# Quantifying Cost-Effectiveness of Systematic Leak Detection and Repair Programs Using Infrared Cameras

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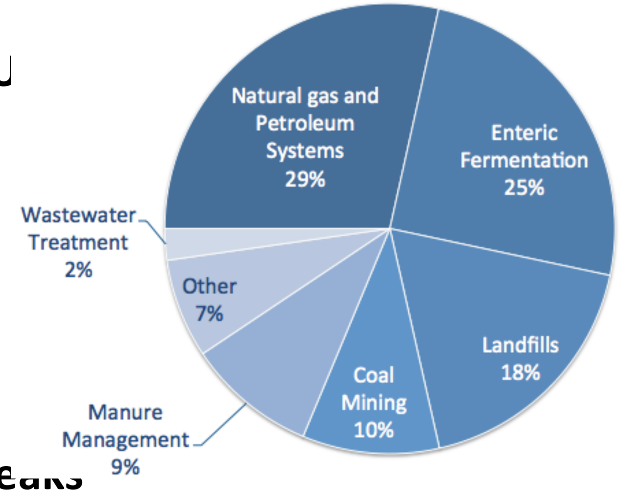
# MOTIVATION

Importance of methane from oil and gas and potential value of IR cameras

Methane is a powerful GHG and reducing methane emissions will be an important approach to reducing the rate of warming over coming decades, in conjunction with $CO_2$ mitigation.

**Oil and Gas is a large source of anthropogenic methane in the U**




Since methane is a main component of natural gas, **technologies that prevent emissions by conserving more gas for sale can be very cost-effective.**

**Our hypothesis is that leak detection and repair (LDAR) programs that find leaks with infrared cameras may be a cost-effective means to reduce methane emissions.**

EPA's 2012 rulemaking on the oil and gas industry (NSPS Subpart OOOO) did <u>not</u> calculate cost-effectiveness ($/ton abated) of LDAR programs using IR Cameras.

# STUDY DESIGN

Two firms which provide leak-detection services provided Carbon Limits with anonymous data quantifying emissions and repair costs of leaks and excessive venting from over **60,000 leaks and vents from 4,000 surveys** of oil and gas facilities.

- *Most data is from Canada; the balance is from US.*
- *Most data is from repeat surveys.*

**The dataset includes ~39,000 individual leaks from static components**

**Overview of the firms' service:**

- Screening the site to detect leaks with IR Camera
- Quantify or estimate the emission rate for detected leaks
- Delivery of an leak inventory, including repair cost estimates, to facility owners

Based on these data, we built a database that includes, for each individual emitter:

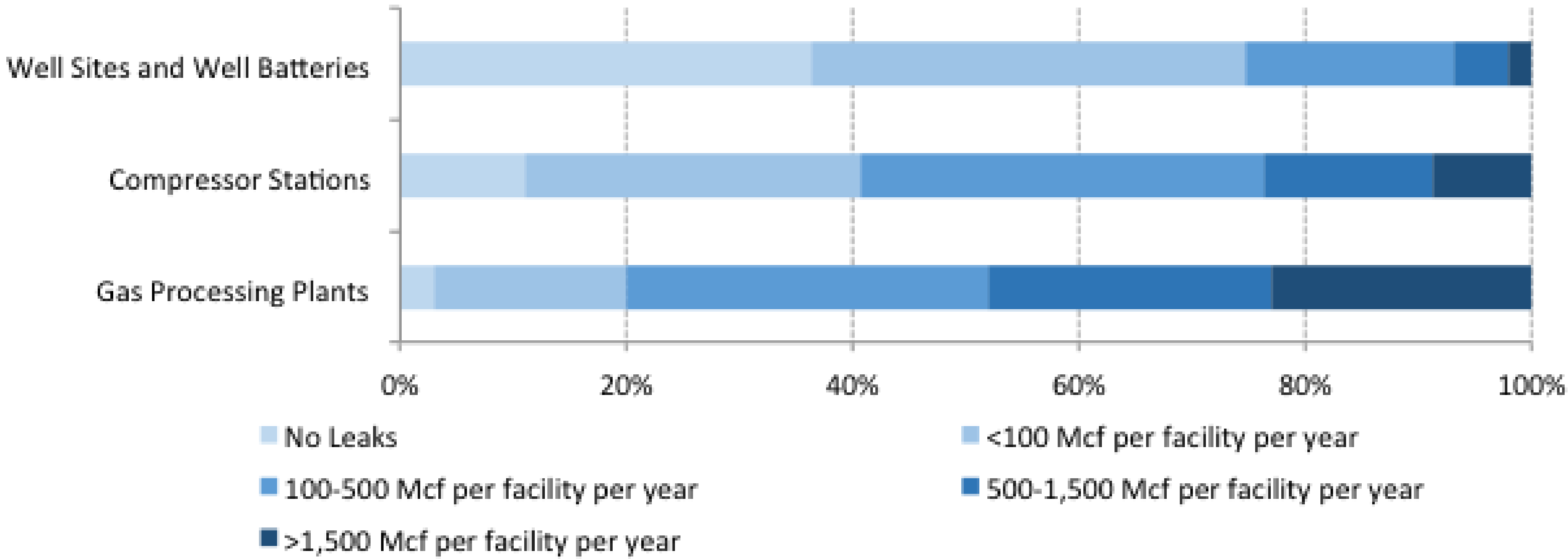
- Type of component
- The gas emissions rate and gas composition
- The repair costs and repair lifetime.

