NYSEARCH Methane Emissions Technology Evaluation & Test Program

WHITE PAPER ON BEHALF OF FUNDERS
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NYSEARCH

Northeast GAS ASSOCIATION

NYSEARCH Organization

- Voluntary RD & D organization, that serves over (20) LDCs in North America
- Part of Northeast Gas Association – 501c (6) non-profit association
- Members are specific to NYSEARCH organization and are not limited geographically in N. America
- Focused on gas operations technology design, development and testing to improve safety, reliability, efficiency and customer service

Funders of the Methane Emissions Technology Evaluation & Test Program*

- Central Hudson Gas & Electric
- Con Edison of NY
- National Grid – KSP
- National Grid – NMPC
- National Fuel Gas
- New York State Electric & Gas
- Orange & Rockland Utilities
- Rochester Gas & Electric
- Pacific Gas & Electric
- PECO Energy
- Public Service Electric & Gas
- Southern California Gas Company
- SouthWest Gas
- Xcel Energy
- Union Gas

* PHMSA/DOT cofunding fourth and active phase addressing Emissions Quantification Validation Process

Drivers for Collaborative Program

- Increased attention to greenhouse gas emissions that may come from or near natural gas industry's infrastructure
- Safety-driven approach for prioritization of 'non-hazardous' leaks
- Interest in best methods for measuring flow rates of non-hazardous leaks
  - Particularly interested in capability of technologies to measure emissions flow rates
  - Ultimately understand impact of emissions & prioritization for repair of non-hazardous leaks
- Many technology providers using equipment from other applications

Program Objectives

- Overall : To identify and evaluate what safe and cost-effective technology or technologies are available, that can be applied from a mobile platform to quantify methane emissions rates of known non-hazardous leaks from the gas distribution infrastructure.

- Test and Validation Program Goals
  - Complete tests of the selected technologies in a controlled environment and in the field to gather extensive data
  - Work with operators and other collaborators to identify, test and implement ways to validate performance of 3rd party technologies in the distribution company leak survey process

Three Technology Provider Selected from Competitive RFP

- Technologies Used
  - CRDS, 2 inlet/sensors (2)
  - Differential Absorption Laser (DIAL) technology
- One week for each provider; separate weeks
- Weather monitored; overall very similar in three consecutive weeks for each series of tests

Flow Rates Tested

Category	Bins for Emissions Flow Rates (SCFH)
Very low	0.2 to 0.5
Low	0.6 to 2.0
Medium	2.1 to 10.0
High	> 10.0

- Following calibration tests, random controlled emissions from 0.2 - 50 scfh
- All Technology Providers given same durations and range of flows to test. After calibration opportunity, tests were conducted blind
- Test plan allowing for quantification and/or binning of relative size emissions
- The range of emission rate test values/bins provided does NOT reflect any one company's leak population distribution

