Leak Detection and Repair Cost-Effectiveness Analysis

Prepared for Environmental Defense Fund

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Project Outline

- Motivation for the Analysis
- Objective of the Stochastic LDAR Analysis
- Modeling Concept
- Limitations of Analysis
- Segment Specific Data Sources
- Segment Specific Scenarios and Assumptions
- Segment Specific Results

Motivation for the Analysis

- Much of current LDAR costs and emissions reduction analysis based on average values
  - However, there is a wide variation in the size of the facilities and types of equipment at each facility
  - Average values do not take into account the variation in emissions rate (and therefore reductions), specifically from super-emitters
  - Difficult to analyze multiple scenarios when using average values
- Propose a LDAR stochastic modeling approach

Objective of Stochastic LDAR Analysis

- Develop facility models that replicate the real world and capture variations in facility size and characteristics
- Use Monte Carlo simulation to analyze facility emissions, reductions, and costs
  - Model includes inter-relationships between different factors, such as leak frequency and time required to conduct LDAR
  - Includes correlations between activity data, count of reciprocating and centrifugal compressors at compressor stations are correlated with each other and the total count of compressor at the station
  - Emissions rate and activity represented by statistical distributions
  - Use data from multiple publications and studies as appropriate
  - Ability to develop multiple scenarios, including impact of changing frequency of LDAR
- Evaluate LDAR cost-effectiveness from the following segments – production well-pads, gathering and boosting stations, processing plants, transmission compressor stations, and storage stations

LDAR Modelling Concept

Library of Component count and leak frequency from various studies.

Model Inputs
- Size of facility
- Count of components associated with each emissions source
- Count of leaking versus non-leaking components
- Leaker components to be represented by an emissions distribution

Leak Detection Cost
Two Options
- Company in-house
- Third party service provider

Leak Fixing Costs
Driven at two levels
- Cost by component type
- Whether replacement or repair

Other Costs
- Travel and Per Diem
- Reporting and Recordkeeping
- Survey Time
- Survey Equipment
- Training

Model Outputs
Distribution of
- Cost
- Emissions
- Emissions Reduced
- Cost-effectiveness

Model Concept - Inputs

- Emission sources include –
  - Fugitive sources - valves, connectors, pressure relief valves (PRV), compressor PRVs, open-ended lines (OEL), compressor starter OELs, compressor blowdown valves, pressure regulators, orifice meters
- Statistical distributions assigned to each emission source activity factor and emissions rate
- Leak frequency identifying percentage of components leaking
  - Range of leak frequencies based on data on number of leaking components from field studies that provide raw data that allows for distribution fitting
- Economic Factors
  - Gas Price, Labor Cost, Time to Survey Equipment, Repair/Maintenance Cost, Survey Equipment Costs, Other Costs
- GWP=25

Model Concept - Simulation

- The simulation is run for 10,000 iterations with each iteration representing a unique and random combination of;
  - Facility characteristics, such as size, type of equipment, count of emissions source
  - Number of leakers for each emissions source
  - Leak rate of each leaking unit of leakers for each emissions source
- General simulation model steps
  - Step 1 – Select random facility characteristic, example – well-pad with specific number of wells and equipment
  - Step 2 – Determine the count of associated components (emissions sources)
  - Step 3 – Determine the survey time and associated costs based on component count
  - Step 4 – Randomly select the percentage of each components that are leaking
  - Step 5 – Randomly assign leak rates to each leaking component
  - Step 6 – Determine if each leak has to be repaired or replaced; assign costs accordingly
  - Step 7 – Determine reductions achieved from repair or replacement
  - Step 8 – Calculate output statistics

Model Concept - Output

- Distribution of emissions per facility
- Distribution of costs associated with conducting LDAR at various frequencies – annual, semi-annual, and quarterly
- Trends in LDAR cost-effectiveness, i.e. $/Mcf-reduced, over time
- The $/Mcf-reduced metric is the ratio of the total cost to conduct an LDAR survey to the difference in Mcf of emissions from the baseline each year where the baseline is assumed to be the uncontrolled emissions in the first year

Limitations of Analysis

- Model results are driven by data inputs
  - The representativeness of results to national, state, company, or facility level is limited by representativeness of the data
- Limited time series data is available on the impact of different LDAR frequencies on reduction in leak frequencies in each subsequent survey
  - Assumption in this study is based on best available data from Colorado
- Costs to repair or replace can vary depending on location and complexity of leak
  - This study uses best available data from Gas STAR published documents and expert judgement where no data was available

