COST-EFFECTIVE METHANE MITIGATION POLICY IN AN ERA OF LOW NATURAL GAS PRICES

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Overview

The electricity sector in the United States has undergone a dramatic transformation over the past 5 years due to recent advances in unconventional natural gas resources. With an expanding liquefied natural gas (LNG) export market, natural gas is likely to play a major role both in the developed and developing economies. Concurrently, awareness and imminent global action on climate change has raised concerns over methane emissions from the oil and gas section. Indeed, many recent studies have shown significant methane emissions from the natural gas supply chain (Brandt 2014, Littlefield 2017). Unlike carbon dioxide, methane – a potent greenhouse gas – is emitted from a large number of highly distributed sources. In this scenario, the Environmental Protection Agency (EPA) recommended periodic leak detection and repair (LDAR) programs using optical gas imaging (OGI) technology at all facilities (EPA 2016). These regulatory updates to the 2012 New Source Performance Standards (NSPS) were expected to reduce methane emissions from the oil and gas sector by 40-45% by 2025. Whether such prescriptive polcies are cost-effective depends on uncertainties in both LDAR program uncertainty as well as emissions uncertainty. Cost considerations are vital to prevent unintended consequences under low gas-price scenarios.

In this work, we systematically analyse the effectiveness of EPA's methane mitigation regulations (updates to 2012 NSPS) based on mitigation related and facility related uncertainties in the natural gas sector. After the overview, the methods section gives a brief overview of the simulation framework used in policy analysis. Following which I discuss preliminary results from this study that describes the twin objectives of cost and mitigation effectiveness. Finally, I summarize the main take-aways in the conclusion section along with specific policy recommendations for cost-effective mitigation.

Methods

We use the Fugitive Emissions Abatement Simulation Toolkit or FEAST framework to simulate various regulatory policy options for emissions mitigation (Kemp 2016). FEAST is an open-source, techno-economic model that simulates the evolution of leaks at natural gas facilities. FEAST uses information about model-plant parameters, generates leaks from an empirical leak-population and applies OGI-based leak detection technology to evaluate mitigation effectiveness (Ravikumar 2017a). Once 'detected' by the technology module, the leaks are considered repaired. New leaks are added over time in a stochastic manner to simulate typical wear and tear, and leak creation. The facility is simulated over a period of 8 years with capital costs amortized at 7% interest rate. Economic and model plant parameters are obtained from EPA's analysis of the methane rule, while the empirical leak-size distribution is derived from published studies in the literature (Ravikumar 2017b).

Results

Based on our model results, we find that the EPA methane rule will cost approximately 27% less than estimated at production facilties, and 50% less at compressor stations at various facilties in the natural gas supply chain. While the model's estimates of amortized capital costs and recurring survey costs are identical to that of the EPA, the variable costs of repair and resurvey are an order of magnitude smaller than EPA estimates. This occurs because EPA over-estimates the fraction of total components that will be found leaking. In our analysis of empirical leak-size distributions and technology models, we expected that OGI will detect the largest ~0.1% of leaks, compared to EPA estimates of ~1.2%. As variable costs are proportional to the number of leaks, our estimates are about an order of magnitude lower, resulting in a reduce overall cost for the mitigation program.

Second, we note that OGI based LDAR progam is likely to miss mitigation targets by 20 – 50%. The happens because of two uncertainties in the system – mitigation related uncertainties and facility related uncertainties. For example, EPA estimates that semi-annual leak detection surveys at production facilities using OGI cameras would reduce methane emissions by 60%. Our work found that this number is highly variable depending on both mitigation related uncertainties like weather (temperature, wind, humidity) and facility related uncertainties like baseline emissions and leak-size distributions. Operator imaging distance is a critical parameter that affects leak detection – the effectiveness of detection falls roughly as the inverse square of the imaging distance from the leak. We also found that baseline emissions – a function of company voluntary maintenance practices and geologic characteristics of the basin – strongly influenced fractional mitigation through an OGI-based LDAR program. Most importantly, we found that increasing survey frequency (policy tool) does not lead to corresponding increases in mitigation benefits. This insight is critical in reducing costs to businesses as well as achieving mitigation targets. Finally, leak-size distributions affect the effectiveness of an OGI-based LDAR program because of the propensity for OGI technology to detect only the biggest leaks. The presence of 'super-emitters' – a small number of very large leaks seen in most empirical studies at natural gas facilities – is inherently conducive to an OGI based mitigation program.

Conclusions

We find that EPA's methane mitigation regulations will cost, on average, 27% less than EPA estimates for production facilities, and approximately 50% less for compressor station facilties. However, because of the uncertainty involved with facility characteristics and mitigation program, emission reductions are likely to fall short of EPA targets by 20 to 50%. Furthermore, preliminary results show that the leak quantification adds only marginal value to the cost-effectiveness of LDAR programs. Through this analysis, we show that leak classification into 'small', 'medium', and 'large' leaks is sufficient to achieve >60% mitigation at all facilities. Based on our work, we suggest three policy recommendations to improve the cost-effectiveness of the methane mitigation program:

1. Leak detection protocols need to be improved to achieve expected mitigation targets. This includes specifying parameters like maximum line-of-sight imaging distance (<5 m) and acceptable weather conditions (warm weather > 25 C, calm winds < 5 m/s) for LDAR measurements.
2. Designing appropriate survey frequency should reflect the marginal costs and benefits of more frequent surveys. Our work has found that while costs roughly increase linearly with survey frequency, benefits do not. Leakage mitigation is more sensitive to effective survey protocols than number of surveys. In this scenario, policy makers can trade off a reduced survey frequency for more stringent LDAR mitigation protocols.
3. Finally, we suggest a super-emitter specific mitigation policy to reduce the frequency of low-probability but high-impact emission events. This could include a combination of higher frequency surveys for components prone to be superemitters like blowdown lines, tank hatches, etc.

These results can be directly used by businesses to develop company-specific LDAR practices, as well as by policy makers to develop cost-effective mitigation regulations.

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