***From this data we are able to calculate LDAR program costs under a range of assumptions***

| Facility Type | # of surveys |
|---|---|
| Compressor Station | 1915 |
| Gas Plant | 614 |
| Well site & Well battery | 1764 |
| Other | 85 |

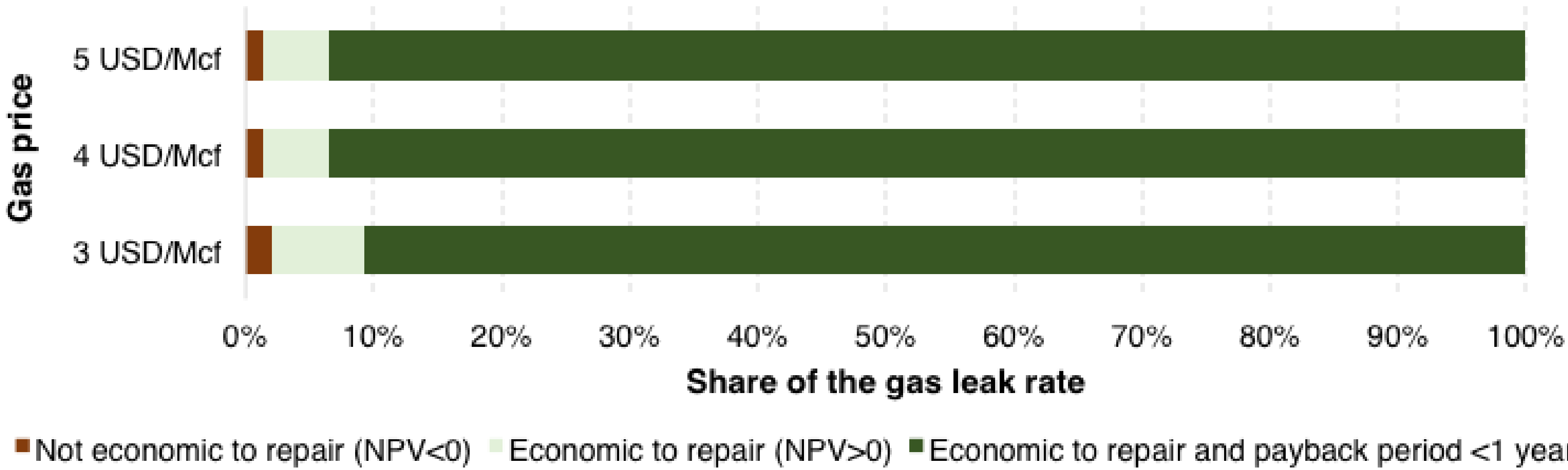
# POTENTIAL LEAKS REDUCTION

## Distribution of Leaks in our Surveys



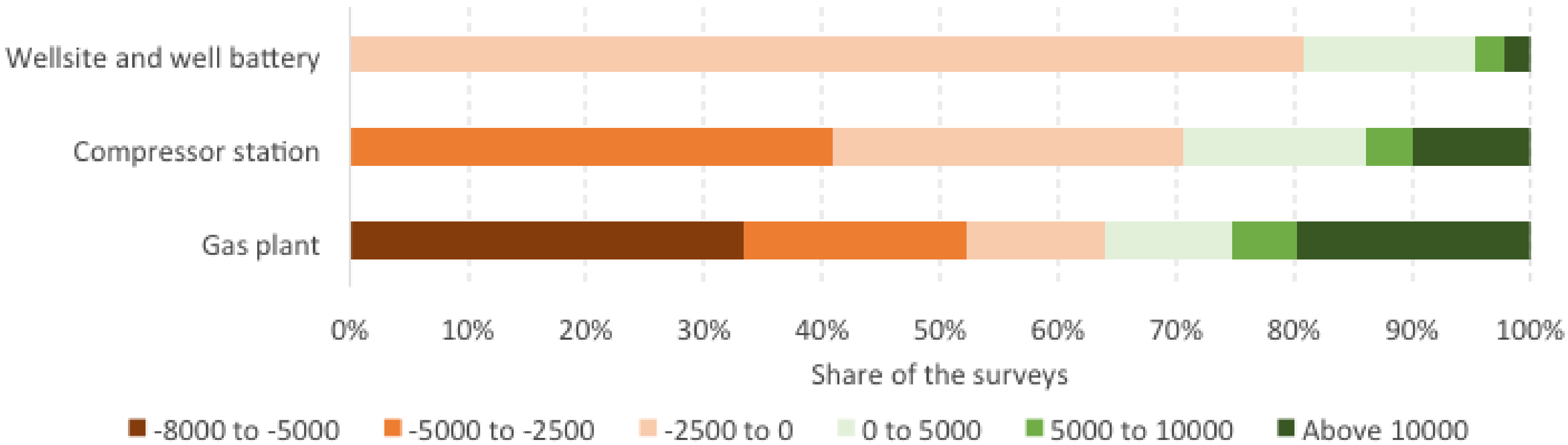
# ECONOMICS OF REPAIRS

## Portion of leak emissions economic to repair




**It is (almost) always economic to repair leaks, once identified**

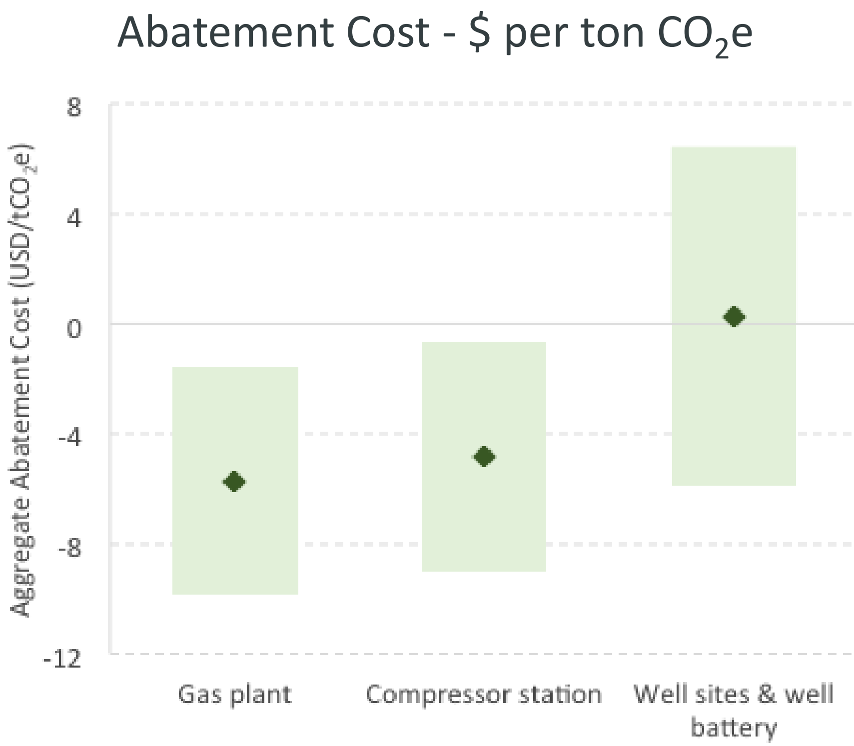
# DISTRIBUTION OF NPVs OF LDAR PROGRAM AT INDIVIDUAL FACILITIES

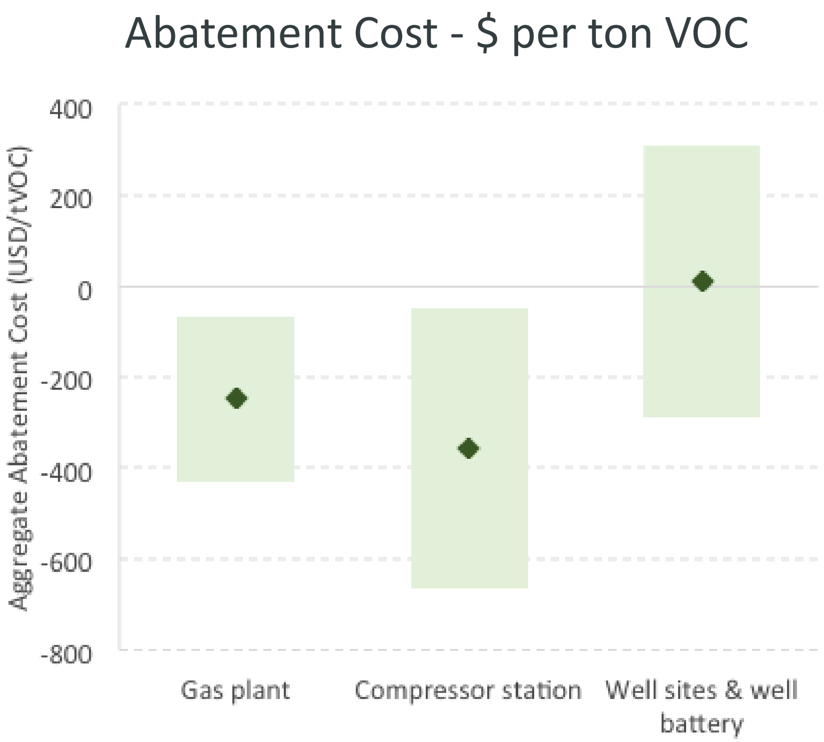