Production Segment Assumptions and Results

Production Model Data Sources

- Data Sources used to model facility
  - Subpart W
  - EPA/ GRI
  - City of Fort Worth Natural Gas Air Quality Study
  - UT Study - Methane Emissions in the Natural Gas Supply Chain: Production
  - UT Study - Methane Emissions from Process Equipment at Natural Gas Production Sites in the United States Pneumatic Controllers
  - Jonah Energy LLC WCCA Spring Meeting Presentation

Component Replacement and Maintenance Costs

Emission Source	Default Replacement Cost	Default Maintenance Cost
Valve	$112.00	$41.67
Connection	$226.67	$20.00
Pressure Relief Valve	$500.00	$100.00
Compressor Pressure Relief Valve	$1,000.00	$200.00
Open-Ended Line	$150.00	$45.00
Starter Open Ended Line	$500.00	$250.00
Pressure Regulators	$300.00	$200.00
Orifice Meters	$775.00	$200.00

Time to Measure Individual Components

Emission Source	Estimated Time to Survey in Minutes
Valve	0.1
Connection	0.1
Pressure Relief Valve	0.5
Compressor Pressure Relief Valve	0.5
Open-Ended Line	0.5
Starter Open Ended Line	0.5
Pressure Regulators	0.1
Orifice Meters	0.1

Survey Equipment Costs Default

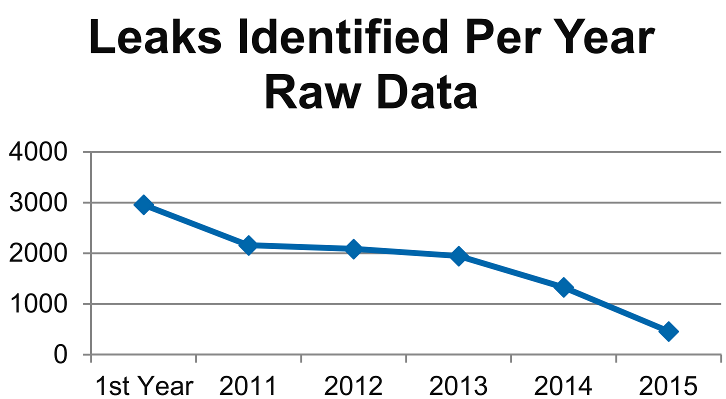
Component	Default Costs
IR Camera	$115,000
Hi Flow Sampler	$20,000
Calibrated Bag	$500
Vehicle (4x4 Truck)	$22,000

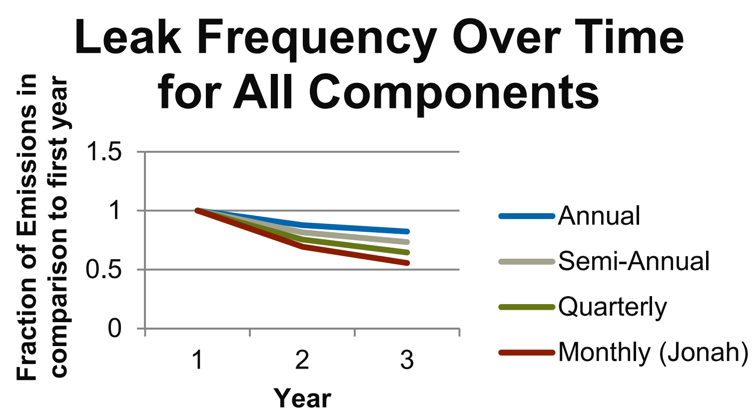
Other Costs

Emission Source	Estimated Time to Survey in Minutes
Prep Time per 4 hours or Working (Hours)	0.25
Percentage of Year Contractor Utilizes Equipment	75%
Contractor Scalar	30%
Years Contractors Recoup Survey Equipment Costs	3
Profit Percentage for Contractors on Survey Equipment	25%
Hours of Training for In-House Operations	80
Lodging and Per Diem	250
Supervision (Inhouse)	$31,200
Fringe (Inhouse)	$46,800
Training for Contractor	$15,600
Reporting and Record Keeping	$100

