Super-emitters at Canadian Production Sites: From Measurements to Mitigation

Dr. Daniel Zavala-Araiza | 11.21.2017

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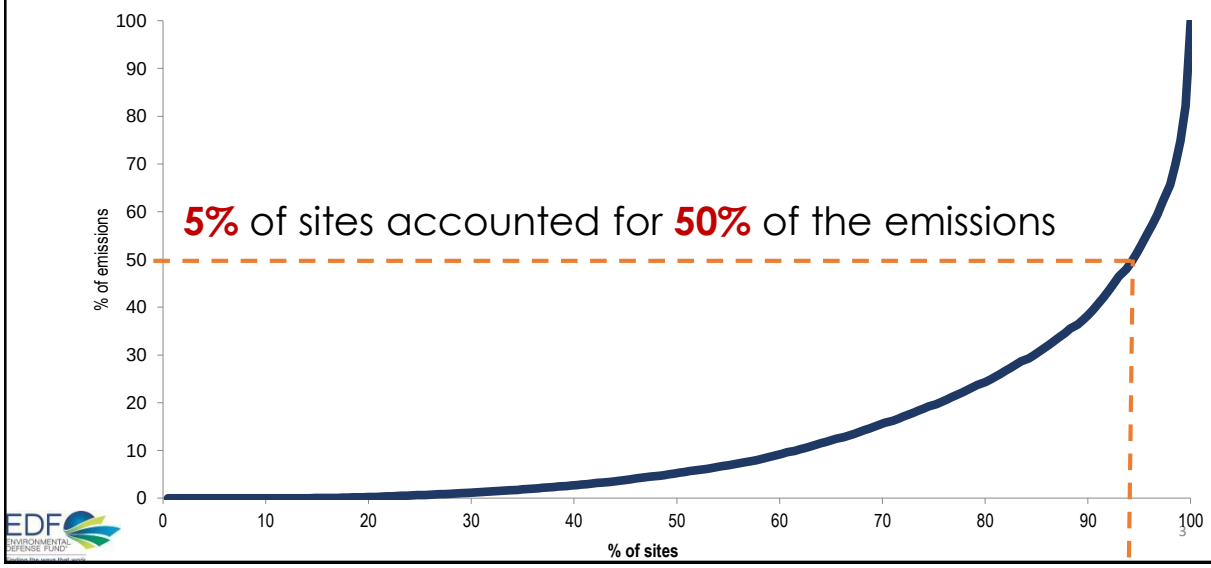
Finding the ways that work[1]

Fat tails, super-emitters, and skewed distributions

Fat tails, super-emitters, and skewed distributions

- Examples of super-emitters in the oil and gas infrastructure

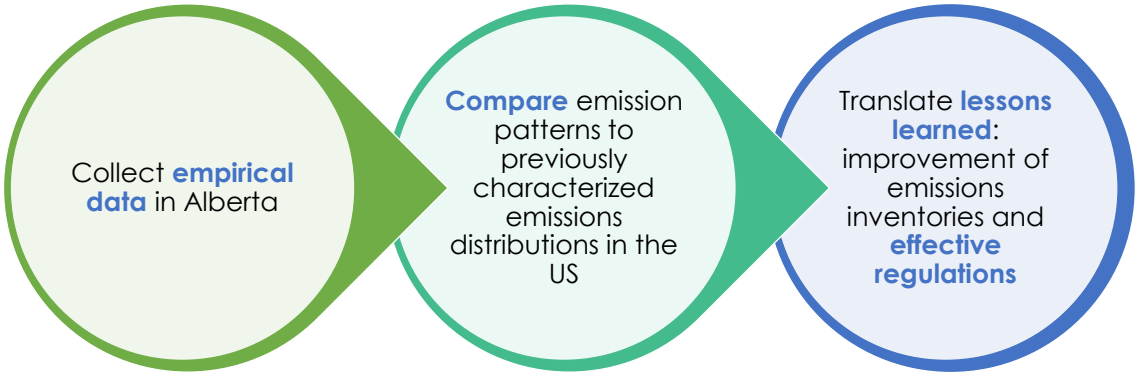


Fat tails, super-emitters, and skewed distributions

- Examples of super-emitters in the oil and gas infrastructure
- Pneumatic Controllers: **13%** of devices account for **88%** of emissions. (Allen et al., 2014)