- Many facilities have negative project NPV (Survey + repair), essentially because few leaks were identified at those sites and the survey has a fixed cost.
- However, even when the project is not economic, the costs involved for the operator are relatively low – survey costs are limited.

# AGGREGATE LDAR ABATEMENT COSTS

## Equivalent to nationwide cost-effectiveness




**Base Case** assumes $4 / MCF for price of gas; "internal costs" to gas producers are 50% of the price paid to have external firm perform the survey, and fixing all identified leaks

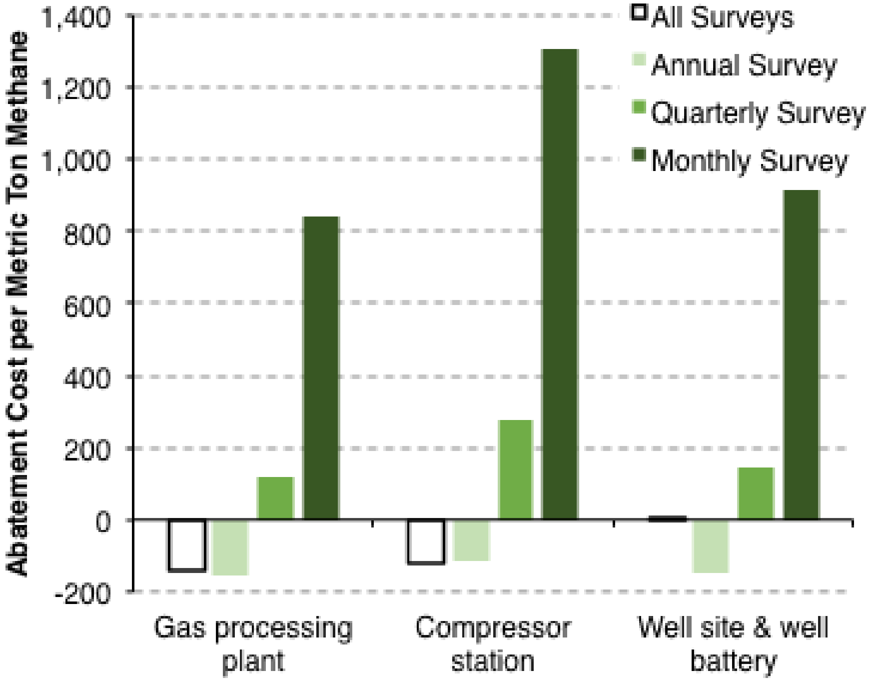
**Uncertainty range** includes gas prices of $3 – $5, "internal costs" from 0-100% of external cost of surveys

