The case for continuous monitoring

Project Canary

The case for continuous monitoring

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Who We Are

● A Public Benefit Corporation, accountable to double bottom line of profit and social good.
● Certified B-corporation

Selected Partners

[Images of logos from various organizations]
What We Do

Trusted, independent data.

**TrustWell™ Certification**
Verification of responsibility in natural gas production with respect to air, water, land and community

**Continuous Monitoring**
Independent, certified, and quantifiable data on methane emissions
Our sensor network

- Over 30 operators under contract
- Primarily, but not only, upstream production facilities
- Network of >200 sensors located across DJ basin, Marcellus, Green River, Permian, SE US
- Sensors each send data every minute
Our Canary sensor

Anemometer
Ultra-sonic

Chemical sensor
TLDAS for methane,
PID for tVOC

Field deployment
Human for scale

Solar panel
(Self-explanatory)
So why continuous monitoring?
Traditionally...

Analytical techniques

Measurement frequency

Episodic

Frequent

High

Low

AVO*

*audio-visual-olfactory inspection
Most emissions are intermittent.
Also: small leaks grow.

Our approach

Analytical techniques
- Episodic
  - Technician + camera/sensor
  - Drones
  - Planes
  - Satellites

Measurement frequency
- High
- Low

Accuracy
- Frequent
- AVO* - audio-visual-olfactory inspection

Project Canary

AVO*: audio-visual-olfactory inspection
FEAST modeling v.1

FEAST model v2.0 results simulating a stationary sensor with 1ppm precision (current CanaryX is 4x more precise) showed gas savings exceeded those of manual infrared camera.

FEAST v3.1 modeling

Using continuous monitoring program (cm) for LDAR with the use of a follow-up OGI camera

- avoids > 80% of emissions
- reduces emissions by >2x compared with OGI camera only

Implementation

Wind Speed & Direction
GHG / Pollution Readings
Sensor Selection
Summa Canister Analysis

List of sites monitored

Site level GHG / pollution alerts sent to operator

Site level wind rose

Current satellite map of facility

Emissions monitor (every circle)
<table>
<thead>
<tr>
<th>Problem</th>
<th>Event Type</th>
<th>Time from Alert to Source Attribution/remediation</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid Knock Out Tank Frozen</td>
<td>Normal Operation</td>
<td>73 hours</td>
<td>Frozen tanks had to have their vapor lines disconnected, leading to emissions.</td>
</tr>
<tr>
<td>Inefficient Flaring</td>
<td>Hardware Inefficiency</td>
<td>42 hours</td>
<td>SCADA data confirmed that a combustor didn’t light, flow pressure issues fixed - improving combustion.</td>
</tr>
<tr>
<td>Vapor Recovery Unit Pressure Issues</td>
<td>Hardware Inefficiency</td>
<td>7 hours</td>
<td>Vapor Recovery Unit pressure levels accounted for, preventing continued emissions.</td>
</tr>
<tr>
<td>Thief Hatch Left Open</td>
<td>Leak</td>
<td>4 hours</td>
<td>Operations team made aware of event; hatch closed and leak remediated.</td>
</tr>
<tr>
<td>Unplanned Storage Tank Venting</td>
<td>Hardware Inefficiency</td>
<td>40 minutes</td>
<td>A seal was stuck open, leading to pressure buildup in storage tanks leading to venting. Closing the seal fixed the issue.</td>
</tr>
<tr>
<td>Water Hauling Emissions</td>
<td>Process Inefficiency</td>
<td>10 minutes</td>
<td>Oil Field Services company didn’t connect to vapor line. OFS companies addressed by HSE Dept.</td>
</tr>
</tbody>
</table>
Automated reporting

Critical to program and saves hours of labor. Thanks to CDPHE for working with us!
Some lessons we’ve learned.
Sensor placement doesn’t matter

Wind shifts frequently in the field, allowing for thousands of measurements even when not in prevailing wind direction.
Sensor placement doesn’t matter

Canary methane sensors collect 376 measurements/day across multiple equipment groups

![Map and graphs showing sensor placement and measurements](image-url)
Sensor placement doesn’t matter

Spotlight on Dec. 17: even when wind doesn’t blow directly, still can capture leaks.
Sensor placement does matter* for a mass emissions flux calculation.

*for a mass emissions flux calculation

This sensor mis-identifies the leaking separator.
Sensor placement does matter*

*for a mass emissions flux calculation

Unclear if detector is seeing a large leak from the tanks or a small leak from the wellhead.
Why placement matters

By contrast, these sensors confuse fewer sources.
Height sensitivity low

- 14 large emission events (>0.4 ppm) were analyzed across for one facility for a 6 week period
- Sensors placed at 5 feet and 10 feet were compared

Source: William Daniels and Dorit Hammerling at Colorado School of Mines with Project Canary data
Height sensitivity low

• Higher units see higher concentrations, but these can be explained by calibration differences (average difference of 0.43 ppm)

• “5 foot height difference has a relatively low impact on observed VOC concentrations”

Source: William Daniels and Dorit Hammerling at Colorado School of Mines with Project Canary data
Sensor response time matters

For big events, a slow sensor response time may not matter (except, of course, in quantification).

For smaller events, a slow sensor response time may result in not seeing the event.
Conclusions

- Market forces driving adoption of emissions monitoring technology in the natural gas supply chain
- Continuous monitoring effective LDAR method to achieve emissions reduction
- Sensor placement not as important as measuring in the first place
- Low sensitivity to height
- Mass emissions flux calculations sensitive to sensor placement, but not event detection
- Sensor response time is important

Reach out anytime at:
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Payne Institute Report
1. Localization matters

Unclear if detector is seeing a large leak from the tanks or a small leak from the wellhead.
Unclear if detector is seeing a large leak from the tanks or a small leak from the wellhead.
Localization

<table>
<thead>
<tr>
<th>Location</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wellhead</td>
<td>10%</td>
</tr>
<tr>
<td>Separator</td>
<td>5%</td>
</tr>
<tr>
<td>Tanks</td>
<td>75%</td>
</tr>
</tbody>
</table>

Wind direction

![Localization Diagram]
Resampling

Minute data is noisy because plume moves around.

Maximum data overestimates, suggesting model incorrectly describes dispersion.

Resampled data provides better estimate, but 2 hourly is best.
2. Background calculation

Non events help calculate the background.