Leak Frequency and Emission Truncation Over Future Surveys

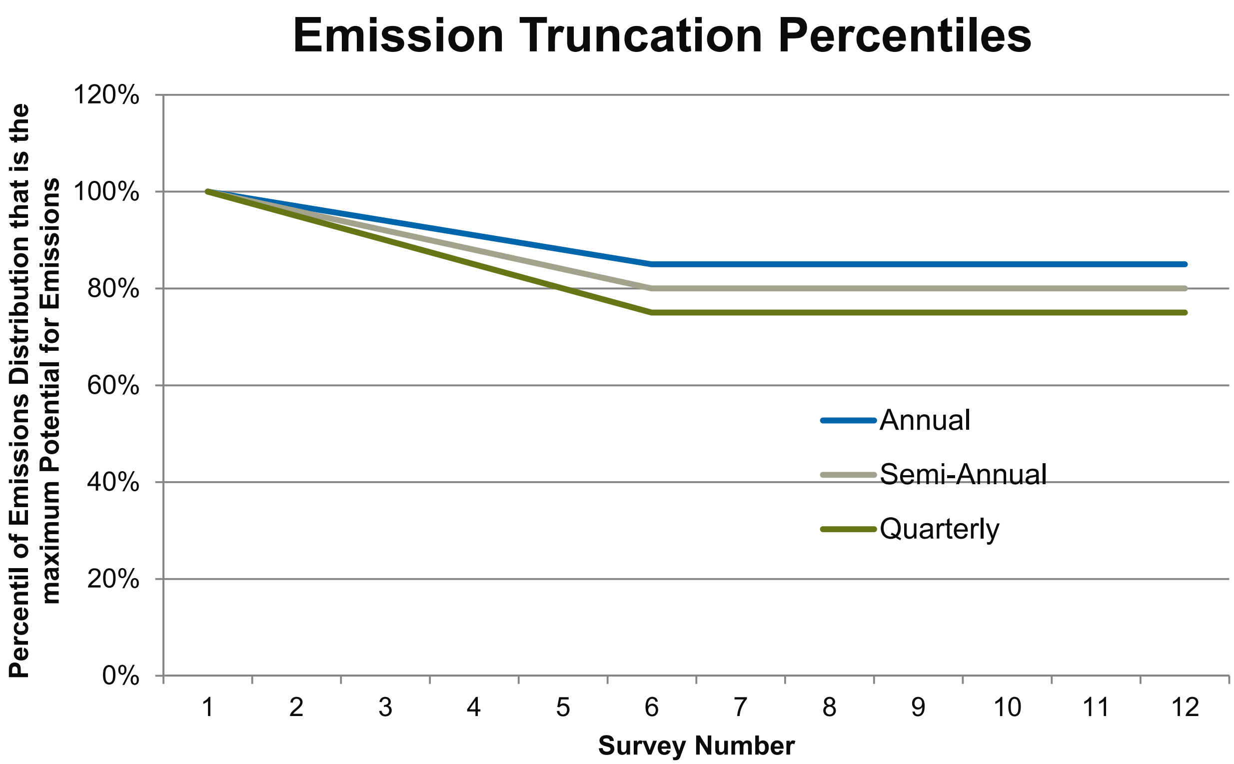
- Leaks occur less frequently over subsequent LDAR surveys
- Reduction in leak frequency was designed based on data from Colorado monthly survey results
- Annual, semi-annual and quarterly surveys assumed to experience slower reductions in leak frequencies





