure 2 Illustrates Monthly Service Orders for Appliance Leaks from 2014 through 2021 (source: SoCalGas Datawarehouse)

The 5 most frequent appliances repaired by SoCalGas Customer Service Technicians (CSTs) from 2014 to 2022 include, ranges, fryers, grills, water heaters and ovens. The most common repairs are connectors, pilot tubing, and burner valves. Service order data suggested pursuing a study of the food sector in relation to ambient methane leaks was warranted.

Commercial Restaurant Market in SoCalGas Service Area

At the time of the analysis, customers in the “Food Services and Drinking Places” NAICS industry constitute roughly 20% of the total SoCalGas commercial customer base. 40,187 of the 187,324 commercial customers belong in this category. In terms of average annual therm usage, these customers make up 15% of the total commercial market.

Study Participants

“Propensity modeling and predictive analysis are methods of assessing what action a customer is likely to take based on available data” (2022 The Power of Innovation). Propensity modeling was utilized in the Innovative Kitchen Management Application Test and Learn Project (K-MA) to determine which food service or restaurants within SoCalGas territory will likely benefit from the test and learn approach. Customer proclivity was based on the probability

of experiencing an appliance leak that may lead to a SoCalGas service request. The modeling strategy used was centered on customer characteristics such as industry sector, typical usage amounts, and high natural gas consumption, which is a strong indicator that a customer will eventually experience an appliance leak.

The Statistical Modeling Utilized

A regularized logistic regression model was employed to predict whether each food service customer bespoke a service order for an appliance leak, along with an associated probability. The probability, or “leak propensity”, enabled the ranking of all food service customers from most to least likely to experience and report a methane leak associated with natural gas appliances, thereby allowing SoCalGas to prioritize and reach out to the highest-ranking customers for possible participation in the project.

The model’s optimal regularization value was found using 10-fold cross-validation. Predictions were generated from the best-performing model, against using cross-validation to avoid overfitting. The regularization aspect of the model selected allowed for insignificant predictors to be expunged (i.e., their coefficients are set to zero) if lacking sufficient predictive power. In this case, the model found the useful predictors to be average monthly therm usage, more specifically, the industry subsector as indicated by the North American Industrial Classification (NAICS) Code (particularly whether the customer is a full- or a limited-service restaurant), and to a lesser extent, the customer’s point ID, which is an indicator of location within the SoCalGas service area.

Description of Data

The following describes the data used in the project.

- All SoCalGas non-residential customers service orders related to appliance leaks between August 2011 and October 2021. For each service order, the dataset includes the submission date, customer and GNN ID, appliance type, and the order charge amount.
- Account information for all non-residential SoCalGas customers, including location, facility type (commercial or industrial), and North American Industry Classification System (NAICS) Codes
- Monthly billed therms for all non-residential customers.

SoCalGas service area.

Enrollment Strategy

3,587 restaurant customers with the highest appliance leak propensity were invited to participate in the program, offering a cash incentive of \$500.00 per location with a mandatory participation period of 2 years. Additional enrollment incentives were a no-cost appliance

diagnosis, a \$1,000 repair credit, and installation of low-cost measures¹ within the enrolled facility. Participating restaurants receive 2 appliance meters and 3 methane sensor detectors to be installed by a SoCalGas technician at no cost. Of the 3,587 invitees, SoCalGas elected to enroll 100 restaurants and will expand upon this initial sample as recruitment capacity allows. See Figure 3 Sample Email invitation. To view the project overview and terms and conditions visit [SoCalGas K-MA Project \(Restaurant Leak Test and Learn Project\) | SoCalGas](#)

