SITE LEVEL QUANTIFICATION OF METHANE EMISSIONS

Phase II.A: Technology benchmark

October 2022

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LABORATOIRE DES SCIENCES DU CLIMAT & DE L'ENVIRONNEMENT

enagas

GERG
THE EUROPEAN GAS RESEARCH GROUP

Context

GERG Project(s) on site level technologies

This project is part of a series of projects launched by GERG recently focusing on site level technologies

Phase I
State of the art study of site level technologies
Lead by RICE (GRTgaz)
2021

Phase II.A.
Technology Benchmark of site level technologies
Lead by Enagas
2021

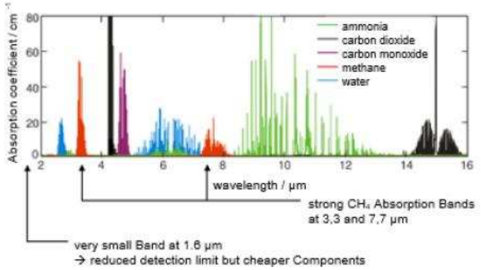
Phase II.B.
Source and site level reconciliation. Test in a site in operation
Lead by Enagas
2022

Final aim is be to elaborate a set of guidelines to be applied when top-down methodologies are used, establishing a harmonised approach within EU (midstream sector) for the application of top-down in combination with bottom-up estimations

Context – Site Level Technologies

- *In situ (in and around the plume)*
- *Remote (from a distance, without contact with the plume)*

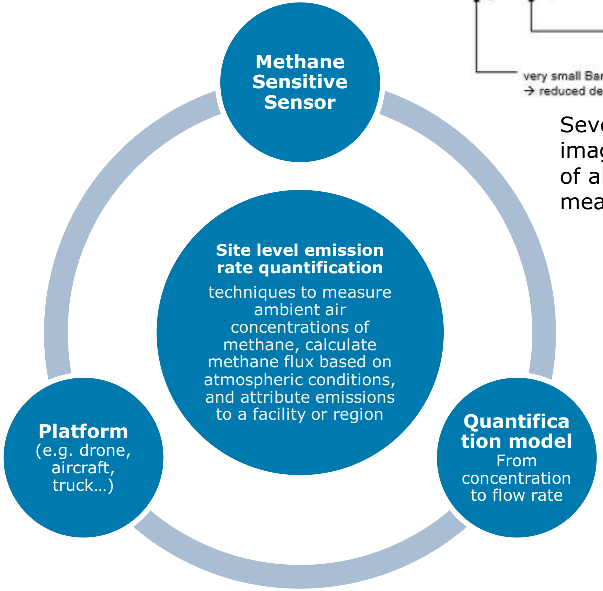
- *Passive (measure changes in background energy, e.g. reflected sunlight)*
- *Active (transmits burtsts of energy in the direction of interest, e.g. laser beam)*



Several different **sensing instruments**, including optical gas imaging and laser absorption spectroscopy, take advantage of absorption features of methane for detection and measurement (typically between 1,6 and 3,3 µm).

The 1650 nm absorption line is a fairly powerful source, easier to generate than the one at 3300 nm. It is not in the liquid water spectrum and therefore does not interfere with this species. The average infrared line at 3300 nm has a wider range and makes it possible to achieve a higher sensitivity than the line at 1650 nm. There may be interference with water.

Conclusions of the state of the art study:
lack of information on quantification accuracy of new technologies



The **sensor placement** determines from where a methane concentration is measured, and therefore what data can be used to calculate emission flow rates. Measuring equipment **can be fixed on site, mobile on the surface, airborne in drones or aircraft, and in different space orbits**. The placement determines the spatial and temporal resolution of what the sensor is able to detect.

To determine flow rates, a model is used to calculate backwards towards the emission point, based on factors such as wind, atmospheric conditions and background methane concentration.
The quantification methods only give estimates, and there are **multiple factors which contribute to uncertainty**: sensor precision, the quantity and spatial extent of measurement data, micrometeorological conditions and background concentration variability, besides difficulty of the models to replicate actual gas dispersion in the atmosphere.
Even with well-designed measurement campaigns, using precise sensors under ideal conditions, there will be significant errors in the estimations of flow rates.