1st Round of Controlled Tests
PSE&G's Training Facility in Edison, NJ

A - Cert Methane Gas

B - Mass Flow Control

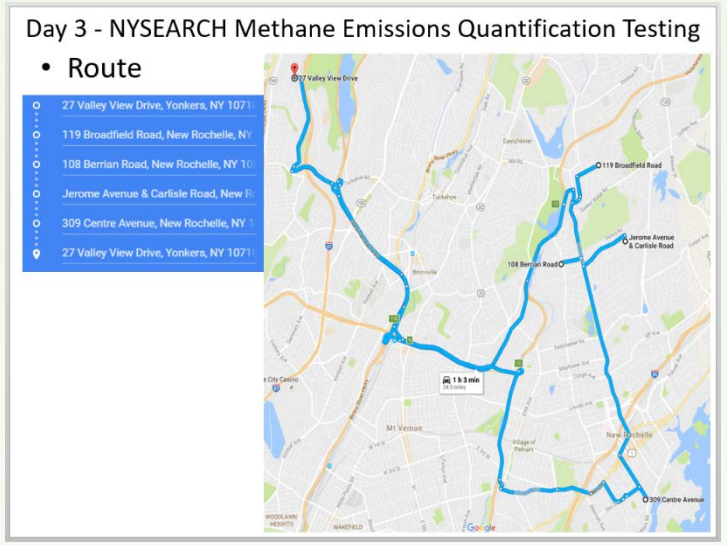
C - 3D Anemometer

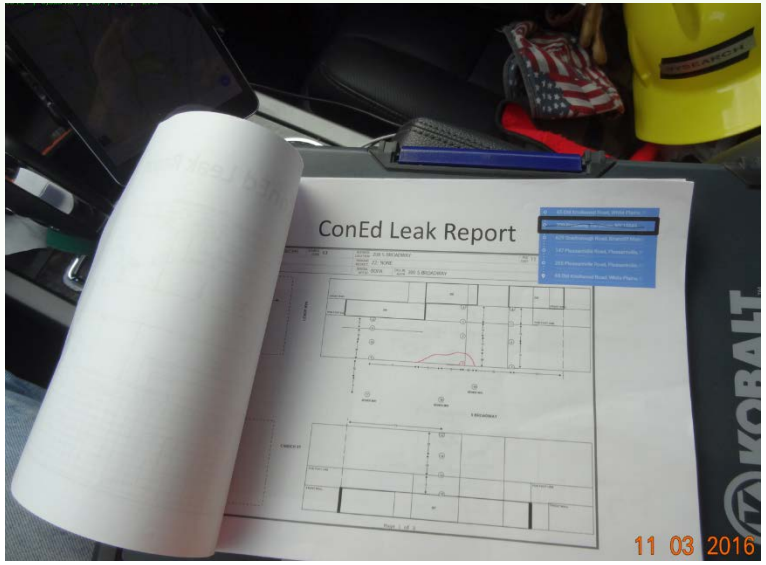
D - Windsock

2nd Round of Controlled Tests
SoCal Gas' Facility, E. Los Angeles, Ca.

Field Test Planning and Setup

- Type 3 Non-Hazardous Leak Log – Con Edison of NY (CECONY)'s Westchester service territory
- Like controlled tests, test plan distributed and reviewed by TPs & program funders





Methods of Validation During Tests

Summary of Data Collected

- Number of Emissions Measurements* Collected by Technology Provider & Test Series

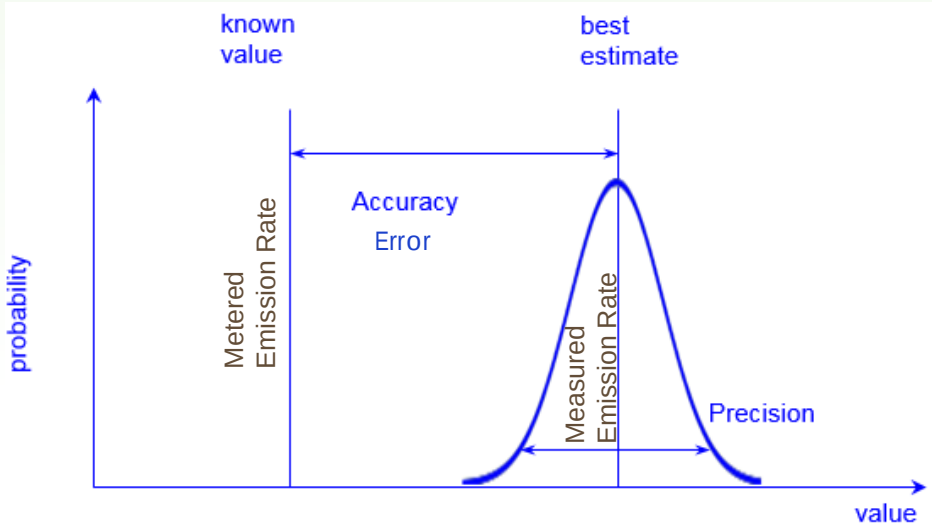
Technology Provider (TP)	2015 Controlled Tests	2016 Controlled Tests	2016 Field Tests
Company A	36	62	19
Company B	36	50	18
Company C	36	50	18
All TPs	108	162	55