Figure 3. Sample Email Invitation



The Approach

There are 4 phases to the project's approach (see Figure 4. Four Phases of the Test and Learn Project). The first is to utilize statistical modeling to identify the right audience and invite those customers to participate in the test and learn project. The second phase is centered on reducing methane emissions and increasing energy efficiency in the food service sector. This phase offers service visits to diagnose and repair natural gas appliances of the top 50 enrolled customers with the highest appliance leak probability, while the bottom 50 enrolled customers receive low-cost energy efficiency measures. Phase three will provide SoCalGas with a better understanding of commercial kitchen's natural gas appliance consumption and their propensity toward ambient leaks, while considering their relationship to the entire building energy usage. Appliance level usage meters, and novel smart devices will be installed in the 100 enrolled restaurant locations enabling SoCalGas to gather extensive data and provide the ability to analyze use and ambient leak trends (see Figure 5. Appliance Meters and Methane Sensors). Phase four's emphasis is on customer education and engagement with the restaurant's natural gas usage, motivating enrolled customers to conserve through a behavioral change strategy of goal setting and rewards. Face-to-face customer outreach will be used to engage enrolled customers and teach them how they can continuously view their appliance and building natural gas usage enabling a better understanding of the possibilities of better control and savings. It will provide personalized energy conservation tips and encourage customers to establish energy savings goals thereby earning rewards for reaching established goals through a dashboard tool.

¹ Low-cost measures offered are pipeline insulation, pre-rinse spray valves, and faucet aerators

Figure 4. Four Phases of the Test and Learn Project

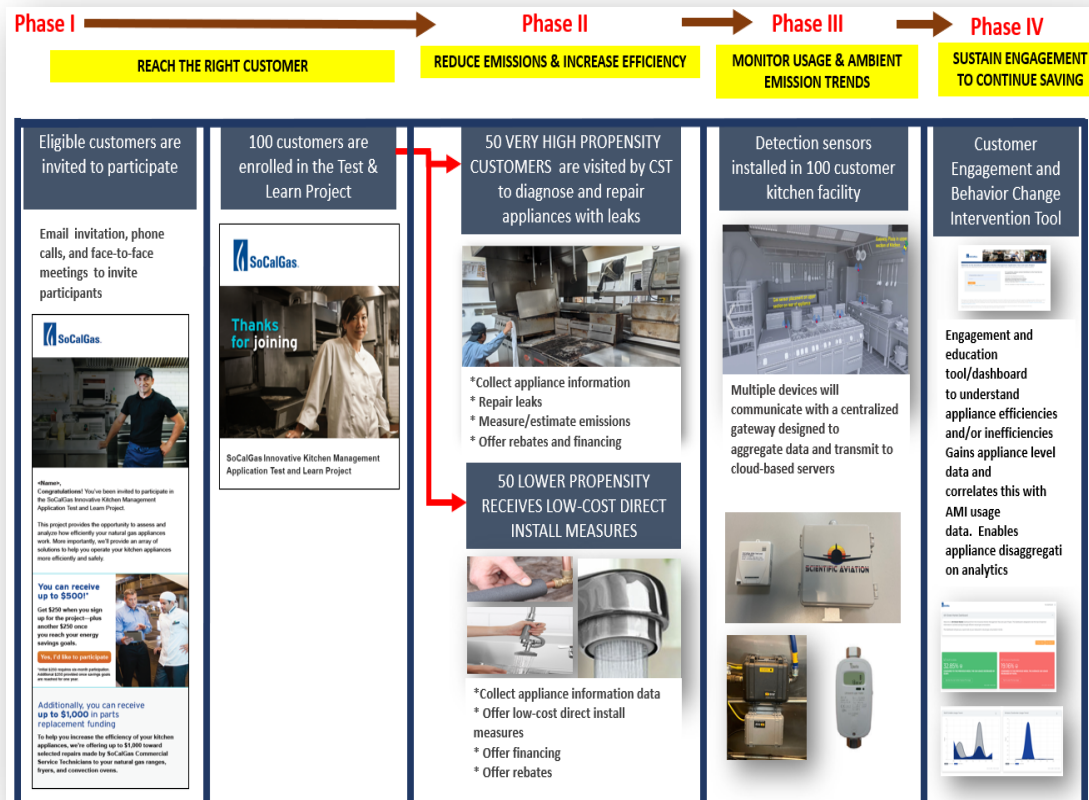


Figure 5. Appliance Meters and Methane Sensors



Results

The project began recruiting participants in August 2021 and enrolled 91 restaurant customers by January 1, 2022. The goal of 100 participants is to be attained by September 2022. Fifty of the restaurants enrolled maintain a low propensity while forty-one have a high probability of experiencing an appliance leak. As of March 10, 2022, nine restaurants in the high probability group were visited by field technicians allowing for diagnosis and repairs. Fifty restaurants in the low probability group received low-cost measures as of February 28, 2022. Nine restaurants have received their methane sensors and appliance meters. Status is summarized in Table 2 (Summary of Status).