Accurate emission estimates | Mitigation of emissions

- Gathering stations: **30%** of facilities account for **80%** of emissions. (Mitchell et al., 2015)
- Transmission and storage: **5%** of facilities account for **>30%** of emissions. (Zimmerle et al., 2015)



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Measurements in Alberta

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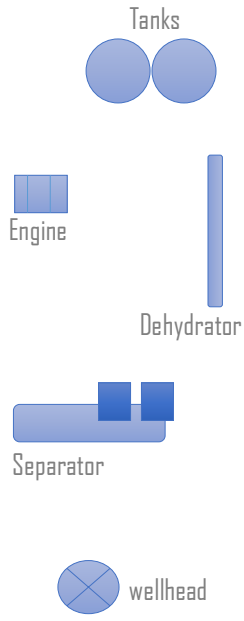
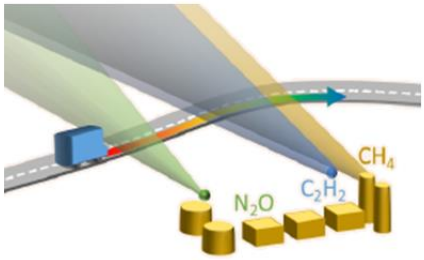


Site-based



VS.

Component-based

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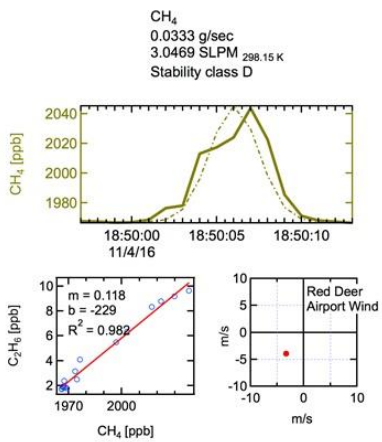
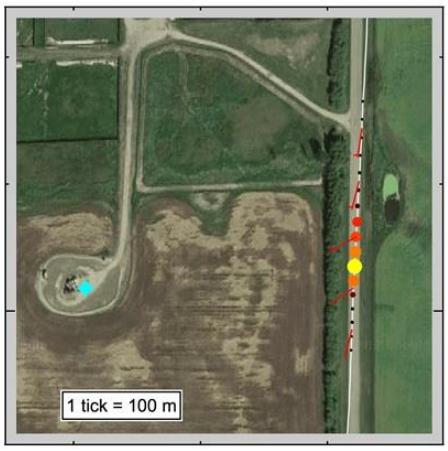
Downwind measurements of production sites





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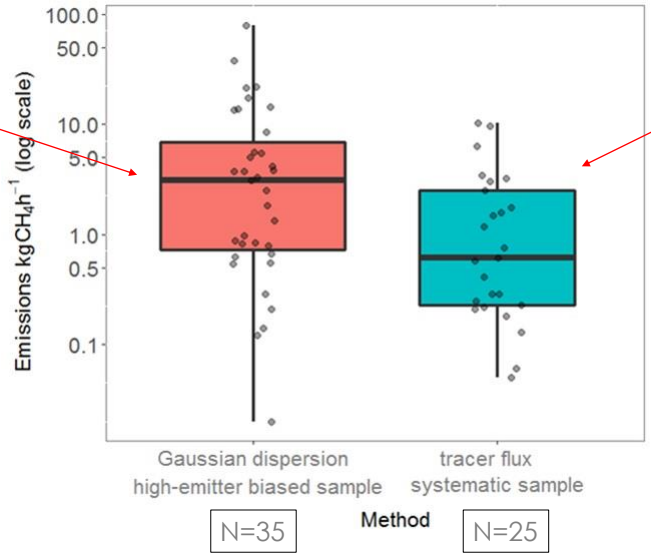
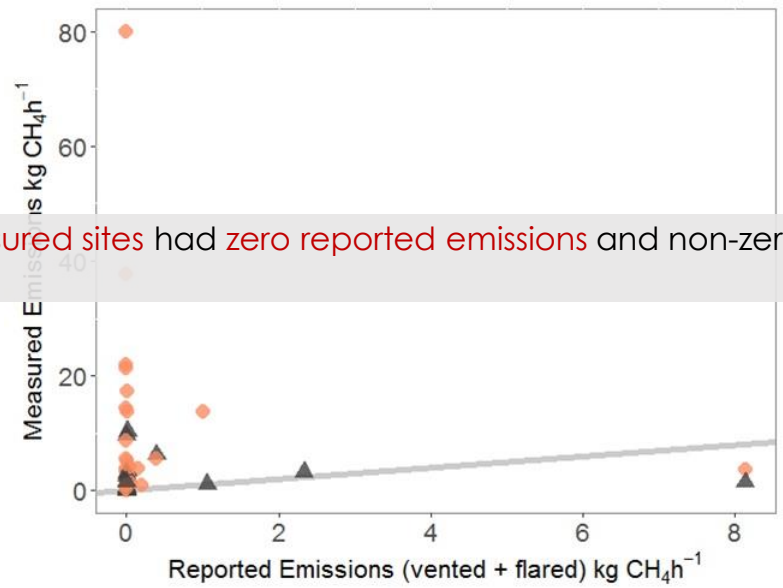
Downwind measurements of production sites