*numerous measurements were taken for each emission tested

Statistical Analysis Metrics

- **Accuracy/Error** - The difference between the best estimate and the known value is **bias**, or a lack of **accuracy** equating to **error**

- **Precision** - The variation (**standard deviation**) for all the measurements of one part is measurement of **precision (+/- 3 standard deviations)**



Results – Error & Standard Deviation

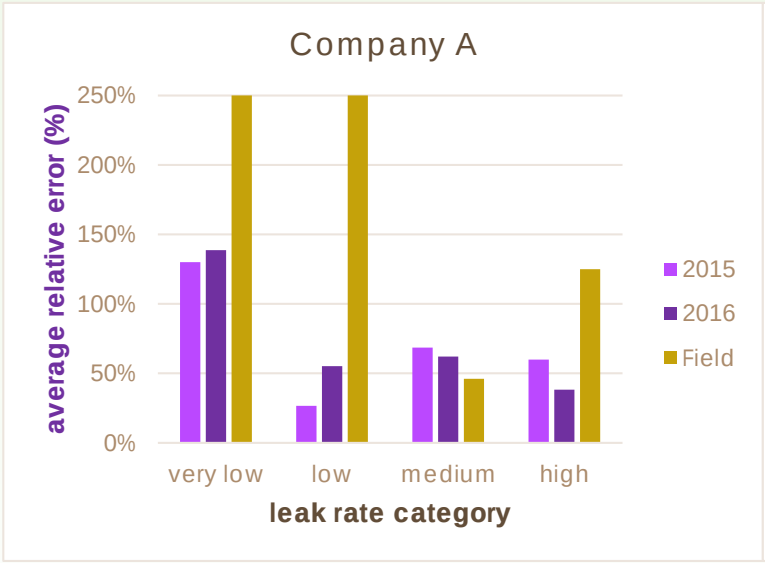
- Error – All Categories

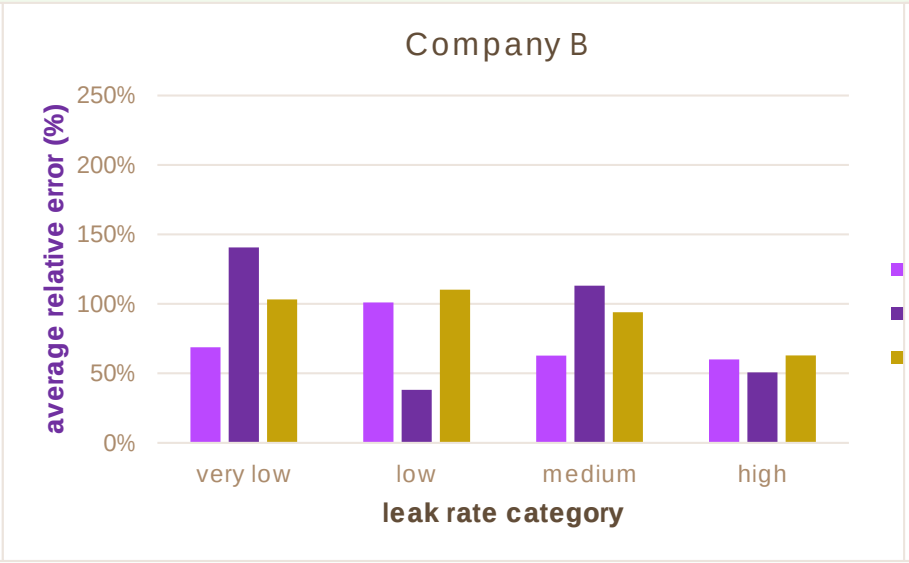
	Units in SCFH	2015 Controlled Tests	2016 Controlled Tests	2016 Field Tests
Actual Test Parameters	Avg Actual	17.0	10.2	8.6
	Emission Range	0.2 – 50.0	0.21 – 49.2	0.01 - 100
Average Error	Company A	58%	39%	90%
	Company B	55%	51%	46%
	Company C	47%	68%	65%
All Avg Error as a % of Average Actual	All	53%	53%	67%

