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Current Project – Methane Emissions Estimation Tool
Current inventory models provide only an aggregated value of emissions. Many of the emission measurements are of a short duration. Hence, it becomes important to estimate the emissions as a time scale series of estimates. Methane Emissions Estimation Tool (MEET) provides a time scale estimate of the emissions in oil and gas facilities. MEET does this by using activity and emission factors provided by the already available GHG reports. Some of the emissions are modelled mechanistically instead of using activity and emission factors. The estimation is done using Monte Carlo and Discrete Event Simulation so that the aggregated emissions match the reported emissions. [1]

My work is to model the failure modes that lead to large emissions in oil and gas facilities mechanistically. Using random variables as inputs to MEET, the software generates a time series estimate of these large emissions that can be scaled with the size of the site. Along with mechanistic modelling, I am working on the software development side of MEET such as implementation of new features and bug fixing.
Research Progress
Basic mechanistic models of a Dumping Separator, a stuck dump valve in Continuous and Dumping Separators and a large emitter based on overpressure in tanks has been implemented in MEET. This provides a way for MEET to estimate the emissions which provide a timescale estimate of the mechanistic modeling. Another implementation into MEET is a system where the activity and emission factors are user defined. This makes it possible to simulate and estimate emissions using any of the GHG reports available. It is also possible to estimate emissions at site level if appropriate data is available.

Mechanistic Modeling:

In Figure 1, total gas flashed in the separator stage 1 is condensate+water flash. The blue arrows represent total liquid flow. When the dump valve at stage 1 separator gets stuck, some x% of vapor slips to the downstream equipment and the remaining goes to gas sales. If the dump valve at stage 2 is working properly, we can expect all the flashes at stage 2 and the remaining vapor from stage 1 to go to the gas sales. When dump valve at stage 2 is stuck in Figure 2, some x% of the total gas in stage 2 slips to downstream equipment (usually tanks). Note that stage 1 and stage 2 dump valves are independent of each other. There is an overpressure threshold at tanks. Once the incoming flow reaches the threshold value, the prv starts to open and we see a large emission at tanks.
Results

Figure 3: We see an overpressure vents open when stage 1 and stage 2 separators have a stuck dump valve.

In figure 3, there wells W1 and W2 have a few states of preproduction in the start and then got the production stage. We can see the wells cycling from unloading to production periodically. Separators S1 and S2 get a stuck dump valve randomly. There is a tank overpressure when we see an overlap of stuck dump valve states between stage 1 and stage 2. Note: This example is for illustrative purposes only, this does not happen at actual facilities.
In Figure 4, the second plot is where the emissions are estimated depending on the overpressure threshold and incoming flows. The small gaps in the emissions are due to wells unloading, so no gas goes to separators at that time from at least one well.

In figure 5, when we zoom in on the overpressure vent plot, there can be seen other plots too. The orange plot shows the excess gas from when stage 1 was stuck and reached the tanks. The purple plot shows the flashing from stage 2 that reached the tanks. The blue plot shows the tank flash that was escaped through the prv when during the overpressure situation.

Research Plans
I hope to understand the failure modes in oil and gas facilities better which would help in making the mechanistic models better. This would help in reducing the numerical errors and would make way for better comparisons between GHG reports and MEET.
Literature cited

A Methane Emission Estimation Tool (MEET) for predictions of emissions from upstream oil and gas well sites with fine scale temporal and spatial resolution: Model structure and applications, Science of The Total Environment, Volume 829, 2022, 154277