Table 2. Summary of Status

Phases	Status	Additional Information
Phase 1: Customer Enrollment	91 restaurants are enrolled (41 high chance and 50 lower chance to exhibit an appliance leak)	Goal of 100 enrolled restaurants to be reached by September 2022
Phase II: Reduce Emissions and Increase Efficiency	9 (high probability group) restaurants received diagnosis and repair visits	19 leaks found and repaired: - 11 burner valves - 7 connectors - 1 line valve 11,855.2 Estimated Cubic Feet of methane saved per year 118.552 Estimated therms saved per year (a reduction of 00.4% per year)
	50 (lower propensity) restaurants received low-cost measures	Measures installed: -100 feet of pipe insulation -32 pre-rinse spray valves -101 faucet aerators 1,800 estimated therms saved
Phase III: Monitor Usage and Ambient Emission Trends	9 (high probability group) restaurants have received their appliance meters and methane sensors	Data currently being collected to understand usage and methane trends. Processes to address specific notifications are being developed
Phase IV: Sustain Engagement and Continue to Drive Energy Savings	Customer dashboard is in development. On-ground outreach is in the planning stage	Phase I of the dashboard design was released in April 2022

Table 3. Methane Emissions Reduced from Diagnosis and Repair Visits

Restaurants	*Cubic Feet per Hour (CFH) Leakage	mt CO ₂ e (unburned)	mt CO ₂ /Year (burned)	CO ₂ e Avoided
Restaurant A	1.17	4.51	137.8	-3.20%
Restaurant B	5.8	22.2	141.8	-13.50%
Restaurant C	1.14	4.39	326.7	-1.30%
Restaurant D	2	7.71	120.4	-6.00%
Restaurant E	1.32	5.09	575.3	-0.90%
Restaurant F	0	0	65.6	0.00%
Restaurant G	0	0	63	0.00%
Restaurant H	0.79	3.04	115.5	-2.60%
Restaurant I	0	0	127.5	0.00%
Overall	12.22	46.94	1673.6	-2.73%

Preliminary Findings from one of the participating restaurants

Restaurant A. Restaurant A is an innovation food hall or a food incubator where several entrepreneurs can use its commercial kitchen facilities to cook a variety of dishes. There are two main kitchens consisting of a culinary lab and east end incubator. Both are open 8am to 8pm. There are 16 vendors that use the kitchen facilities throughout the week having varied operating hours. The cooklines consist of ranges, convection ovens, a griddle, and a broiler.

Figure 6. Restaurant A Market Cookline



Figure 7. Restaurant A Broiler and Griddle



Restaurant A has a very high probability of exhibiting an appliance leak. Throughout a 12-month period, Restaurant's A total gas usage ranged between 1,300 and 3,200 therms per month, putting them in the top 5% of all restaurants in terms of monthly usage. Restaurant A had inconsistent working hours, which resulted in higher-than-normal month to month usage fluctuations. Out of the 70 commercial food service sites analyzed, the natural gas consumption ranged between 500 to 12,000 therms per month, which is impacted by the size of the location. The average natural gas use was 1,840 therms per month. Restaurant A's use was close to average. The analyzed food service participants were selected based on their monthly gas consumption and the number of service orders due to potential appliance methane leaks.