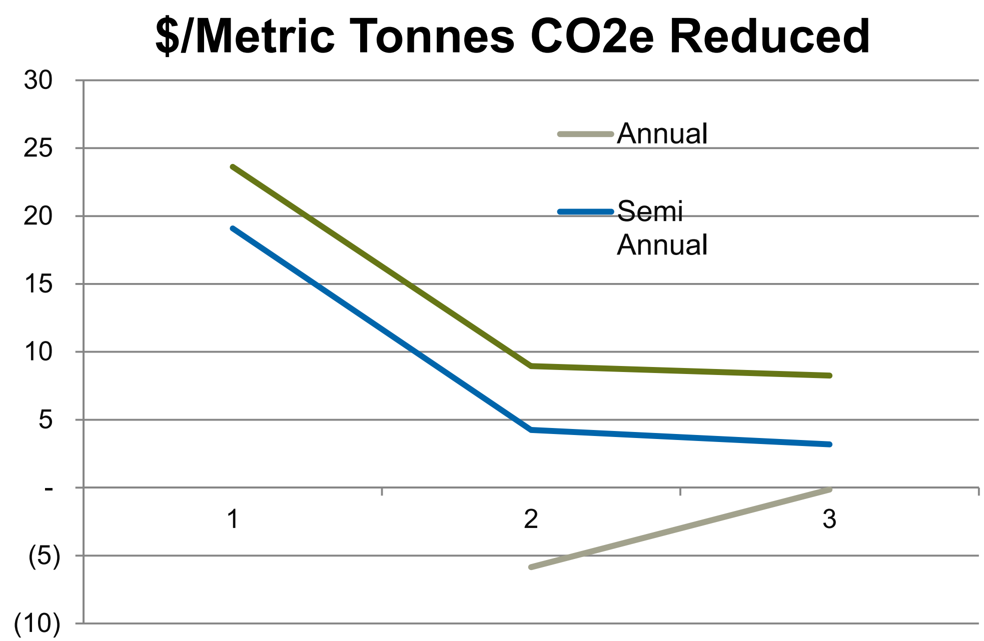
Emission Truncation Over Future Surveys

- Fewer high emitting leaks are identified from subsequent LDAR surveys
- Trend has been captured by truncating the right tail of emissions rate distributions



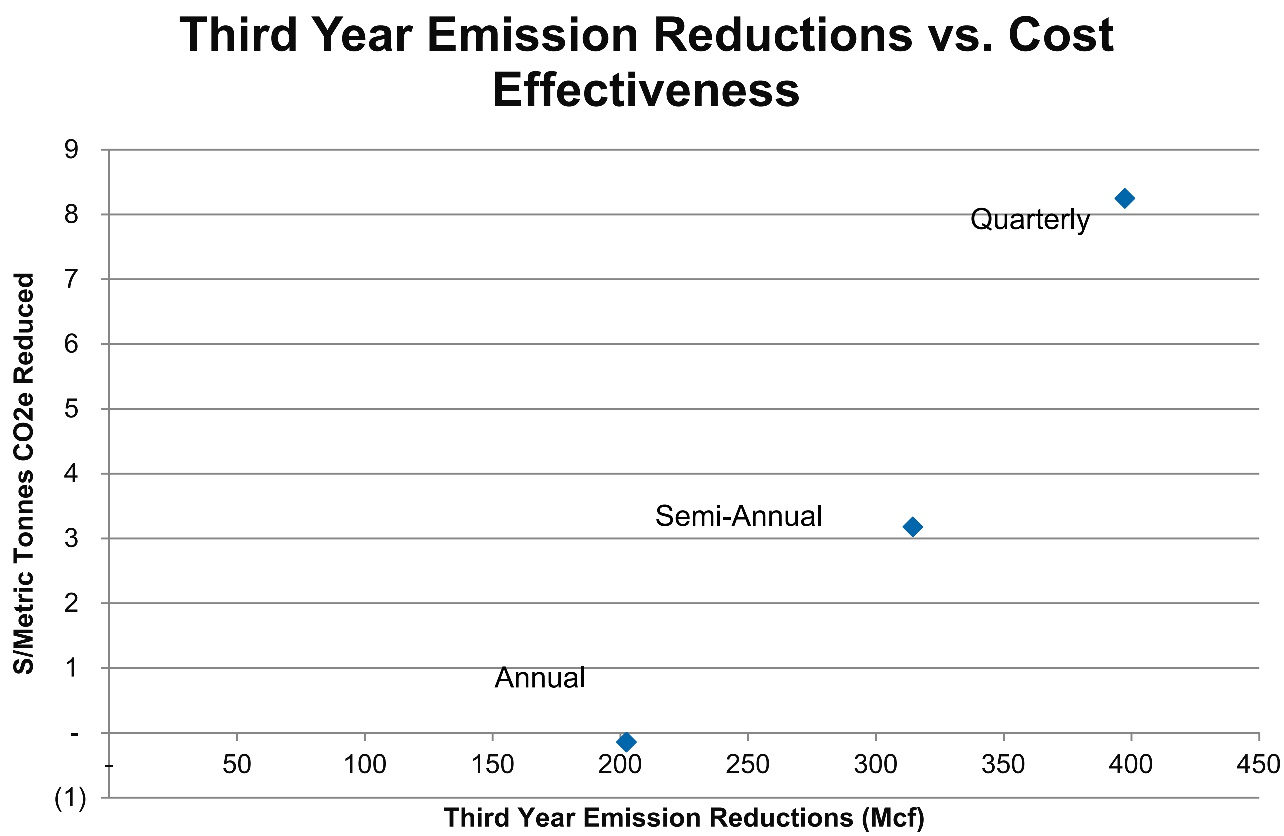
Fugitive Sources Case 1

- Case 1 Parameters:
  - Gas price: $3 dollars/Mcf
  - Evaluates fugitive sources
  - Assumes two contractors are hired