***BASE CASE ASSUMPTIONS APPLY ON FOLLOWING SLIDES*** unless stated otherwise…

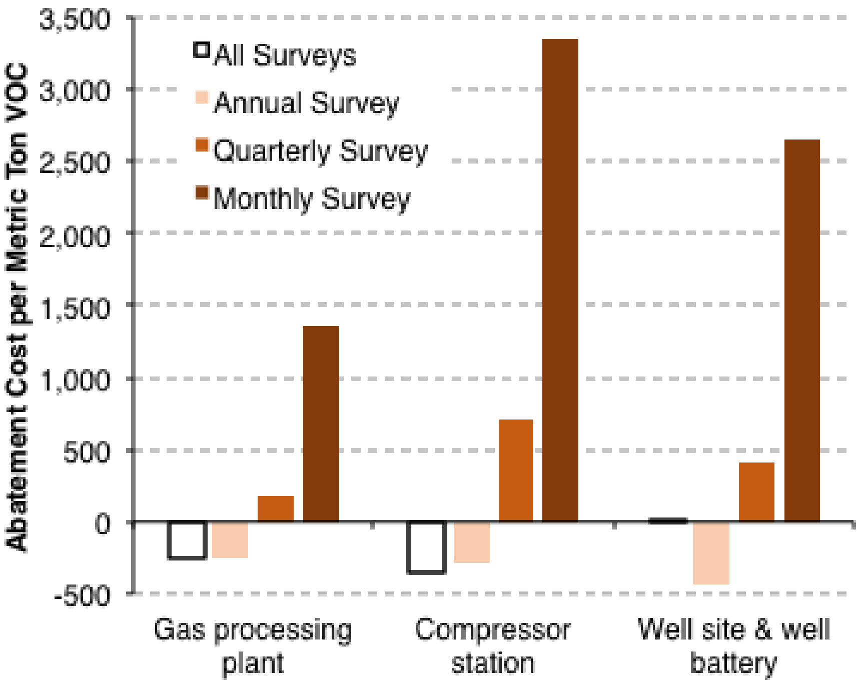
# FREQUENCY & COST-EFFECTIVENESS

A subset of surveys (12%) are known to be repeat visits (typically annual)
This allows calculation of cost-effectiveness of surveys of various frequency.