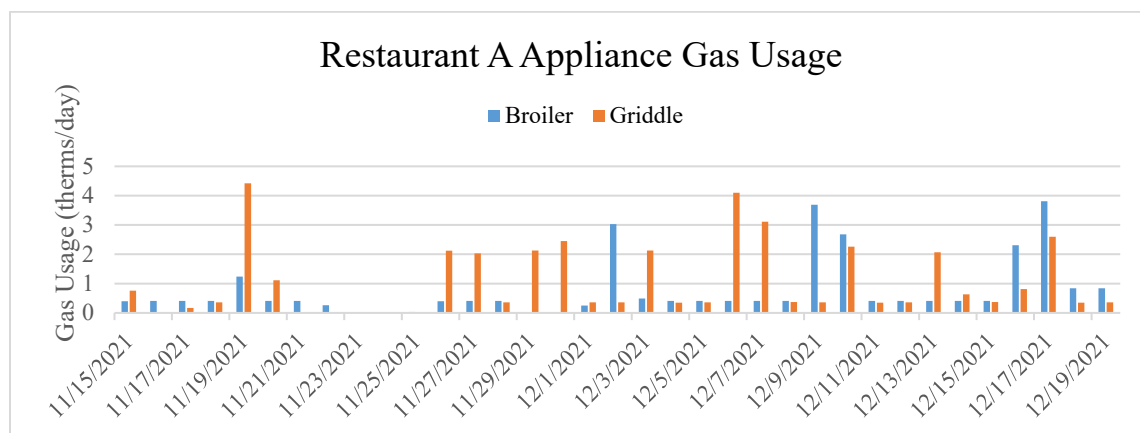
A natural gas leak survey of 17 appliances on September 1, 2021 resulted in gas shutter adjustment, burner cleaning on four ranges, and repair of four other appliance leaks. The range gas shutter adjustments and burner cleaning reduced the combustible gas methane parts per minute (PPM) from 600 to 200. 0.3 Cubic Feet per Hour (CFH) of leaks were found in three connectors in the range, griddle and broiler. These were repaired. A range burner valve was also repaired which obviated another leak. The repair of all these leaks resulted in the savings of 103 therms per year, which amounts to an estimated methane reduction of 4.51 metric tons of Carbon Emission at this location. It was assumed that each therm (100,000 cu. ft) of unburned natural gas leaked is equivalent to 0.044 metric tons of CO₂ in terms of emissions. See Table 4 for details of the repairs made in Restaurant A.

Table 4. Details of repairs made in restaurant A

Appliance Leak	Solution	Leak Repair Date	Appliance Age	Therms Saved Per Year	CO ₂ (unburned) mitigated
Range (Vulcan)	Connector Replaced	9/1/21	5	31	1.36
Griddle (Wolf)	Connector Replaced	9/1/21	5	22	0.97
Range (Vulcan)	Burner Valve Replaced	9/9/21	5	22	0.97
Combi Oven (Blodgett)	Connector Replaced	9/9/21	8	28	1.23

Appliance Level Usage. Two appliances were sub metered for gas consumption on the main cookline: the underfired charbroiler and griddle. Figure 8 shows the appliance gas usage from November 15 through December 19, 2021.

Figure 8. Restaurant's A Appliance Gas Usage from November 15 through December 19, 2021



Underfired broilers are amongst the most energy intense pieces of cooking equipment, generating enormous amounts of heat. Restaurant A uses its' broiler a few times a week and is operated for only a limited number of hours per day when used. Usage of the griddle is limited to a few hours per day most days. Both these appliances have a standing pilot and are non-thermostatic, necessitating manual operation. The broiler is on for 1 to 6 hours on the days it is in use, averaging one hour per day per week. The griddle is on for 1 to 8 hours on the days it is in operation with a weekly average of less than two hours per day. The short hours of operation of these two appliances expend one therm per day each. When the broiler and the griddle are non-operational, pilot lights consume 0.4 therms per day for each. Figure 9 shows Restaurant's A Broiler and Griddle Hourly Gas Consumption on December 10, 2021.