Explicitly looking for low probability high-emitters



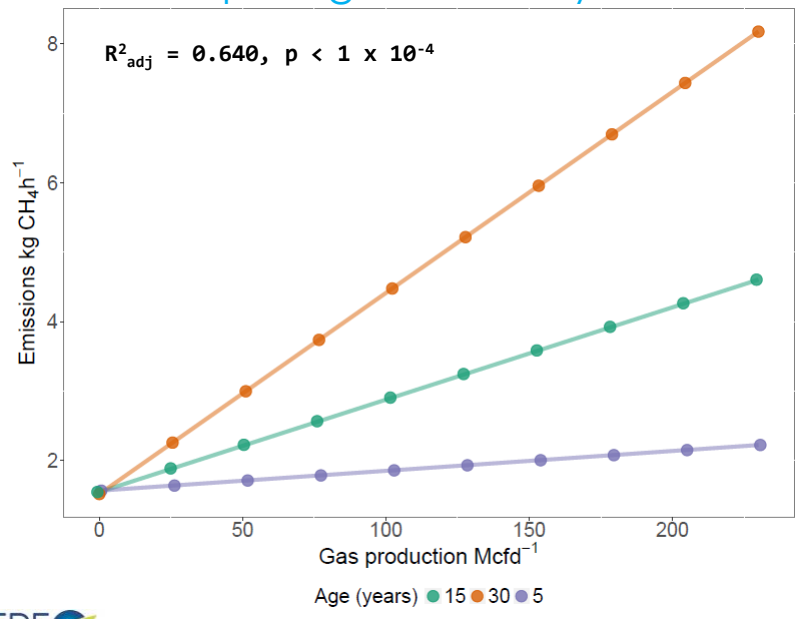
Random

Results: Emissions mainly unreported



60% of the measured sites had zero reported emissions and non-zero measured emissions.