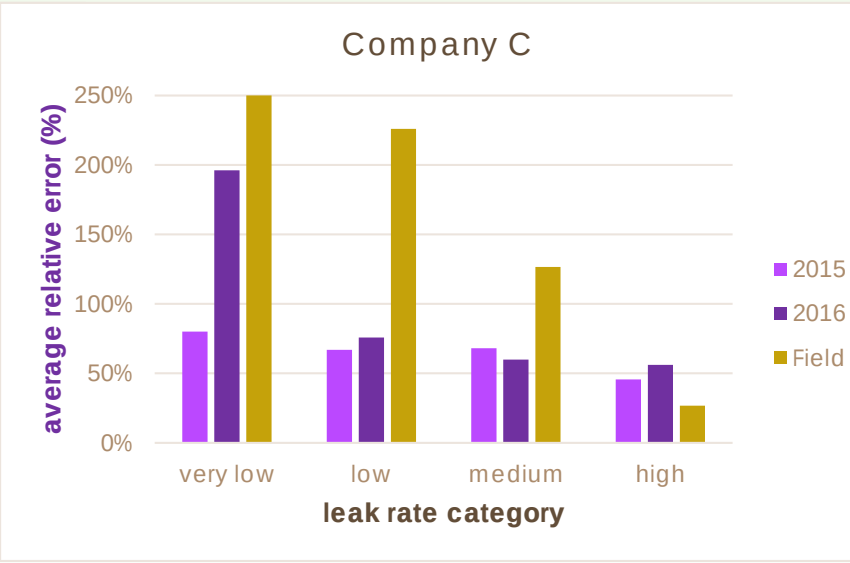
- Standard Deviation of Group of Measurements – All Categories

Technology Provider (TP)	2015 Controlled Tests (SCFH)	2016 Controlled Tests (SCFH)	2016 Field Tests (SCFH)
Company A	9.4	7.6	13.5
Company B	12.8	9.3	4.6
Company C	9.3	11.3	6.1
All TPs	10.5	9.4	8.1