Phase II.A: GERG 'Technology Benchmark for site level methane emissions quantification'

A first-of-its-kind research project covering midstream assets was launched

Blind controlled release tests
To analyse the accuracy / performance of most promising site level technologies (quantification)

Funding Partners

ADVISORY BOARD to validate the scope and test program and to contribute to the data analysis of the results
Internationally recognized experts from Authorities and Institutions, Academia, Industry and Civil Society

Project Definition

Inerted and isolated Compressor Station

9 most promising site-level technologies

3 bottom-up

Independent analysis to assess accuracy and repeatability

17 blind tests with controlled releases of methane (1 week)

Project Definition

Inerted and isolated Compressor Station

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Tests organization and coordination

Releases plan determined by a collaborative team

17 blind tests with controlled releases of methane (1 week)

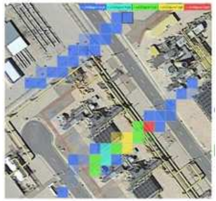
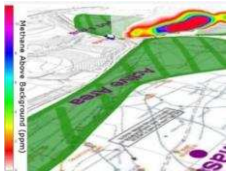
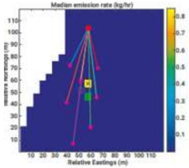
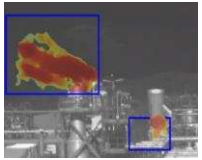
Technologies involved

Identifier	Technologies
Drone 1	TDLS
Lidar 1	Helicopter borne DIAL LiDAR
Tracer	Tracer release
Fixed 1	Integrated path scans
Lidar 2	Truck borne DIAL LiDAR
OGI 1	Hand-held OGI
Drone 2	SeekIR
Fixed 2	Fixed OGI
OGI 2	Hand-held OGI

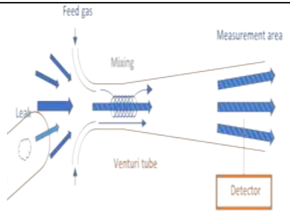
A prototype of a Hi Flow Sampler (Hi-Flow) was also tested in some releases, to assess its accuracy for fugitives' quantification

*Two additional technologies were tested by they didn't provide any results (measurement technique to be optimised).