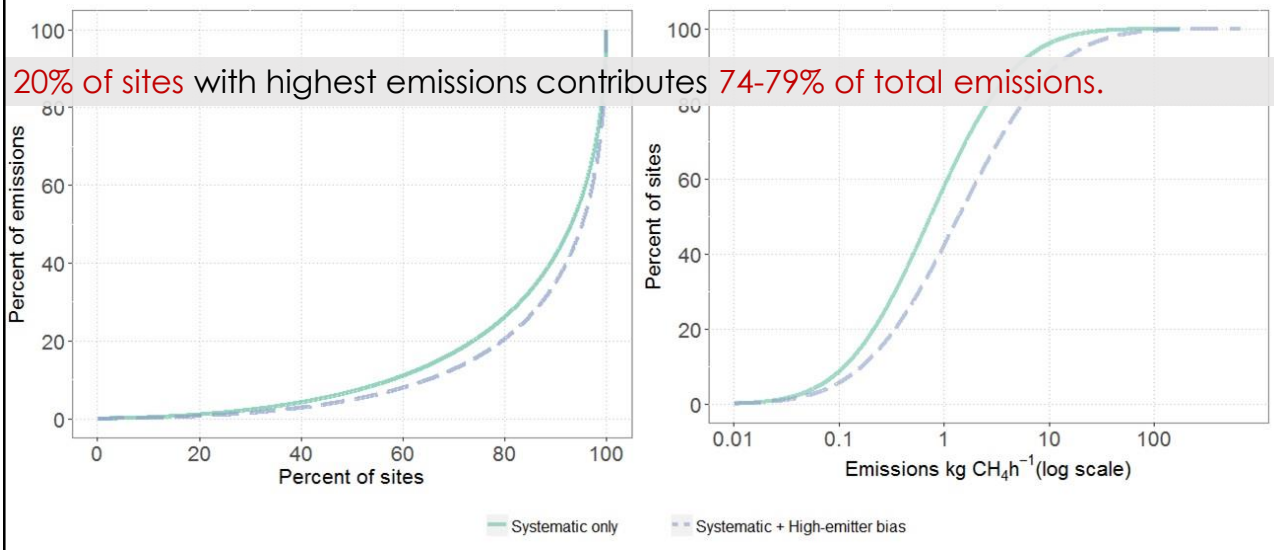
Results: Multiple regression analysis



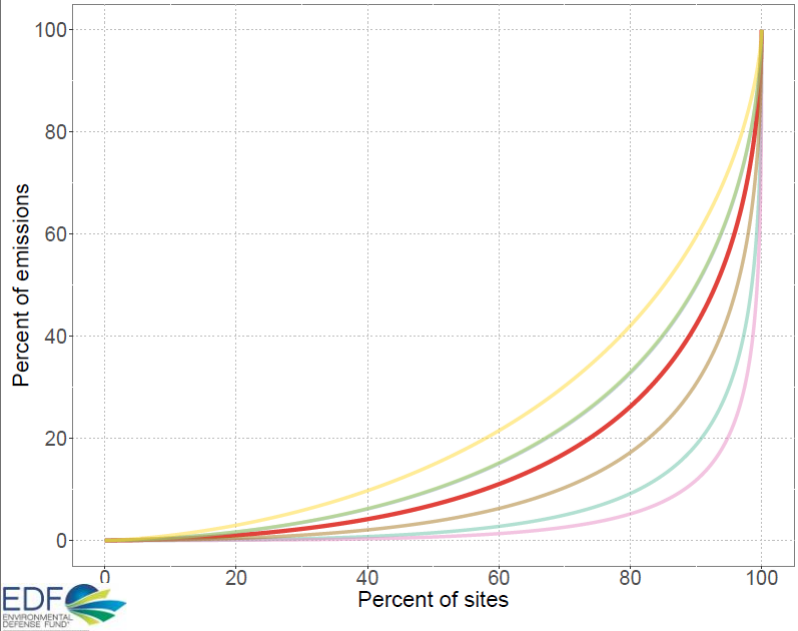

```
Emissions ~
Gas production +
Oil production +
Age +
Gas production : age
```


Results: Disproportionate impact of high-emitting sites

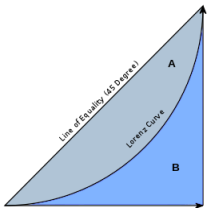
20% of sites with highest emissions contributes 74-79% of total emissions.



Results: Comparison to other US production regions



Red Deer, Alberta(this work)
Barnett Shale, Texas
Denver-Julesburg, Colorado
Fayetteville, Arkansas
Marcellus Shale, Pennsylvania
Uintah, Utah
Upper Green River Wyoming



$$G = \frac{A}{A+B}$$

G = 0 Equal contribution
G = 1 Disproportionate contribution

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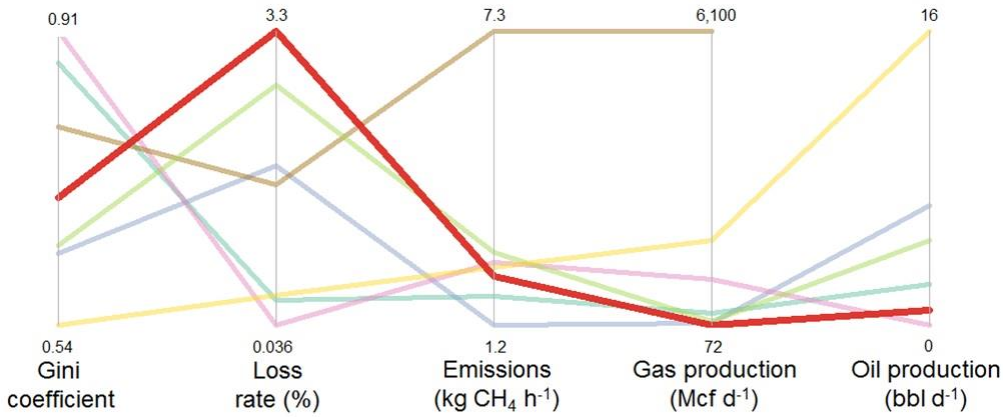
Results: Comparison to other US production regions



Red Deer, Alberta(this work)
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Policy implications

Measured emissions higher than reported.

