Accelerated Detection and Repair of large leaks
Emission Calculations

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The concept of Super Emitters

- Methane emissions in distribution system are driven by a relatively small number of large leaks named Super Emitters.

WSU Study Data

- WSU study: Only 2% of leaks were > 10 scfh but accounted for 56% of total emissions

- Opportunity for substantially reducing methane emissions by accelerating detection and repair of large leaks.
The opportunity

- Large leaks are **easy to detect** with mobile surveys (Picarro).
- Leak flow rate quantification is still challenging with mobile devices but:
  - Solid data coming from NYSEARCH study is now available

![NYSEARCH Tests Unity Plot](image)

- 78% of data points within doted lines
Proposed Method

1. Drive Picarro car on an accelerated basis (e.g. once a year)
2. Filter out any indications <10 scfh (Picarro’s algorithm)
3. Investigate and repair leaks associated with large indications (>10 scfh)
4. Savings from two sources:
   a) Accelerated detection and repair of “super emitters”
   b) Reduction of Emission Factors for other leaks
1. What is the probability for a SE to be detected as a SE

\[
P(A|B) = \frac{P(B|A) \times P(A)}{P(B)} = \frac{P(B|A) \times P(A)}{P(B|A) \times P(A) + P(B|\bar{A}) \times P(\bar{A})}
\]

2. What is the emission factor of a leak detected as a SE

\[
EF(B) = P(A|B) \times EF(A) + (1 - P(A|B)) \times EF(\bar{A})
\]

Nysearch data leads to:

<table>
<thead>
<tr>
<th>Term</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>( P(B</td>
<td>A) )</td>
</tr>
<tr>
<td>( P(A</td>
<td>B) )</td>
</tr>
<tr>
<td>( P(B</td>
<td>\bar{A}) )</td>
</tr>
<tr>
<td>( P(\bar{A}) )</td>
<td>90%</td>
</tr>
<tr>
<td>( P(A) )</td>
<td>10%</td>
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Emission Calculations

Using 2017 data we calculate the average emission factor for all leaks:

\[ EF = \frac{2017 \text{ Emissions}}{\sum_{\text{Leaks},i} \Delta t(i)} \]

Assuming that the leak size distribution is similar to WSU’s distribution:

\[ 0.02 \cdot EF(A) + 0.98 \cdot EF(\bar{A}) = EF \]
\[ 0.02 \cdot EF(A) = 0.56 \cdot EF \]

[WSU Study Data graph showing frequency vs. methane emission (Scfh) with data points labeled SE: 47 scfh, Average: 1.7 scfh, Non-SE: 0.75 scfh]
Emission Calculations

$x_B$ and $y_B$ Super Emitter leaks were detected in 2018 in the surveyed and non-surveyed area respectively:

\[ P(A|B) \cdot x_B \] were actual Super Emitter leaks

\[ \frac{P(A|B) \cdot P(\bar{B}|A) \cdot x_B}{P(B|A)} \] were missed Super Emitter leaks

We can therefore calculate the Emission Factor to be assigned to detected Super Emitter leaks and non-Super Emitter leaks:

\[ EF(B) = P(A|B) \cdot EF(A) + (1 - P(A|B)) \cdot EF(\bar{A}) \]

\[ EF(\bar{B}) = \frac{P(A|B) \cdot P(\bar{B}|A)}{P(B|A)} \cdot \frac{x_B}{x_{\bar{B}}} \cdot EF(A) + \left(1 - \frac{P(A|B) \cdot P(\bar{B}|A)}{P(B|A)} \cdot \frac{x_B}{x_{\bar{B}}} \right) \cdot EF(\bar{A}) \]

Knowing the date of repair of leaks, we can calculate the emissions of 2018:

\[ \text{Emissions} = \sum_{x_B, y_B} EF(B) \cdot \Delta t_B + \sum_{x_{\bar{B}}, y_{\bar{B}}} EF(\bar{B}) \cdot \Delta t_{\bar{B}} \]

For a WSU distribution:

\[ EF(B) = 20 \text{ scf h} \]

\[ EF(\bar{B}) = 1 \text{ scf h} \]
Thank you

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WSU GRI and CARB (PG&E) Study Data

Carb Leak Measurements at PG&E
1. Tested the approach in the field by directly measuring flow rate of 58 large leaks related to large detection by Picarro system (>10 scfh)
   - Found about 2 large detections per week
   - Picarro prediction within order of magnitude of actual leak rate
Field tests results

<table>
<thead>
<tr>
<th>Term</th>
<th>Observed values</th>
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<tr>
<td>$P(B</td>
<td>A)$</td>
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<tr>
<td>$P(A</td>
<td>B)$</td>
</tr>
<tr>
<td>$P(B</td>
<td>\bar{A})$</td>
</tr>
</tbody>
</table>
Example 1

Measured: 60 scfh
Actual: 98 scfh

source locations
Example 1

Bar-hole locations:
Example 2

Measured: 29 scfh
Actual: 19 scfh
Example 2
Example 3

Measured: 12 scfh
Actual: 18 scfh
Example 3