Figure 9. Restaurant's A Broiler and Griddle Hourly Gas Consumption on December 10, 2021

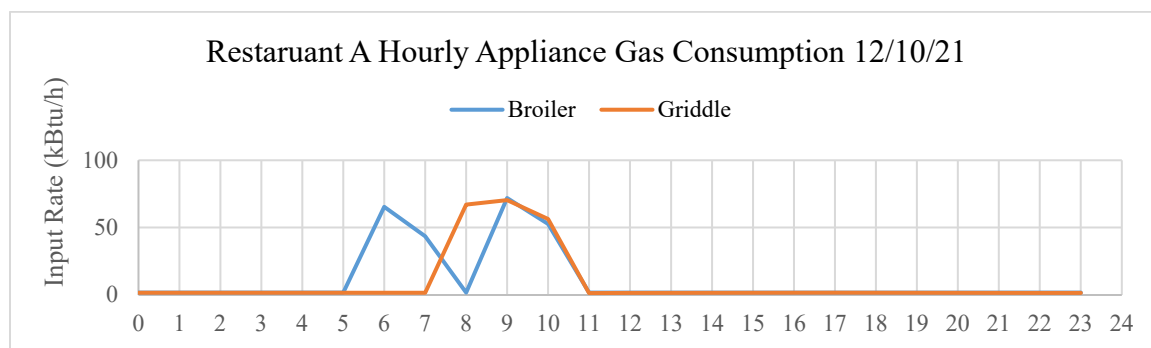


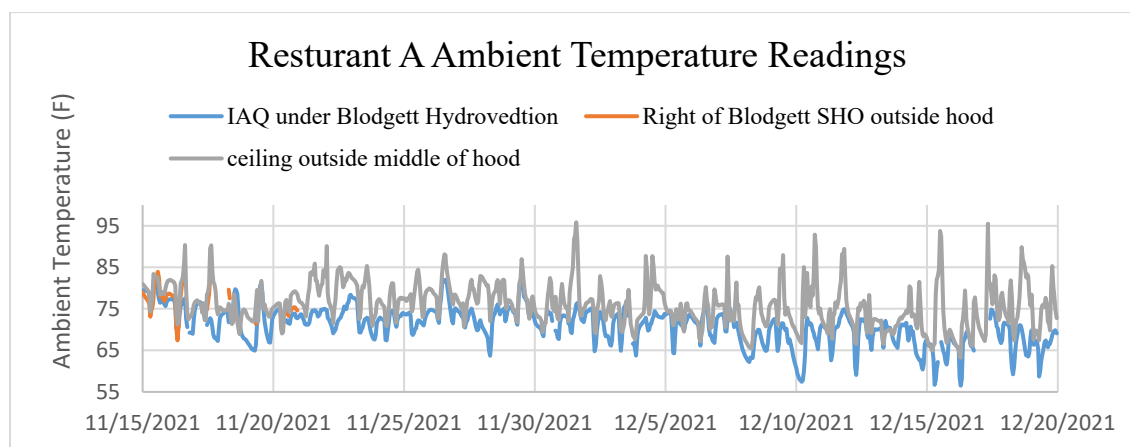
Table 5. Restaurant A's Broiler and Griddle Input Rate and Therm

Appliance	Broiler	Griddle
Type	Baseline	Baseline
Max Input Rate (kBtu/h)	105	81
Time on Per Day (h)	1.06	1.93
Energy Per Day (therms)	0.88	1.25
Energy Per Year (therms)	321	457

The baseline broiler could be replaced with an infrared (IR) burner broiler to save up to 35% energy (Livchak. 2017). IR burners use less energy than conventional tube burners while having minimal effect on cook time, based on laboratory and field studies. Due to the low operational hours of these two appliances, cooking energy is relatively low, the pilot energy accounting for a more significant portion of the total. Replacing the broiler and griddle with pilotless ignition units could save 0.4 therms per day per appliance amounting to 146 therms per year.