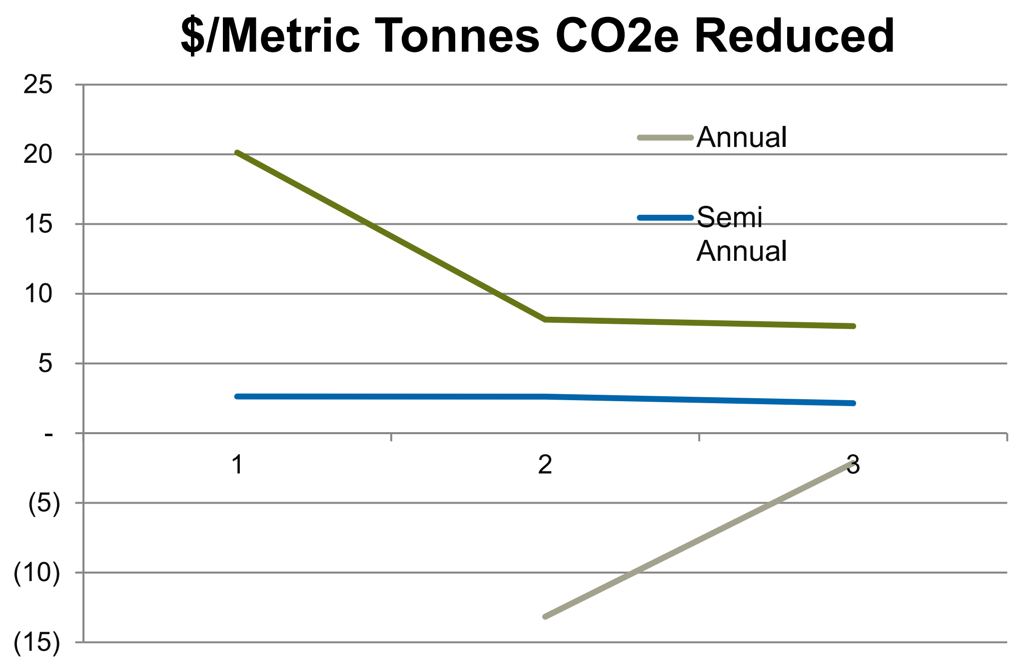
Fugitive Sources Case 1

- Total emissions reduced in year three plotted against average cost effectiveness of reductions in year 3.