Abatement Cost - $ per ton $CH_4$

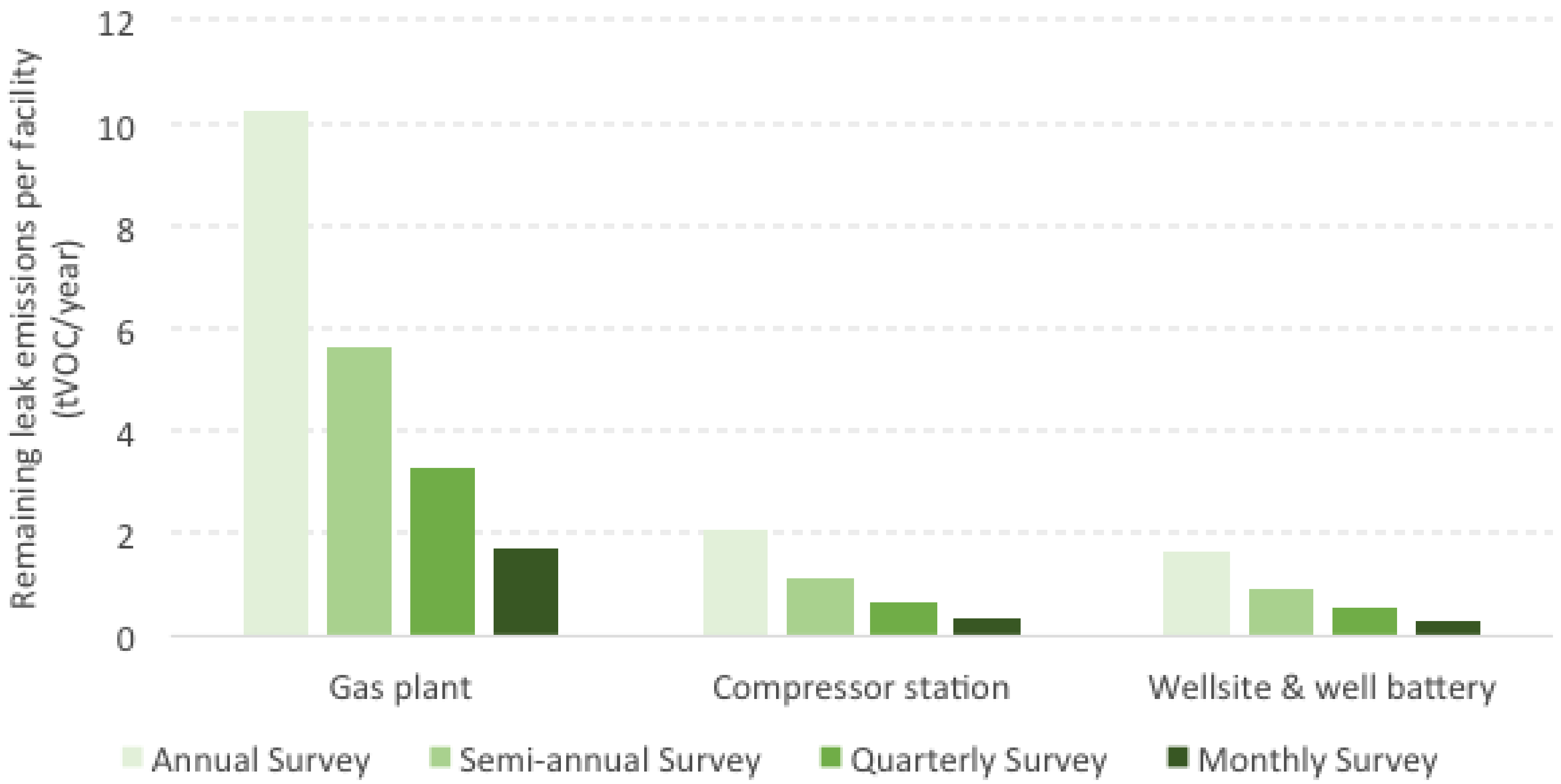



Abatement Cost - $ per ton VOC




This is an overestimate of true abatement costs, because it only includes leaks found in repeat surveys. *Without earlier surveys, leaks would have been higher*.

# MORE FREQUENT SURVEYS WOULD RESULT IN LOWER EMISSIONS



# COMPARING POLICY APPROACHES

| | |
|---|---|
| **Base Case** | Repair all the leaks |
| **Strategy 2** | Repair the leaks which are economic to repair |
| **Strategy 3** | Repair all the leaks over an emissions rate threshold, such as 20 Mcf per year. |

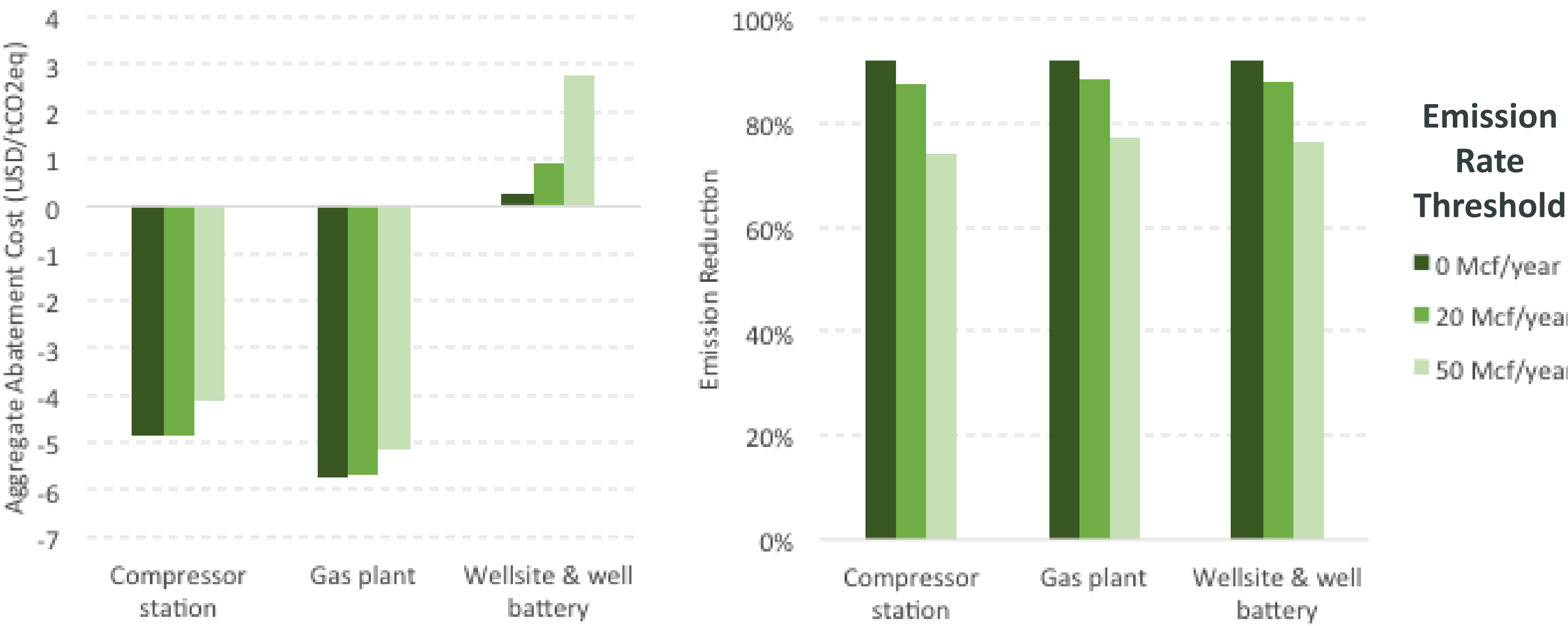
# COMPARING POLICY APPROACHES

## Emissions abatement and cost-effectiveness of 3 strategies

| Compressor Station | Base Case (all identified leaks) | Strategy 2 (leaks with NPV>0) | Strategy 3 (leaks > 20 Mcf/yr) |
|---|---|---|---|
| Potential leak reduction after each survey | 94.7% | 93.0% | 87.7% |
| Methane abatement cost (in USD/$tCO_{2e}$) | -4.9 | -5.0 | -4.8 |
| VOC abatement costs (in USD/tVOC) | -355 | -368 | -357 |
| Average number of leaks to repair per facility | 11.3 | 10.2 | 6.9 |
| **Multi well Battery** | **Base Case** | **Strategy 2** | **Strategy 3** |
| Potential leak reduction after each survey | 94.5% | 92.6% | 88.1% |
| Methane abatement cost (in USD/$tCO_{2e}$) | 1 | 0.8 | 1.7 |
| VOC abatement cost (in USD/tVOC) | 46 | 41 | 79 |
| Average number of leaks to repair per facility | 3.8 | 3.5 | 2.9 |

# COMPARING POLICY APPROACHES

## Sensitivity to Emission Rate Threshold (Strategy 3)




Policies exempting smaller leaks from repair requirements reduce emissions less, but are **not** more cost-effective on an aggregate basis – the small leaks are often economical to repair and help offset the cost of the surveys.

