Techno-economic Assessment of Options to Mitigate Super-Emitters in the Natural Gas Supply Chain

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1. Introduction

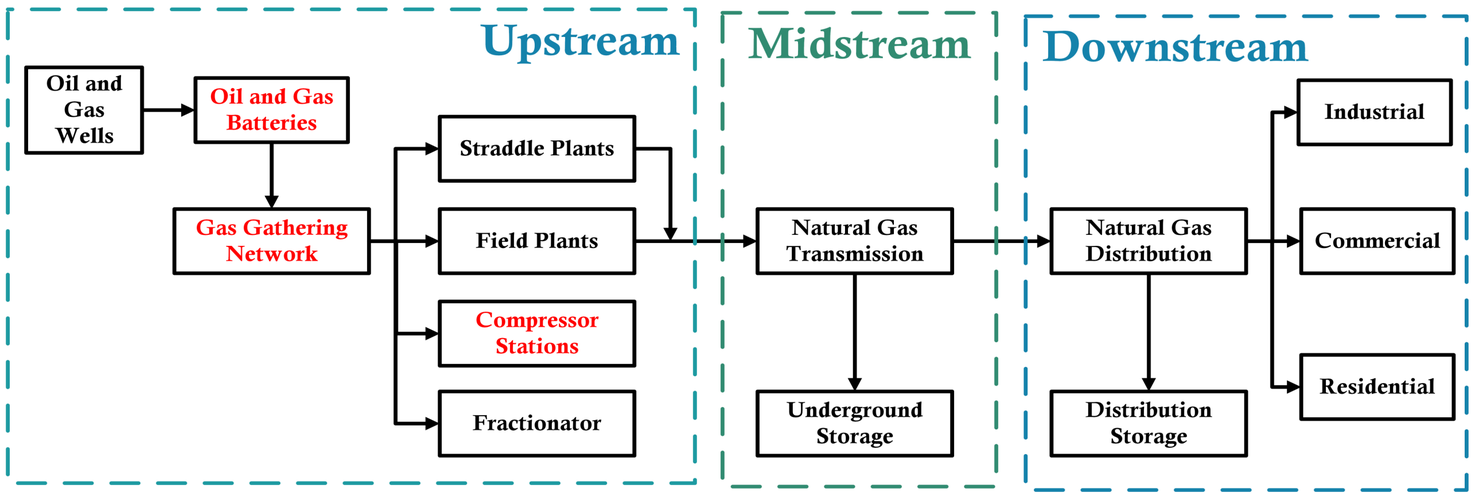

Figure 1: Natural Gas Supply Chain in Canada. Adapted from Umeozor et al (2019)

Methane (CH_4) is a prominent greenhouse gas and its emissions are frequently reported in the natural gas supply chain. However, a phenomenon called super-emitter exist in the supply chain. Super-emitters are described as a group of emitters, whether it is an equipment or facility-specific emitter, that emit an extremely high amount of methane. Typical super-emitters are characterised as leaked emissions. Chosen geographical location for this study is Alberta, Canada since Alberta is known to have the largest source of methane emission out of all the industry sectors[4].

2. Research Objectives

1. Evaluate the super-emitters in a considered supply chain stage using statistical analysis. The chosen stages are gas batteries, compressor stations and gas gathering systems. Stages marked red in Figure 1.
2. Economically assess low-cost innovative mitigation technologies to reduce the impact of the super emitters.

3. Emissions Model/Economic Assessment

- The idea of creating a probabilistic emissions model was to fit appropriate statistical distributions to a methane emission dataset to quantify the outlier appropriately. Data used are methane emissions measured directly from the emission source. Model was created in RStudio.
- The model is then used to perform Monte Carlo simulations and construct Lorenz curves for technical evaluation. Mitigation cost for technologies were calculated in a 45% reduced emissions scenario and sensitivity analysis was performed to model cost fluctuations.