Average Relative Error – normalized by magnitude of actual flow rate





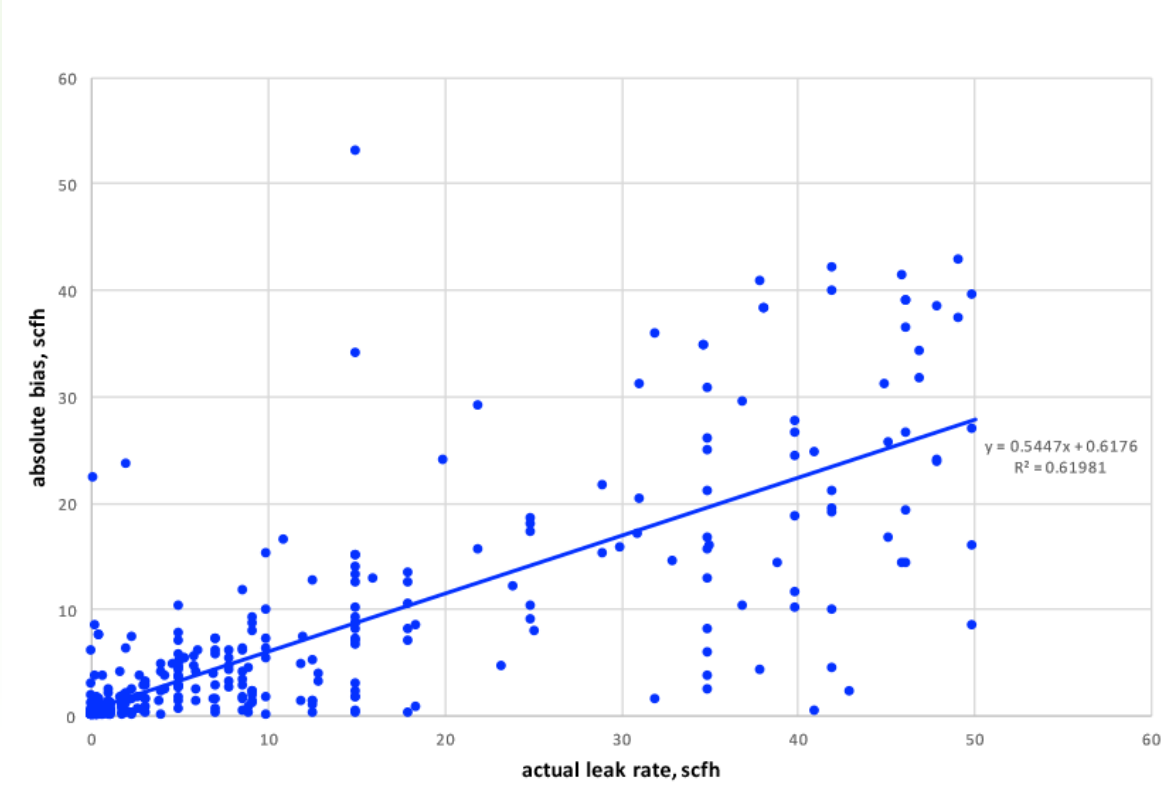


Sample Effect of Different Bucketing

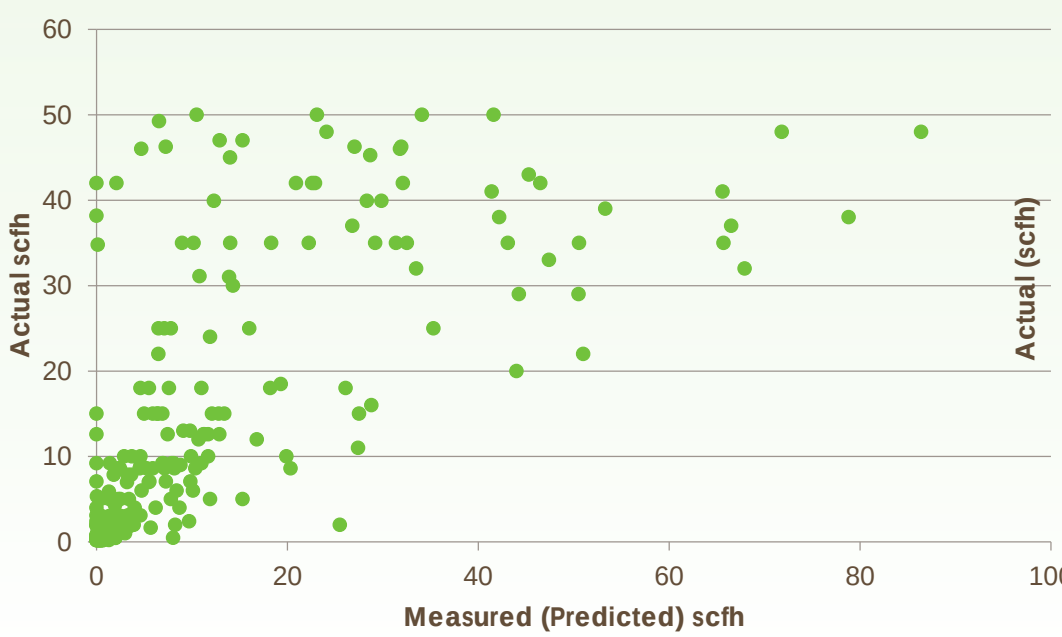
	range (scfh)	trials	correct	percent correct	average absolute error (scfh)
cat 1	0 - 1	58	48	82.8%	0.53
cat 2	1 - 10	63	41	65.1%	2.81
cat 3	> 10	41	28	68.3%	15.88
all categories		162	117	72.2%	5.30