# LIMITATIONS OF THIS STUDY

**This dataset contains valuable information about the cost-effectiveness of routine leak detection & repair, but little information about current US emissions from leaks.**

Most of the data is from repeat surveys (see slide 15)

(we are only able to *prove* that 12% of surveys are repeats, because of anonymity of data, but we know that far more that 12% are repeats)

**Data is mostly from Canada**

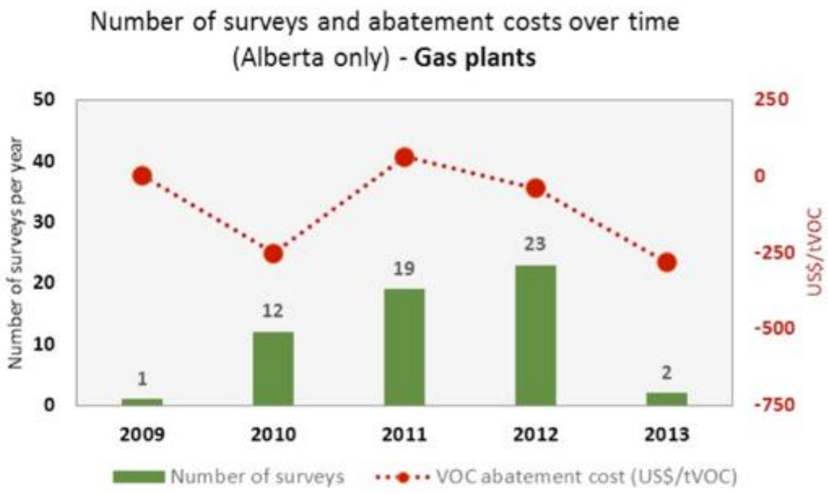
Data from US facilities shows higher emissions per facility, and LDAR programs at US facilities are more cost-effective

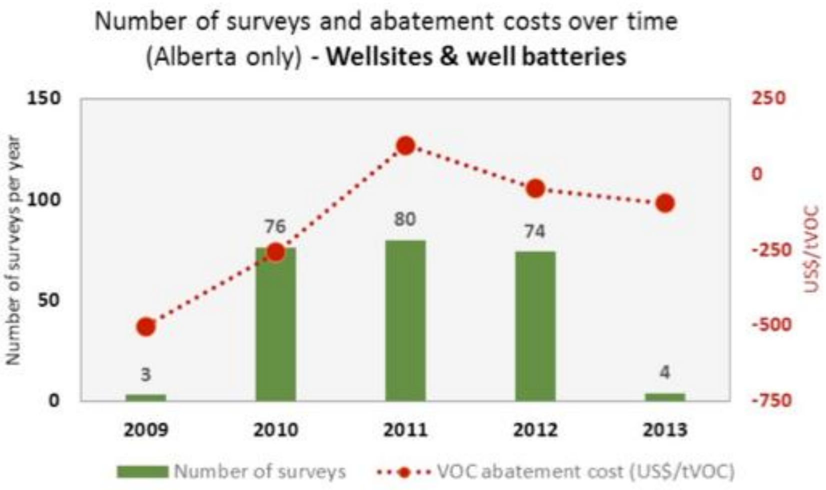
**Database contains some estimated leak rates**

Excluding surveys with high portions of estimates in total emissions does not have large effects on cost-effectiveness

# REPEAT SURVEYS

## Aggregate Results for Alberta (2007 Regulation Requiring LDAR)




**Aggregate VOC abatement cost for LDAR surveys in Alberta, by year**

LDAR remains cost-effective, even in the third year of surveys. There is no pattern of compounded decreases in leaks in successive years.

Despite the Alberta rule being in place for several years, no trend in the dataset towards higher cost per ton of avoided emissions in later years.

# INCLUDING COMPRESSOR ROD PACKING REPLACEMENTS IN LDAR PROGRAMS

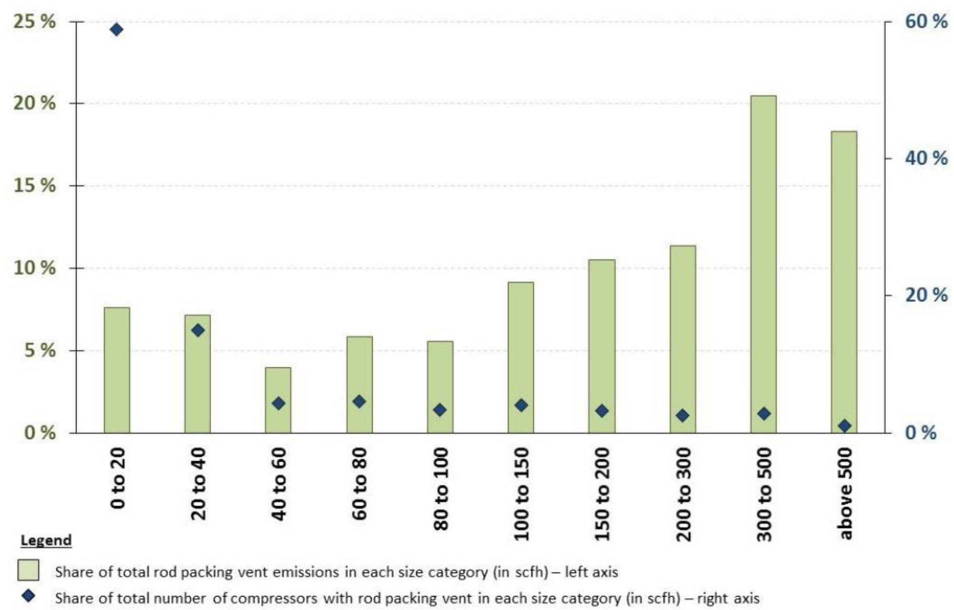
Rod packing emissions in our database:

- 21% of gas plant emissions
- 17% of compressor station emissions
- Less than 1% for well sites and well batteries

**Rod packing replacement** can cost-effectively address 70% of rod packing emissions at gas plants and 73% of rod packing emissions at compressor stations.

**Substantial increase in program emissions reductions**: +21% for CO2e and +14% for VOC

A large portion of emissions originate from a relatively small fraction of compressors; 50% of rod packing emissions is from less than 7% of compressors emitting more than 200 scfh.



# CONCLUSIONS

Leak Detection and Repair programs at oil and gas production and processing facilities using IR cameras have low abatement costs and are cost-effective on a aggregate basis

Most leaks are cost-effective to repair (payback < 1 year), and survey costs are low

Cost and emissions reduction are not highly sensitive to program design

Many facilities do have positive abatement costs (NPV < 0) but these are limited by the low costs of surveys

Some firms appear to be taking the approach of "don't measure it, just fix it" once surveys are underway

# COMING SOON

**Carbon Limits is currently working on a separate report on Gas Utilization Technologies appropriate for Tight Oil Formations. This should be published in a few weeks!**

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# Additional Material

# Comparison of Canadian & US Facilities

**The prevalence of Canadian data in this this dataset suggests that these conclusions are conservative with respect to US cost-effectiveness**

Identified differences between the two countries (based on interviews):

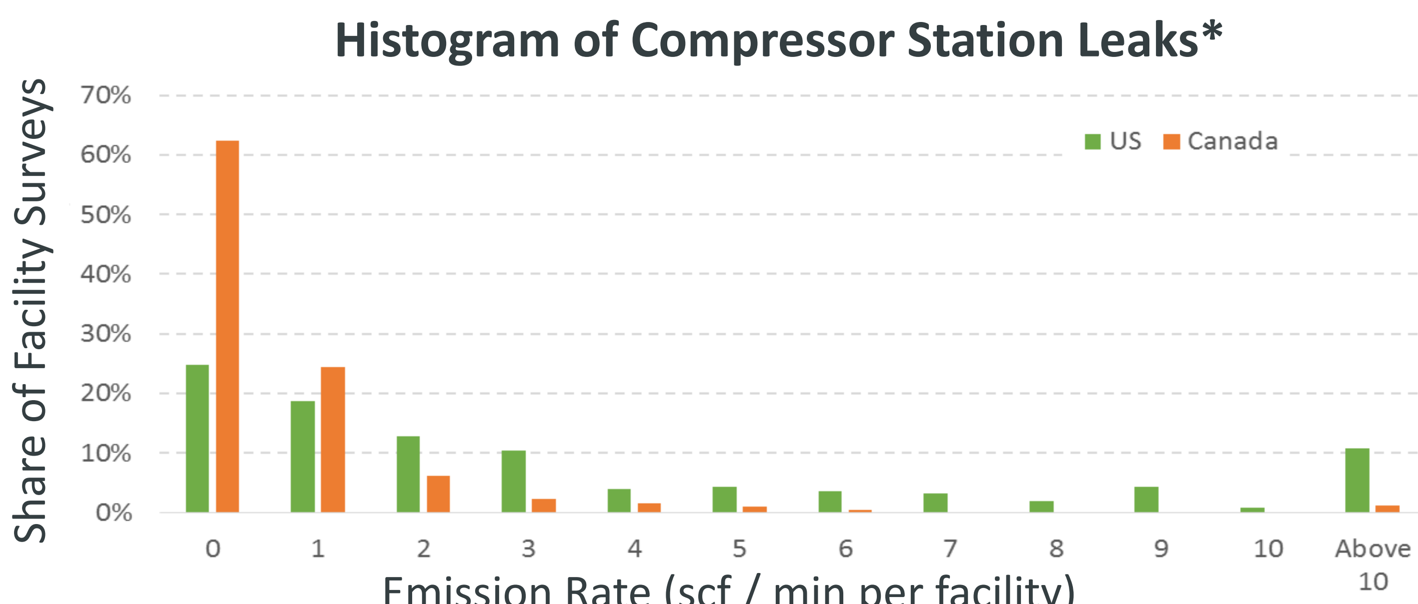
- Similar designs, equipment, same suppliers
- *Maintenance practices vary significantly from site to site*
- Key difference: Different regulations

US facilities are typically larger

# Comparison of Canadian & US Facilities

**US facilities have higher emissions; surveys at US facilities are more cost effective**

| Average Leaks*, scf / min | Canada | US |
|---|---|---|
| Compressor station | 0.9 | 4.8 |
| Gas plant | 2.1 | 6.1 |