4. Monte Carlo Simulation

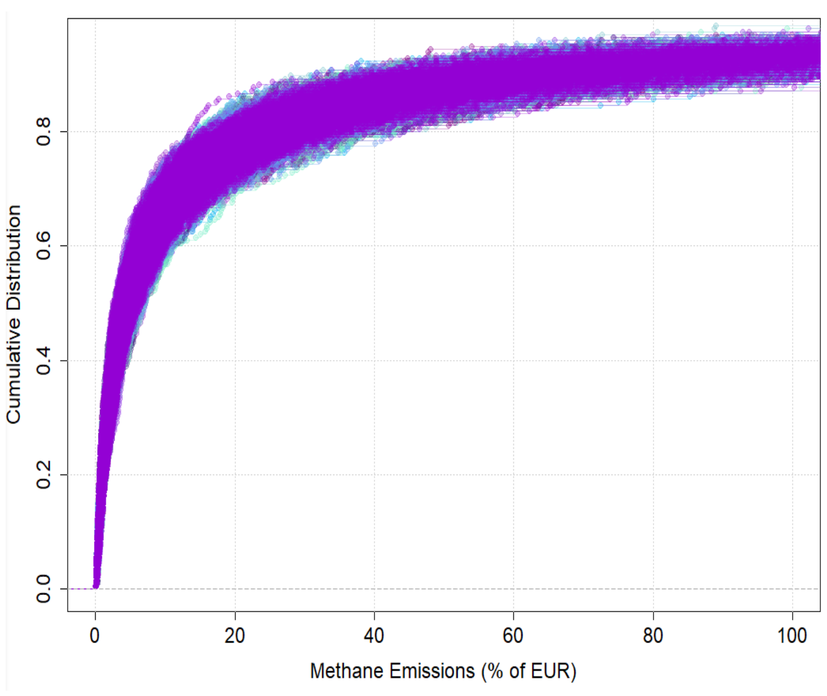

Figure 2: 10,000 cumulative distribution curves of methane emissions (%of EUR)

- There is an incentive that the lifetime gas production, also known as the estimated ultimate recovery (EUR), has a significant impact on methane emissions
- Methane emissions were allocated to the EUR as an emission percentage of the EUR.
- Monte Carlo simulations were conducted to produce 10,000 cumulative distribution curves.
- Simulation results showed that super-emitters are more significant when methane emissions are high and the EUR is low
- The upper bound (light blue curve) shows that the remaining 20% of total population emits between 20-100% methane emissions. This is an indication of the existence of the super-emitters within the dataset.

5. Lorenz Curves

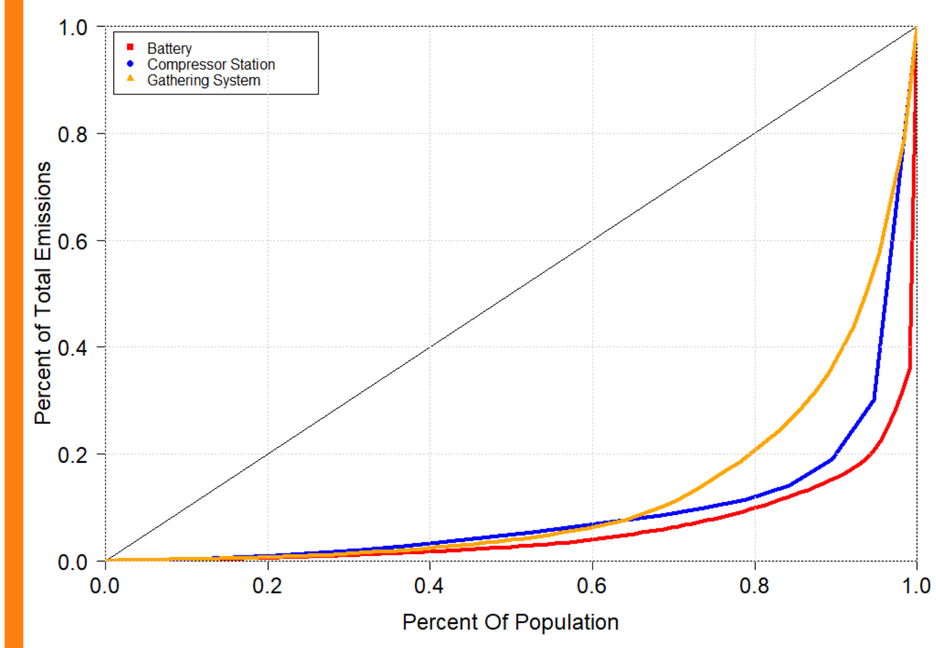

Figure 3: Lorenz curves of gas batteries, compressor stations and gas gathering systems