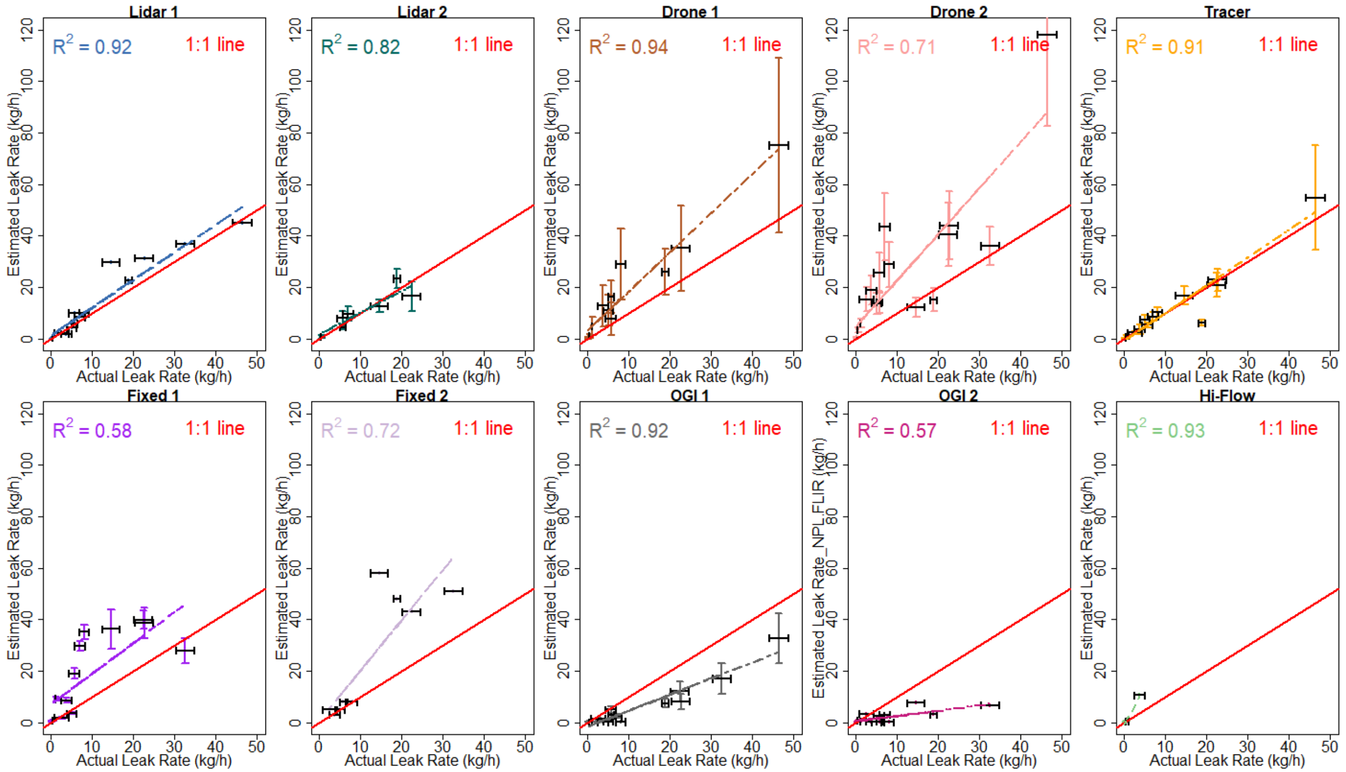
Technologies involved: site level

	Top Down / Site Level Technologies					Continous Monitoring	
	AEROMON	CHARM (OGE)	DIAL (NPL)	SeekOps	Tracer Gas Methodology (DGC)	MIRICO	Sensia
Picture of the equipment							
Picture of their measurements							
Sensor used	Tunable Diode Laser Spectrometry (TDLS). NDIR and MOS sensors were also implemented, but NDIR failed to detect methane in majority of tests and MOS failed to detect methane in a few tests.	LiDAR DIAL (by Adlares). Measurements (IR-DIAL) provide directly the georeferenced total column density of methane (in ppm*m). Background concentration is subtracted.	Differential Absorption Lidar (DIAL). Laser is operated at two wavelengths (one is absorbed by methane and the other not). The difference in the absorption is used to calculate methane concentration.	SeekIR sensor (an in-situ turnable diode laser absorption spectrometer). Concentration is mesaured in ppmv.	Concentration of methane and acetylene measured with a ultra portable gas analyzer: off-axis integrated cavity output spectroscopy (OA-ICOS) by Los Gatos Research + Garmin GPS recevier.	The instrument is based on a patented technology called laser dispersion spectroscopy (LDS) operating in the midIR region. LDS is measuring the change in frequency of the returned light, making it insensitive to weather conditions (rain, fog, snow or dust).	Two OGI cameras were used; Carolyne fyl (an uncooled LWIR detector) and Mileva 33-F (cooled MWIR detector).
Platform used	Drone: UAV Matrice 300 RTK from DJI	Helicopter (AirLloyd)	Truck	Drone: DJI M300 UAS	Van	Sensor with rotating scanning head, 360° horizontal coverage and ±10° vertical.	Unmanned cameras

Technologies involved: bottom up

	Bottom up/source Level		
	FLIR OGI	**OPGAL OGI**	**Venturi Prototype**
Picture of the equipment			
Picture of their measurements			
Equipment used	FLIR OGI camera + QL320 tablet for direct quantification	OPGAL uses EyeCGas 2.0, a handed Optical Gas Imaging (OGI) Camera. It was specifically designed for gas leak detection for the Oil and Gas industry.	A venturi tube, supplied by a compressed air cylinder, generates a vacuum suction near the gas leak diluting it in a controlled and defined flow rate. A methane detector, placed downstream, measures the concentration of methane in the outgoing flow.