# MOTIVATION (cont.)

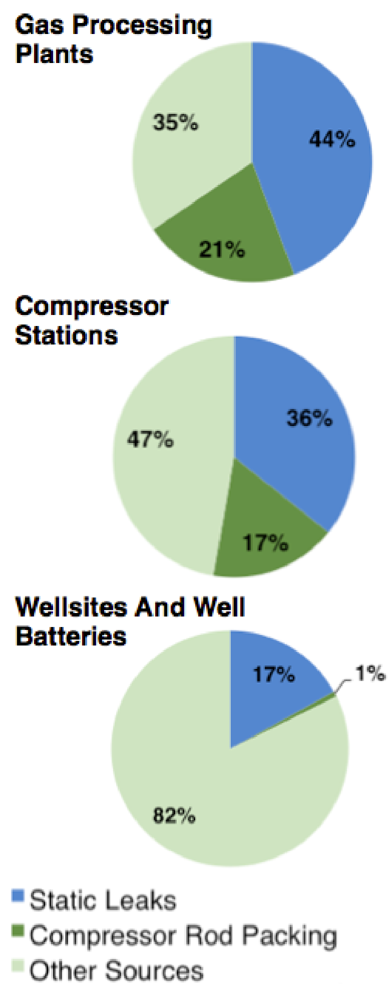
## Leaks as a share of total oil and gas methane emissions

**Primary** analysis looked at cost-effectiveness of LDAR to reduce static leaks.

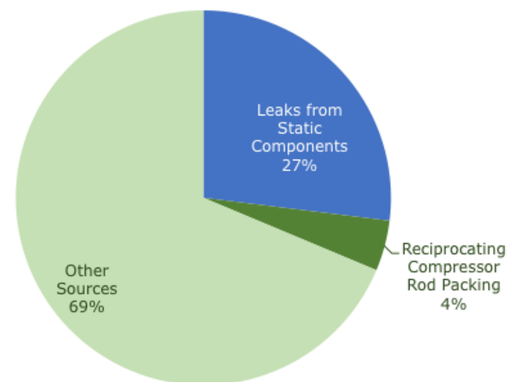
**Secondarily**, looked at co-benefit of reduction of emissions from high-emitting compressor seals.

While surveys identified other sources of emissions that could be reduced economically, limitations of our database prevent us from quantifying the benefits of these reductions.

**Distribution of Methane Emissions in our Database**



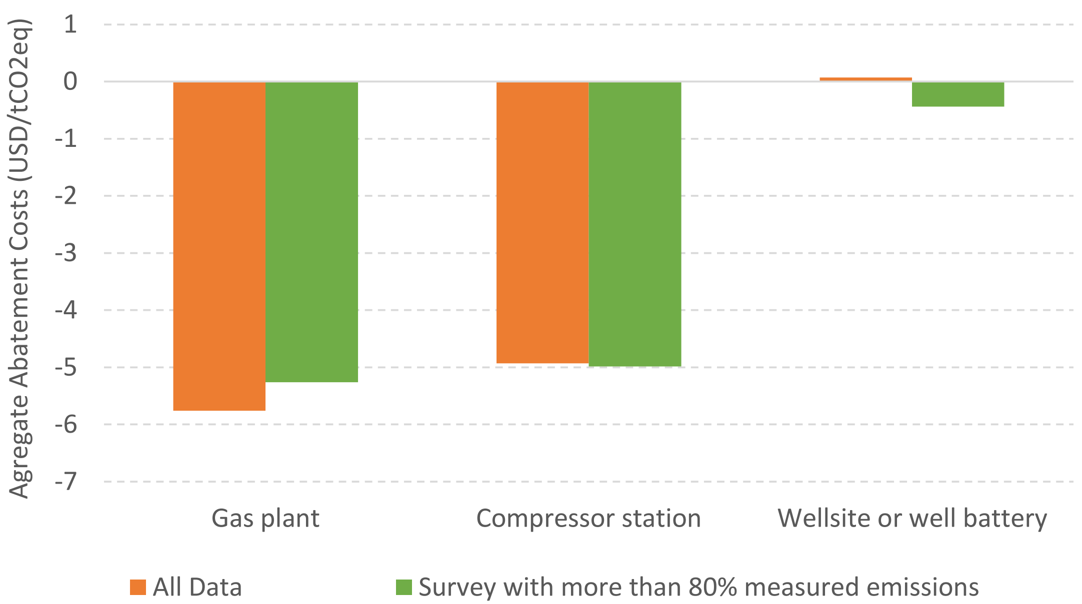

**Distribution of Methane Emissions in U.S. Oil and Gas Production**




Data Source: ICF 2014

# Does leak estimation skew results?

We calculated cost-effectiveness for the subset of surveys with more than 80% of total emissions from measured emissions. The cost effectiveness for those surveys is very similar (within \$1.50 / t $CO_2e$) to the results for the entire dataset, for each facility type.



# LDAR SURVEY COST AND REPAIR COST ASSUMPTIONS

| Facility type: | Cost of hiring an external service provider, USD: |
|---|---|
| Compressor station | 2,300 |
| Gas plant | 5,000 |
| Multi well batteries | 1,200 |
| Single well batteries | 600 |
| Well site | 400 |

| | | Rate (cfm) | | | Repair Cost (USD) | | | |
|---|---|---|---|---|---|---|---|---|
| | # in DB | Min | Average | Max | Min | Average | Median | Max |
| Valve | 10,575 | 0.01 | 0.12 | 36 | 20 | 90 | 50 | 5,500 |
| Connector/Connection | 23,577 | 0.01 | 0.10 | 60 | 15 | 56 | 50 | 5,000 |
| Regulator | 1,081 | 0.01 | 0.12 | 5 | 20 | 189 | 125 | 1,000 |
| Instrument Controller (Leak only) | 1,106 | 0.01 | 0.14 | 5 | 20 | 129 | 50 | 2,000 |