Improvements needed for measured and reported data.

Frequent or even continuous site-level monitoring of emissions or process conditions will most likely be required to address emissions from these sites (spatio-temporally dynamic super-emitting sites).

Very high proportional loss rates across the Red Deer production sites — the highest amongst all the regions compared in this work. Other sources of unreported emissions (e.g., pneumatic controllers, fugitive emissions) are likely causes of non-zero emissions at a large fraction of production sites.

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US Lessons learned: from measurements to mitigation

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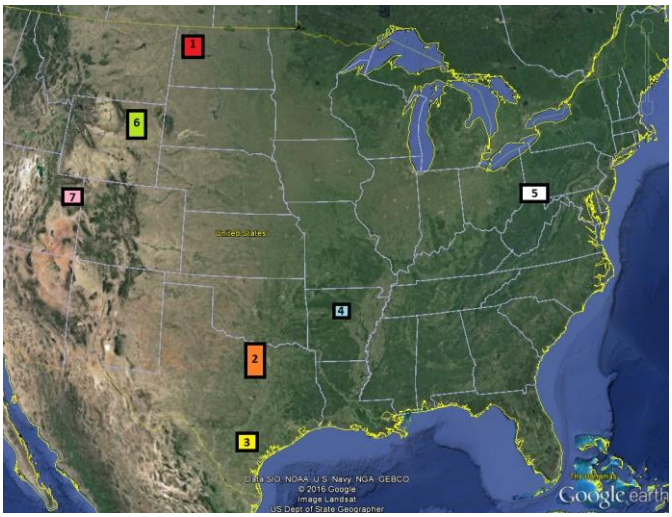
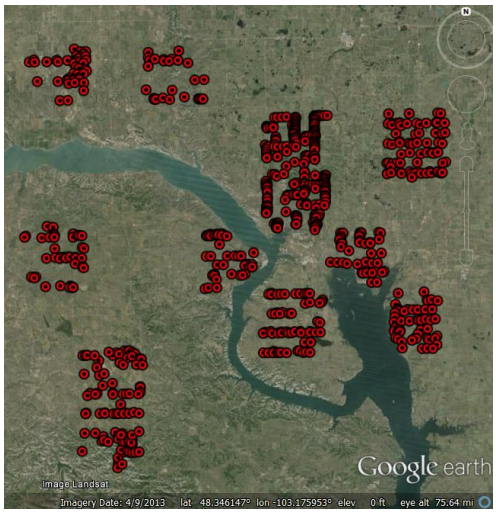
US Helicopter IR survey





8,220 well pads in seven basins selected by stratified random sampling

[Source: Lyon et al, ES&T 2016]

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US Helicopter IR survey

- Large emissions most commonly from tanks but location cannot be predicted.
- Super-emitters are more common in oil producing regions but their individual occurrence is stochastic.
- Frequent monitoring required since occurrence of large emissions is stochastic.

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[Source: Lyon et al, ES&T 2016]