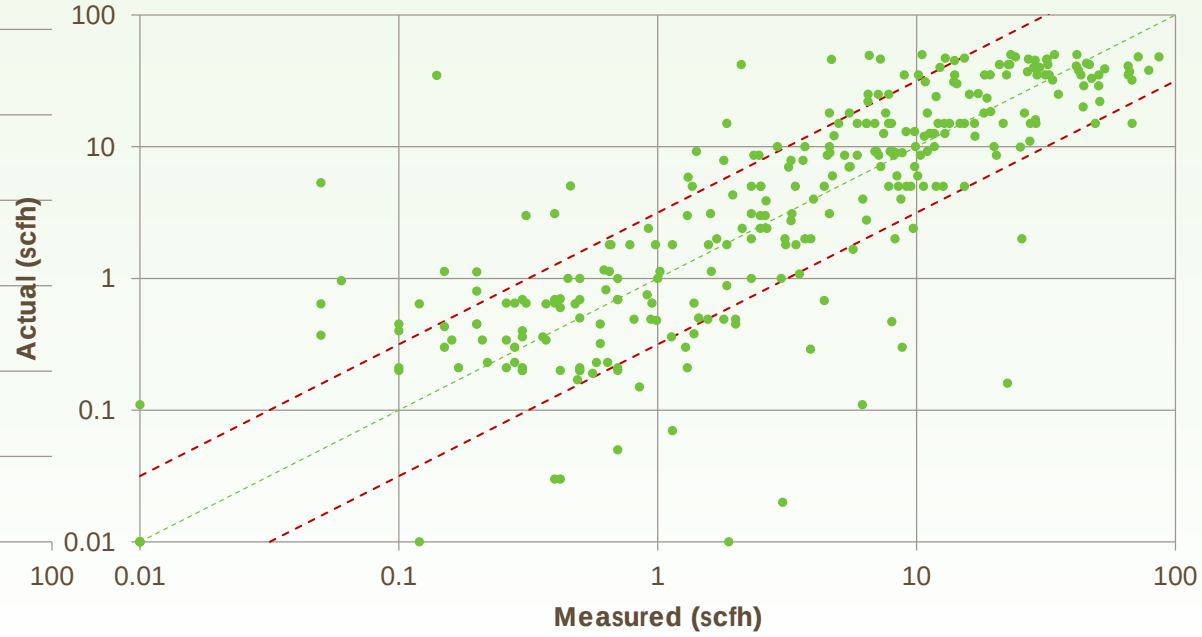
- Results are for evenly distributed emission flow rate data that were collected in test scenarios; not reflective of any one company's leak size distribution

Error/Bias correlated with Actual Emission Flow Rate



Actual Flow Rates vs. Predicted Flow Rates, all tests





Log Scale

77% of Measured values within one Order of Magnitude

Process for Independent Validation of Methane Emissions Technologies

- Methods for performing validation of these technologies with funders and users since 2016
- Decision made in late 2016 to develop validation framework modeled after API 1163 (Standard used for In Line Inspection tools used in gas industry)
- Independent expert worked with funders on similar framework
  - Formal Guideline
  - Flexible for a broad range of objectives, conditions, policies, weather patterns
- 3rd Party technologies being used to test draft process in fall 2017

Next Steps/Summary

- This project has produced an extensive validation dataset that can be used by scientific community
  - Model and comparison to other data
  - Investigate how flow rate is impacted by different conditions
- Our Validation Process development project is ongoing and draft test protocols are being tested for the first time in fall 2017
- We believe that more work is required to define the process and to implement quantification practices that reduce methane emissions from the gas infrastructure by leveraging new measurement techniques

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