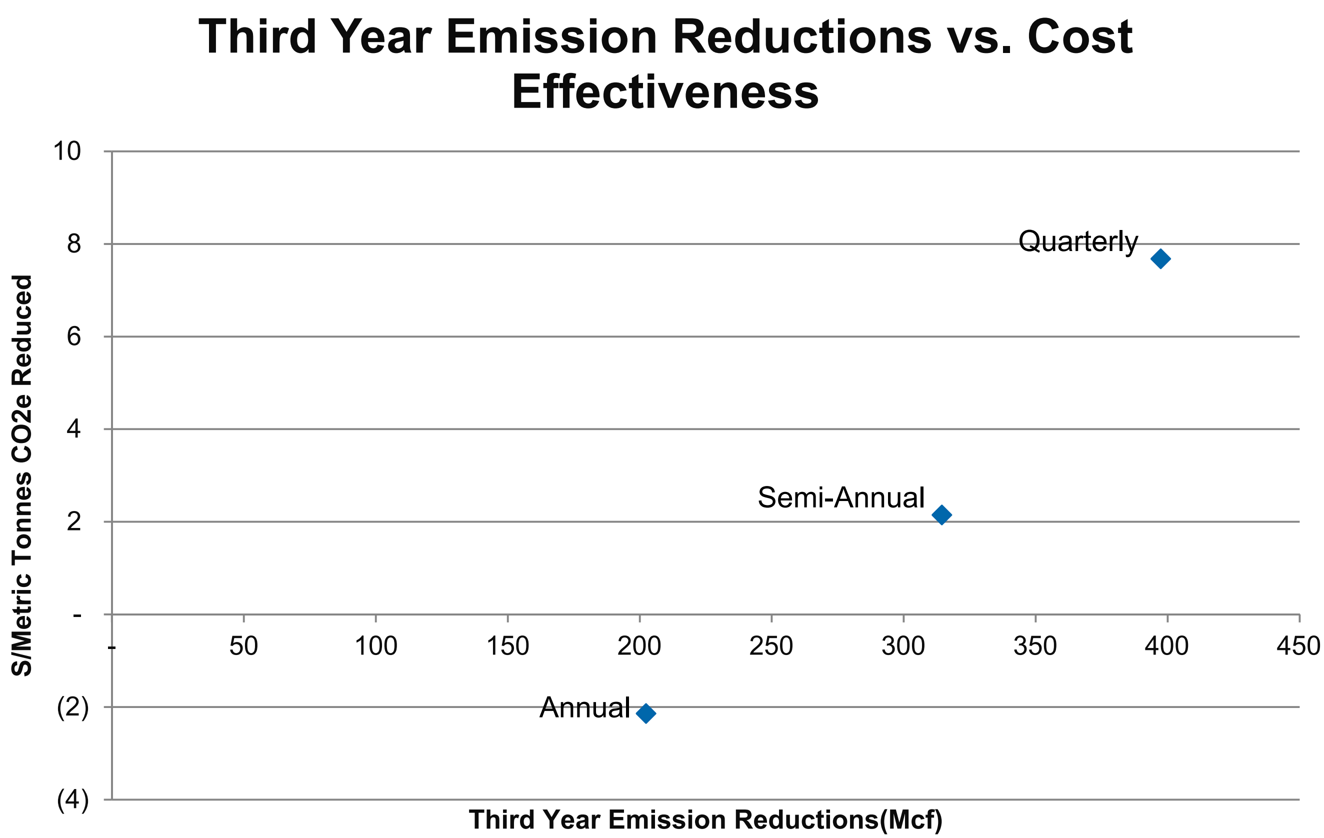
Fugitive Sources Case 2

- Case 2 Parameters
  - Gas price: $4 dollars/Mcf
  - Evaluates fugitive sources
  - Assumes two contractors are hired



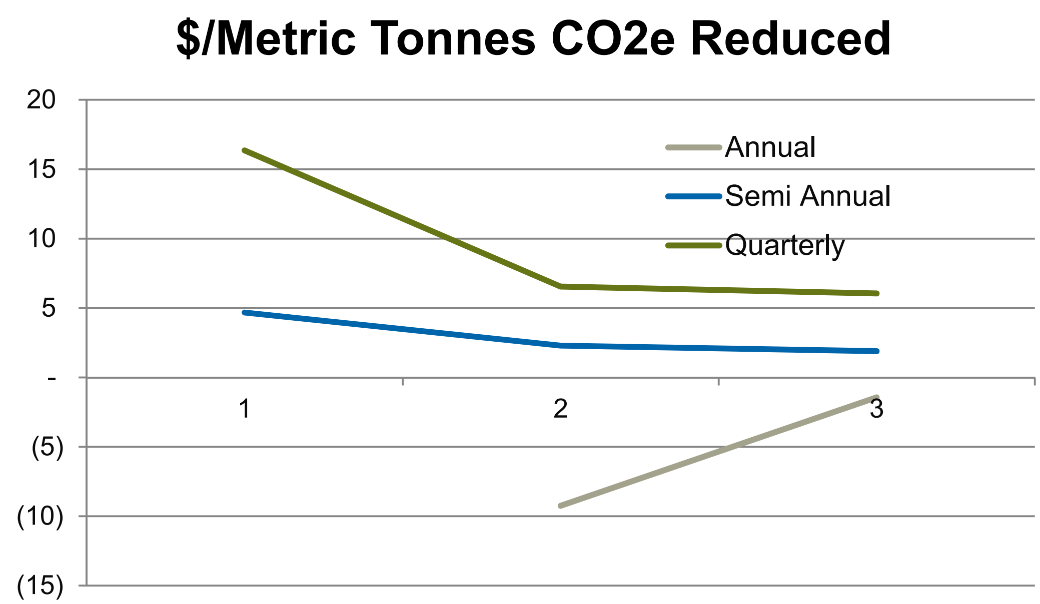
Fugitive Sources Case 2

- Total emissions reduced in year three plotted against average cost effectiveness of reductions in year 3.



