Use of “Next Generation” Open-Path Monitoring Systems for Source Detection, Emission Inventory Improvement, Root Cause Analysis and to Direct Emission Reduction Strategies

Steven H. Ramsey, P.E., BCEE
Houston, Texas
Presentation Outline

- State of the market
- Brief overview of technologies
- Application example
- Recent market developments
- Market needs
Formal EPA/TCEQ approvals of open-path/remote sensing technologies for regulatory compliance purposes are spotty:
- Use of optical imaging cameras as an alternative work practice to Method 21.
- Incorporation of radial plume mapping methods into Other Test Method 10.
- Compendium Method TO-16 for use of OP-FTIR for toxic air pollutant measurements.
- Other approvals typically via case-by-case project plans.

Potential end-user understanding of the available technologies is often not robust.

Technologies provided mostly provided by small, boutique, entrepreneurial entities.

Limited number of suppliers, many are not based in the US.

Limited delivery capacities for many of the technologies.

Limited validation studies for most technologies.

Many of the suppliers only offer one solution.
ABRAHAM MASLOW

IF THE ONLY TOOL YOU HAVE IS A HAMMER
YOU TEND TO SEE EVERY PROBLEM AS A NAIL

WWW.MAISIAOSIAO.COM
Numerous factors need to be considered when evaluating the various technologies for a specific application:

- Extent of geographic area to be covered.
- Importance of collecting data over time (steady state v. transient or variable sources).
- Pollutants of interest.
- Importance of two-dimensional vertical source profiling.
- Ground-level or elevated source.
- Temperature profile of target release relative to background.
- Loss prevention v. environmental compliance v. affirmative defense.
- Need to accurately quantify emissions.
The Challenge with Quantification is Always the Same

Windflow analysis for Castle house, a 43 story, 408 unit apartment building at Elephant and Castle in Southwark, London
State of the Various Commercially-Available Technologies

- Differential Absorption Light Detection and Ranging, “DIAL”
- Solar Occultation Flux, “SOF”
- Passive optical gas imaging systems:
  - Passive Fourier Transform Infrared (“PFTIR”)
  - Hyper-spectral imaging
  - Forward-Looking Infrared (“FLIR”) cameras
- Active optical gas measurement systems:
  - Open-path FTIR (OP-FTIR”) systems
  - UV Differential Optical Absorption Spectroscopy (“UV-DOAS”)
  - Open-path Tunable Diode Laser Spectroscopy (“OP-TDLAS”)
- Extractive systems:
  - Cavity Ring-Down Spectroscopy (“CRDS”)
Currently, the only commercial supplier is the UK National Physical Laboratory.

New mobile system launched in 2014:
- Twin DIAL (UV and IR)
- Improved lasers, detection systems
- New software and analysis algorithms

Sensitivity of 5 – 200 ppbv (dependent upon target pollutant) at a range of up to 1.5 km.

Reference EU Best Available Technology for periodic quantification of refinery emissions.

EPA Source “DIAL is the best method for measuring emissions from problematic sources.”

Opportunity to use laser return signals to create accurate 2-dimensional wind-field profiles? After all, it is a LIDAR . . .
Technology developed by Dr. Johan Mellqvist, Chalmers University, Göteborg, Sweden.

Commercial provider is FluxSense.

Also a reference EU Best Available Technology for periodic quantification of refinery emissions.

Recently opened an office in San Diego.

Excel at combining technologies to obtain the desired information:

- SOF – C$_2$+ alkanes and alkenes.
- Mobile Sky DOAS – SO$_2$, NO$_2$, formaldehyde.
- Mobile Whitecell DOAS (“MWDOAS”) – Combined with MeFTIR and SOF to estimate BTEX mass flux.
- Mobile Extractive FTIR (“MeFTIR”) – Combined with SOF and MWDOAS to estimate BTEX mass flux and plume height.

Source: FluxSense AB
IMACC PFTIR system performed very well in 2010 flare evaluation conducted by TCEQ and UT Austin at the John Zink test facilities in Tulsa.

Now widely used for evaluating elevated flare combustion efficiency.

Recent test conducted by Atmosfir Optics Ltd. using Bruker Scanning Infrared Gas Imaging System, or SIGIS 2, instrument showed very interesting results for a elevated flares high in alkenes:

- Essentially no relationship between steam/vent gas ratio for a flare using no center steam.
- Very high combustion efficiency (>98.4%) for all operating conditions on two different flares.
Hyperspectral Imaging

- Two hyperspectral imaging systems, Telops and DOD system, were evaluated during 2010 TCEQ/UT flare study. Neither performed well relative to extractive benchmark.

- Rebellion Photonics:
  - Houston-based, relatively new entrant to market.
  - Product has been well received by industry.
  - Claim to be able to detect and quantify up to 20 compounds simultaneously.
  - Very fast scan rate (15 frames/second).
  - EPA and TCEQ are interested in working with Rebellion to validate performance.

Source: Rebellionphotonics.com
Year-Long Study of Emissions from the Houston Refining LP 737 Unit Delayed Coker
Cavity Ring-Down Spectroscopy

Source: Environmental Science & Technology, 2014
Example: Using SOF Results to Prioritize Emission Reduction Strategies

SOF Survey of wastewater treatment facilities at a non-US petroleum refinery.

Slide #14

Source: FluxSense AB
Example: Using SOF Results to Prioritize Emission Reduction Strategies

SOF survey of refined products storage tank farm and ship loading emissions.

Source: FluxSense AB
Recent Market Developments

- Petroleum refinery sector RTR requires fenceline monitoring for benzene.
  - EPA risk assessment indicates that a limited number of refineries will have impacts greater than action level (2-week $\Delta C > 9$ µg/m$^3$). *This analysis assumes reported benzene emissions are accurate.*
  - EPA believes that refinery reported inventories are under-reported by a factor of at least five.
  - 14-day passive-diffusive monitors provide insufficient information for either conducting a root cause analysis or presenting an affirmative defense that elevated benzene is due to off-site sources.
  - EPA’s preference is permanent, fenceline monitors. Didn’t propose it because of concerns about OMB review.

- Bay Area Air Quality Management District proposed recently proposed rules that will require all refiners in the District to install permanent, open-path fenceline monitoring systems.

- South Coast Air Quality Management District is moving forward with a multi-million dollar campaign to survey emissions from a number of petroleum hydrocarbon sources in the district. The campaign includes use of multiple technologies provided by multiple commercial entities.
- Continued improvement in data analysis methods.
- Improved algorithms to process wind speed and direction data with path-integrated (or averaged) concentrations.
- Solve the wind speed and vector problem.
- Improved commercial availability of key technologies, such as DIAL and SOF, in the US.
- EPA global approval of technologies and methods – no more “send us the results and we will see if we like them, first.”
- Solve the “chicken-or-egg” problem. We need more capacity and more competition to improve reliability and lower delivery costs. But for this to happen, there needs to be a significant infusion of investment capital . . . and that requires a dependable market. Will recent regulatory developments solve this problem?
Steven H. Ramsey, P.E., BCEE
Principal
Geosyntec Consultants
11490 Westheimer Road, Suite 150
Houston, TX 77077
Office: +1 281.810.5027
Cell: +1 713.725.7037
Email: sramsey@geosyntec.com