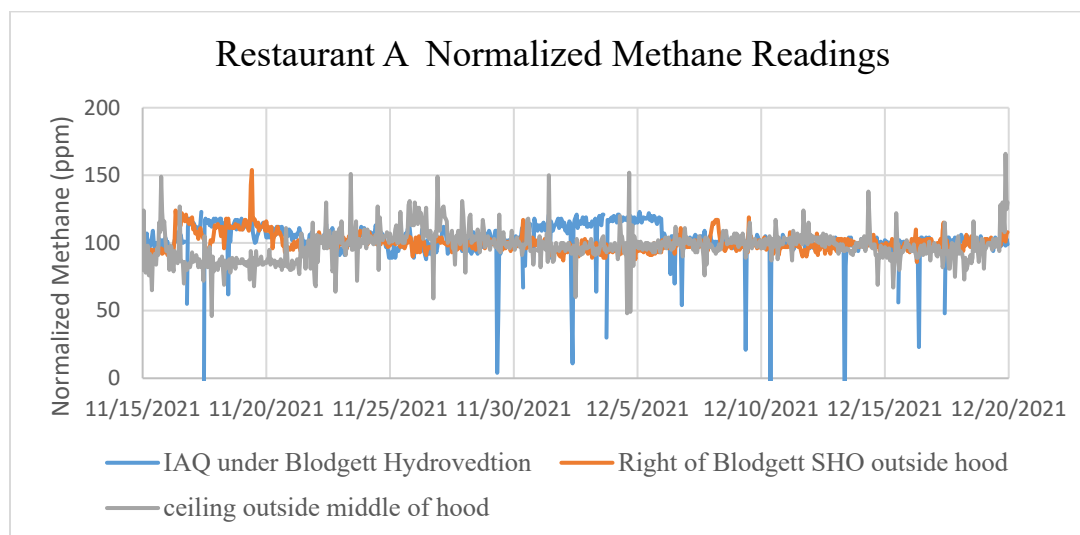
Ambient Condition Findings. Restaurant A's average temperatures across three sensors was 74.7°F. The sensor located on the ceiling outside the middle of the hood exceed the 87°F threshold for a total 23 hours throughout an entire month period. While kitchen temperatures are unrelated to methane leaks, it is an indicator of either poor ventilation or inefficient kitchen equipment. Kitchen temperatures can be used to motivate food service customers to upgrade their old inefficient equipment. Figure 10 illustrates Restaurant A kitchen temperature for a month.

Figure 10. Restaurant A kitchen temperature for a month



The normalized methane readings from the air temperature sensors in the kitchen did not fluctuate by more than ± 100 ppm. Stability within the ambient temperature controls indicates the absence of leaks in the environmental systems. Figure 11 shows Restaurant A's normalized methane readings from November 15 through December 20, 2021.

Figure 11. Restaurant A's normalized methane readings from November 15 through December 20, 2021



Conclusion

Due to the limited number of commercial food service customers (9 locations) who have received the devices and the amount of time these devices have been in the locations, data presented is inconclusive. Obtaining more data to analyze necessitates the observation of at least 100 commercial food service participants with 2 appliance meters and 3 methane detection devices per location for a period of at least one year. This is crucial and will supply an ample amount of methane usage data for more reliable conclusive findings. Information gathered will be instrumental in determining daily and monthly fluctuations of methane emissions and gas use. Furthermore, various methane sensors and appliance meter's sensitivity and accuracy will be evaluated. This information will aid in identifying commercial equipment appliances that are more likely to exhibit methane emissions and will provide a time frame in which this could potentially manifest itself. Knowledge gained from the K-MA test and learn project can help commercial food service customers identify and understand the least efficient equipment in their cooklines, make changes to how they use and maintain this or replace equipment and enable them to participate in energy efficiency programs that will streamline their operations.

Commercial food service participants receptiveness and level of engagement with the project must also be evaluated. There are several phases to this project and each phase interacts with participants. Securing suggestions and recommendations from the participants at various phases of the program will be instrumental to improving the approach and implementation of future opportunities discovered from the test and learn.

Outcome from the K-MA test and learn project will be helpful in the development of various methods of addressing ambient natural gas equipment methane emissions, inefficient equipment replacement options and will provide motivators to encourage equipment maintenance.

“SoCalGas will continue to implement the K-MA test and learn project which it is hoped will engender successor pilots as well as offer additional innovative approaches to address fugitive methane emissions for all customers. The initial pilot is focused on commercial food service establishments; future efforts are envisioned to include hospitals, residential systems, and others (B. Prusnek, 2022. 2024 General Rate Case Proceeding Testimony).

The Innovative Kitchen Management Test and Learn Project will conclude in December 2023. Findings will be analyzed soon thereafter.

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