- Lorenz curves were applied to model the total emission contribution by the total population of a considered supply chain stage
- The figure shows all considered supply chain stages, the remaining 20% of total population emit at least 80% of total emissions.
- This finding suggested that the contribution to this skewness in emissions are from the super-emitters
- Top 5% emitters from the supply chain stages were evaluated on its skewness contribution to the data
- Top 5% emitters were found to emit 5 - 100m^3/day on average, with a few emitters to emit 100-1500m^3/day. These emitters significantly skewed the methane emissions data more than the emitted average

6. Economic Assessment and Results

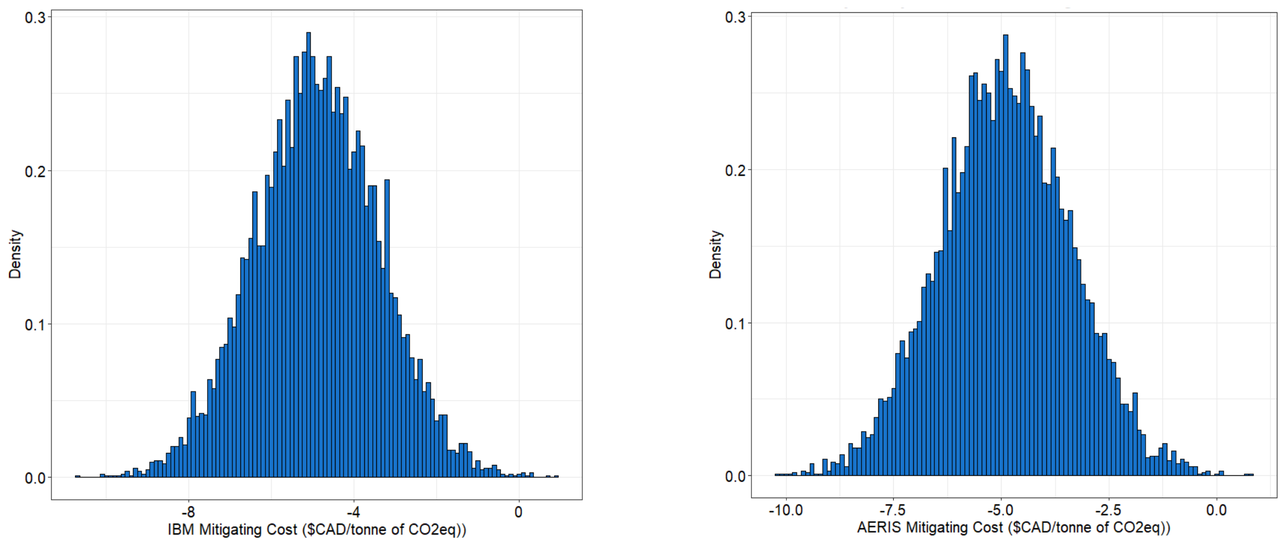

Figure 4: Sensitivity analysis of IBM and AERIS's mitigation costs in CO_2 eq

- MONITOR (Methane Observation Networks with Innovative Technology to Obtain Reductions) technologies from the ARPA-E (Advanced Research Projects Agency-Energy) program were evaluated
- IBM (International Business Machines) and Aeris's technologies are low-cost methane detection systems. IBM's technology provides 24/7 continuous monitoring and data storage to IBM's cloud system. Aeris's technology was embedded with a deep learning algorithm to provide more efficient methane emission detection
- Mitigation costs for both technologies are shown to be between -$95 and -$158CAD/tonne CH_4
- Negative mitigation cost shows the amount of money that is saved per tonne CH_4

7. Conclusion

- The super-emitters skewed the methane emissions distribution data, an underlying characteristic for super emitters. This can be quantified appropriately by choosing the right statistical distribution
- A low EUR significantly impacts the methane emissions, promoting the existence of the super-emitters
- Average super-emitters' emissions are in the range of 5 - 100m^3/day. With significant skewness from super-emitters' with emissions volume more than the average emission volumes
- Mitigation costs for low-cost innovative technologies proved to be cost-effective

References: Umeozor, E. *et al.* (2019) *Economic and Environmental Impacts of Methane Emissions Reduction In The Natural Gas Supply Chain*. Canada.

[4]Government of Alberta (2019) *Reducing Methane Emissions*. Available at: https://www.alberta.ca/climate-methane-emissions.aspx (Accessed: 12 September 2019).