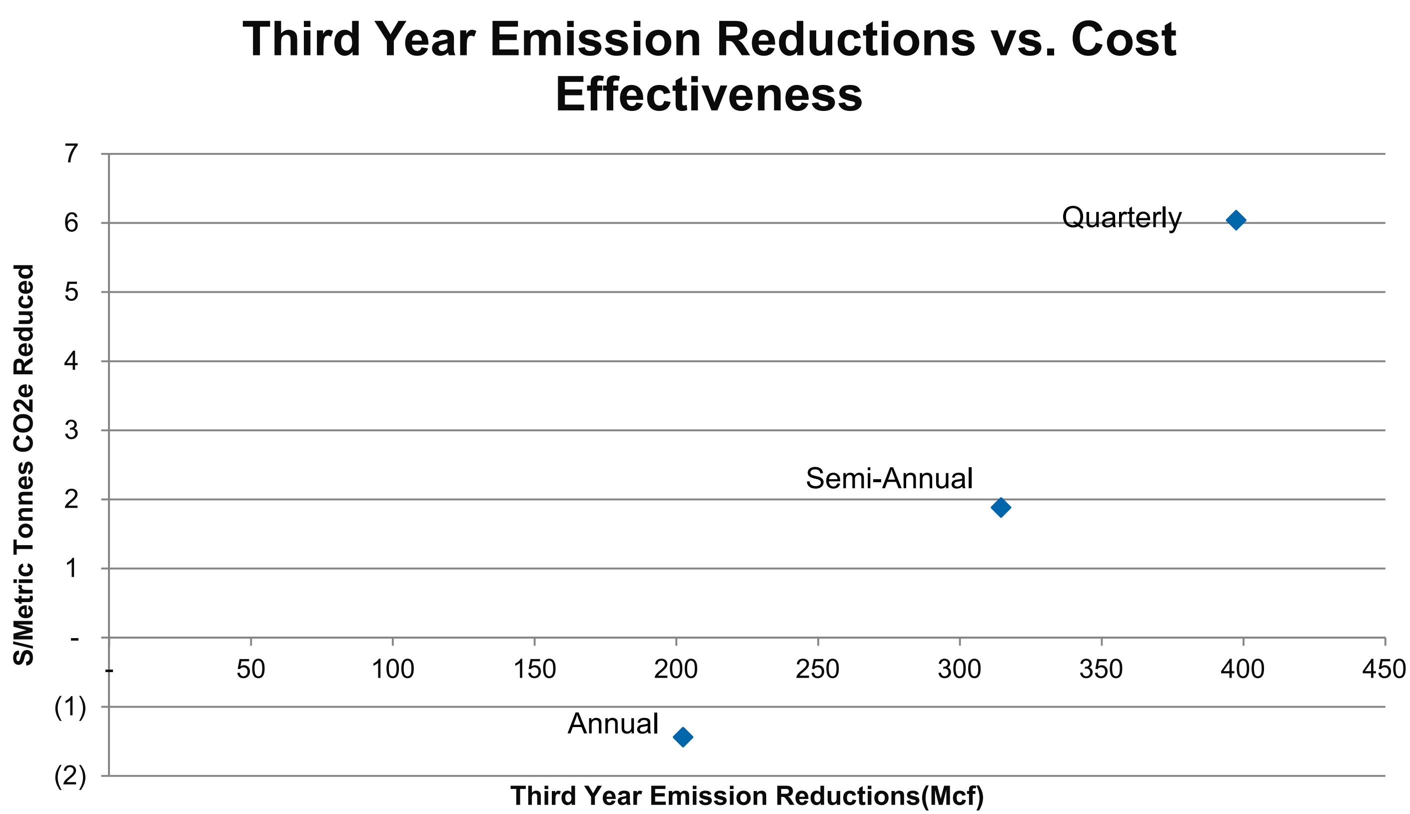
Fugitive Sources Case 3

- Case 3 Parameters:
  - Gas price: $3 dollars/Mcf
  - Evaluates fugitive sources
  - Assumes one contractor is hired



Fugitive Sources Case 3

- Total emissions reduced in year three plotted against average cost effectiveness of reductions in year 3.



Total Three Year Production Mean Fugitive Results

	$/Metric Tonnes CO2e Reduced		
	$3/Mcf	$4/Mcf	$3/Mcf One Contractor
Annual	-4.76	-11.19	-7.86
Semi-annual	4.94	2.39	2.29
Quarterly	11.56	10.32	8.27

GWP=25