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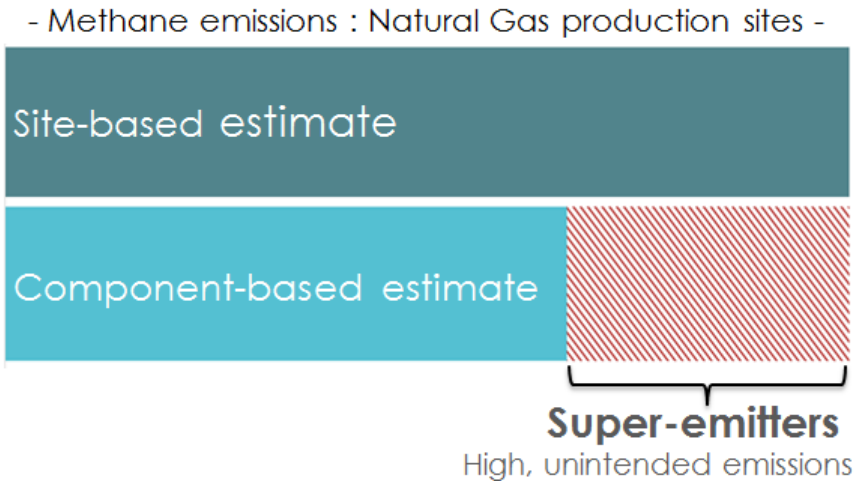
Super-emitters in natural gas infrastructure are caused by abnormal process conditions



[Source: Zavala-Araiza et al, Nature Communications, 2017]

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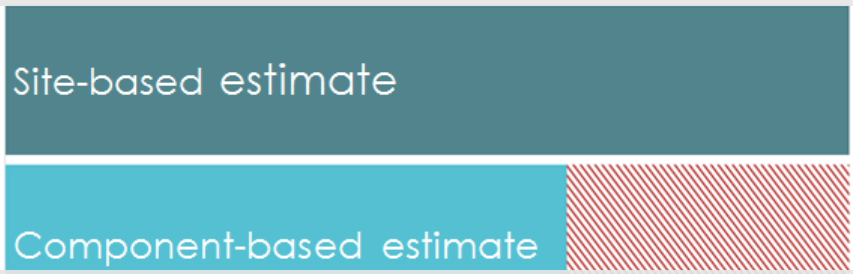
Super-emitters in natural gas infrastructure are caused by abnormal process conditions

Component-based estimates do not produce enough high-emitting sites (condensate flashing, liquids unloadings are not enough).



The inability of routine operating conditions to explain high-emitting sites reveals the existence of **super-emitters: sites with abnormal process conditions.**

[Source: Zavala-Araiza et al, Nature Communications, 2017]

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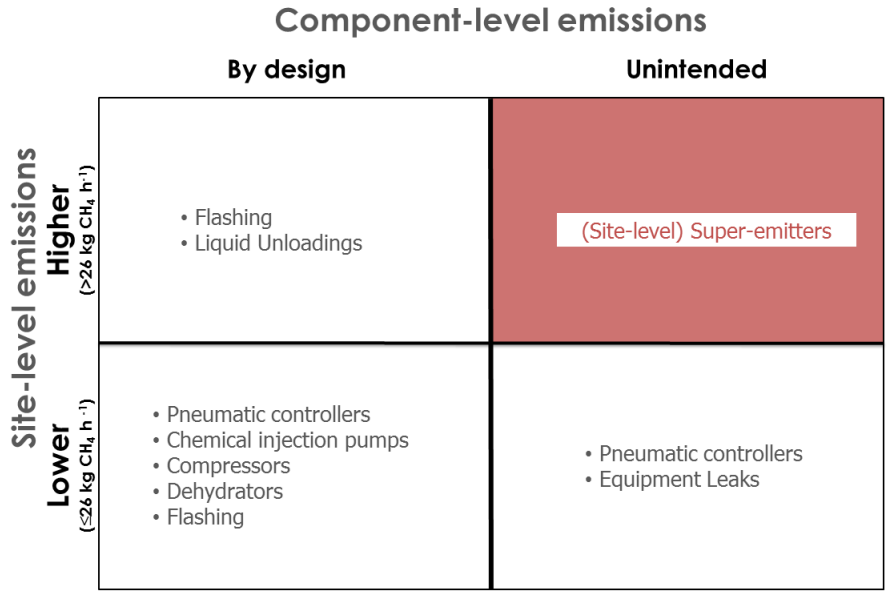

[Source: Zavala-Araiza et al, Nature Communications, 2017]

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Final thoughts

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Final Thoughts

High emission at a site are often a consequence of a few components with malfunctions/equipment issues.

A zero-emitting site at a snapshot in time, could easily turn into a super-emitter when a malfunction/equipment issue appears.

Improvements needed for measured and reported data.

Frequent or even continuous site-level monitoring of emissions or process conditions will most likely be required to address emissions from these sites.

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Dr. Daniel Zavala-Araiza | dzavala@edf.org

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