Analysis of results

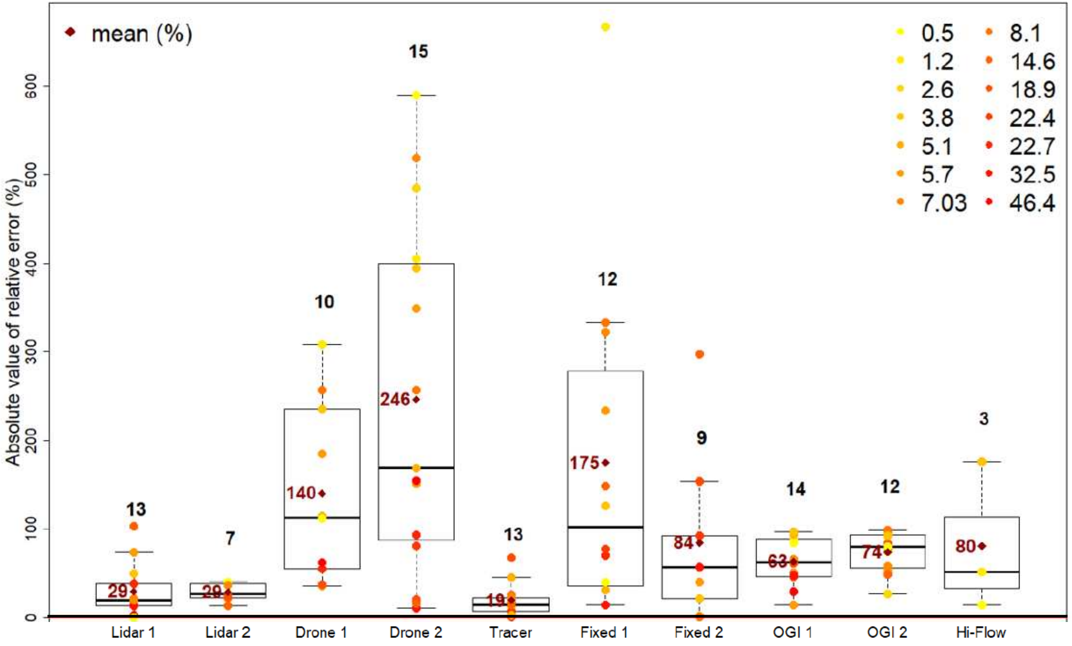


Summary of results: estimated vs actual leak rate and linear regression

Including uncertainty indicated by technology providers

Liu et al., in prep 2022

Analysis of results



The dots correspond to the total flow rates of the different tests (kg/h)

Absolute value of the relative errors (ARE, %) on the quantification estimated for each test

Bars indicate median and interquartile range of the distributions

Number of points accounted for in the statistical distribution of each provider is indicated on top of each bar plot

Lower releases: 0,01 kg/h and 0,1 kg/h are not included in the assessment of accuracy, the objective of these releases was to assess the detection/quantification thresholds

Liu et al., in prep 2022

Analysis of results

Technique	Provided Uncertainty, %	Actual Relative Error, % (absolute value)	% within 0.5-2x	% within 0.1-10x
LiDAR 1	N/A	29	92	100
LiDAR 2	17	29	100	100
Drone 1	55	140	40	100
Drone 2	29	246	33	100
TRACER	15	19	92	100
FIXED 1	13	175	50	100
FIXED 2	N/A	84	78	100
OGI 1	36	63	36	79
OGI 2	N/A	74	25	69

Indicated uncertainty, mean ARE (%) and percentage of quantified release rates within a particular multiplicative range of the actual leak rate

Liu et al., in prep 2022

Conclusions

- Only three technologies obtained average errors below 50 % (LiDAR 1 and 2, Tracer).
  - 'LiDAR' requires deployment of helicopter or heavy truck.
  - 'Tracer' requires localised emissions to obtain this performance.

- The average absolute value of error was above 100 % for both drones involved in the project. Weather conditions, in particular low wind speeds (below 3 m/s), may have affected drones' performance during the tests.

- Most of site level methodologies are not able to precisely locate the source of the emissions.

- Several techniques will be further limited in other mid-stream contexts (e.g. LNG terminals or industrial clusters with several emitters).

Errors above 50 % for most of the technologies and tests, indicate that
not all technologies have enough accuracy to allow a quantitative comparison

Added value of site level measurements is to guarantee that all emission sources are taken into account
Qualitative analysis may be a good approach considering current limitations for quantification by most site level technologies in the market

Further work needed to determine how these technologies can be applied to reconcile with bottom-up estimates

Phase II.B - tests on operating sites – Zelzate CS

Photos Fluxys Belgium - David Samync

Tests took place in May

Results will be available in the upcoming months

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