



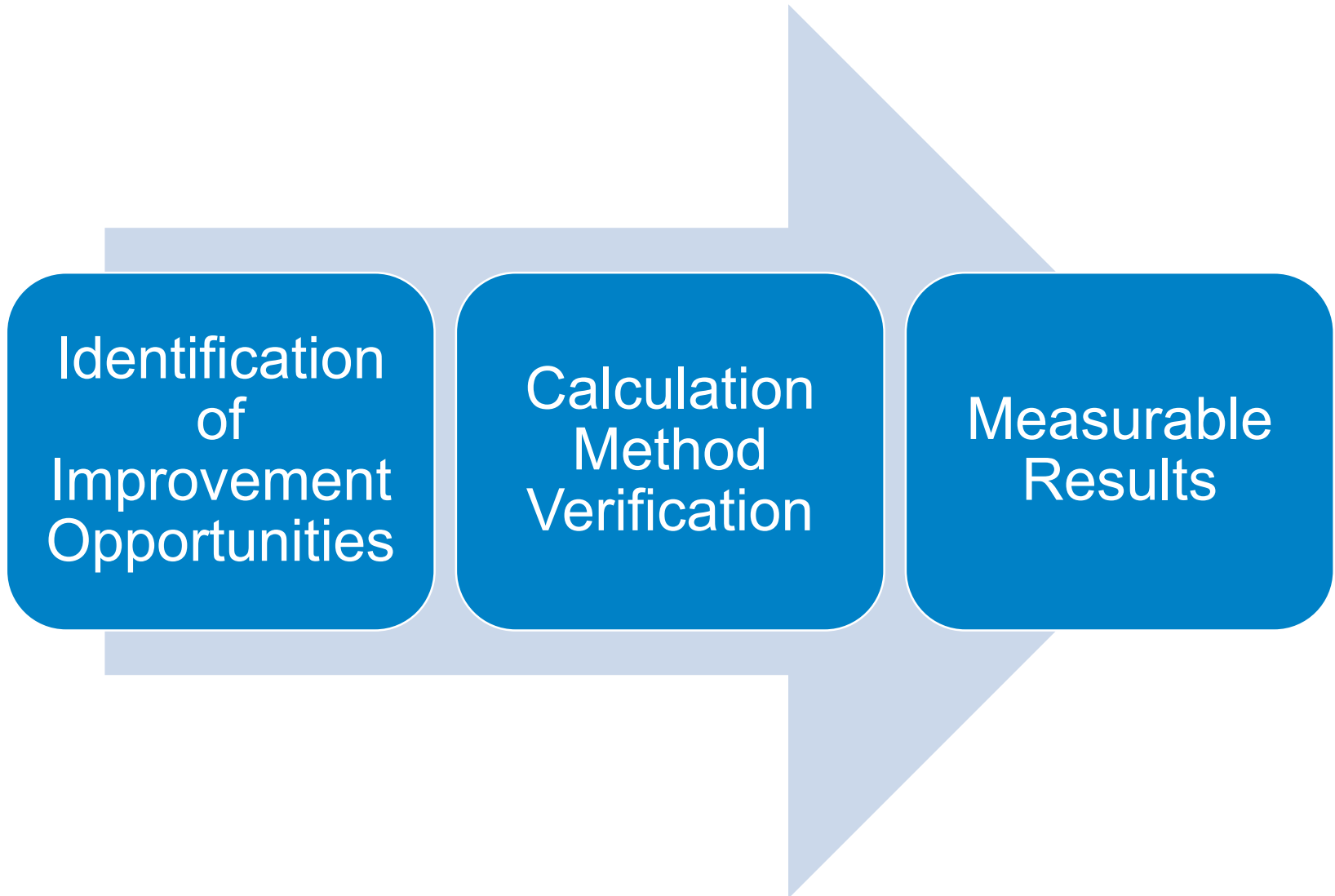
R RANGE RESOURCES®

Emission Verification and Reduction Initiative

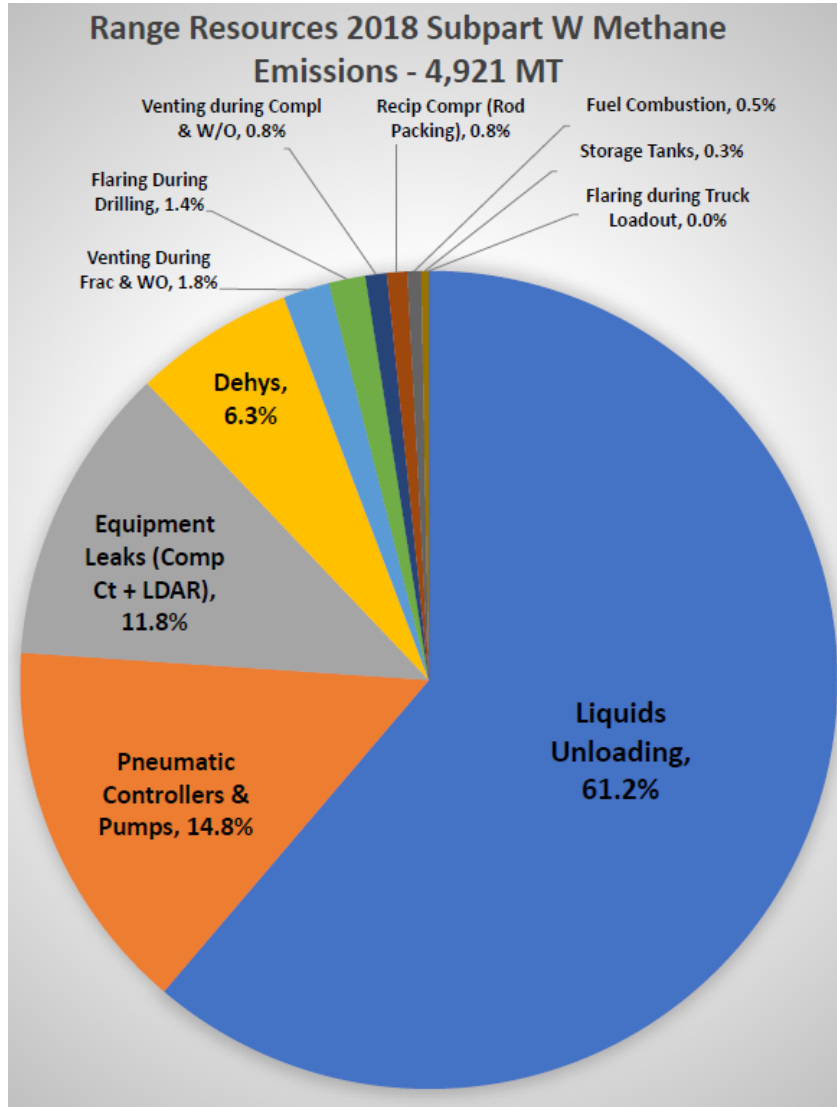
NOVEMBER 19, 2019

MICHAEL ONDASH

Emission Reduction Initiative Overview



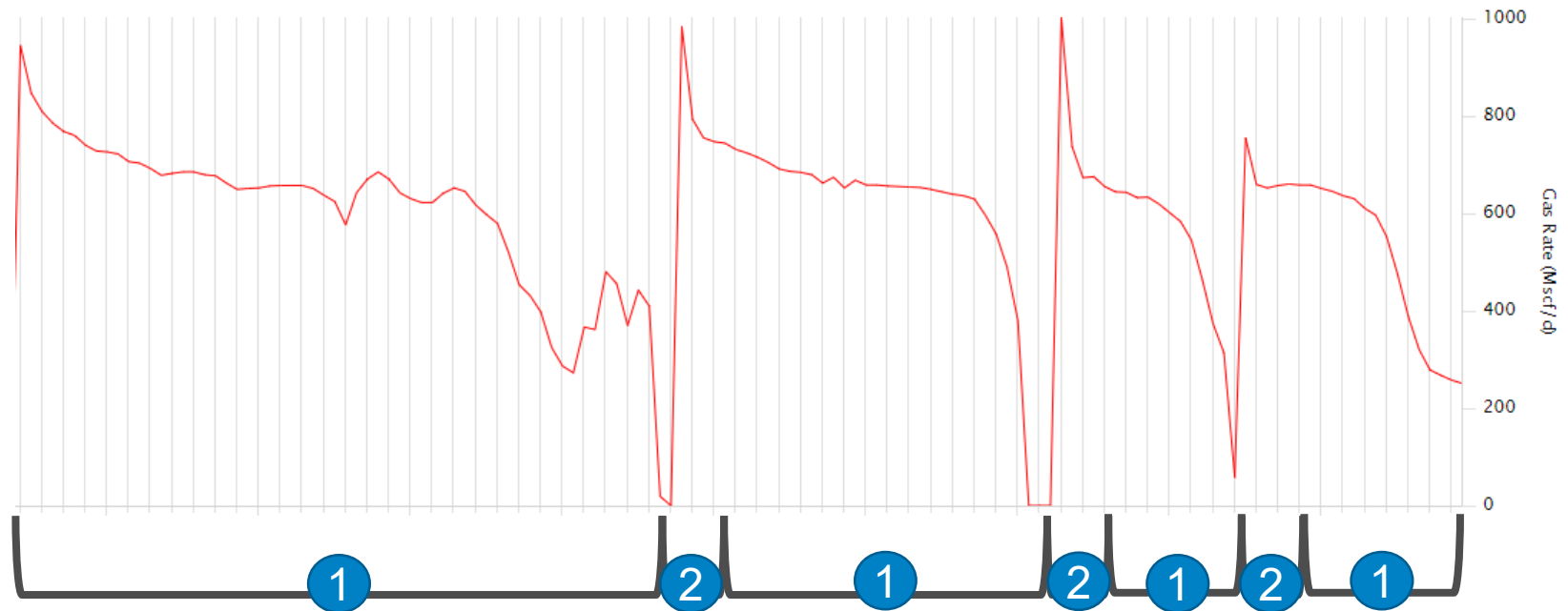
Emissions Reported by Category (Subpart W CH₄)



Identification of Improvement Opportunity

- Liquids unloading was the main contributor to 2018 Subpart W CH₄ emissions
- Occurs during process of unloading a well to allow for gas flow
- How can we reduce this number through engineering actions?
 - System contained unloading events
 - Plunger Lift
 - Capillary Strings
 - Pad Compression

Liquid Unloading Example



1: Loading

Well production declines and eventually zero flows causing the well to load up.

2: Unloading

Well is shut and return to production by flowing to atmosphere, causing a “liquid unloading event”

Process Improvements Timeline

2017

- Begin testing plunger lift installs in middle of 2017.
- Identified 118 wells that required numerous manual liquid unloading events.
- Complete reduction in manual unloads on all operated plunger lift wells
- Total Systems Installed by year end 2017= 16

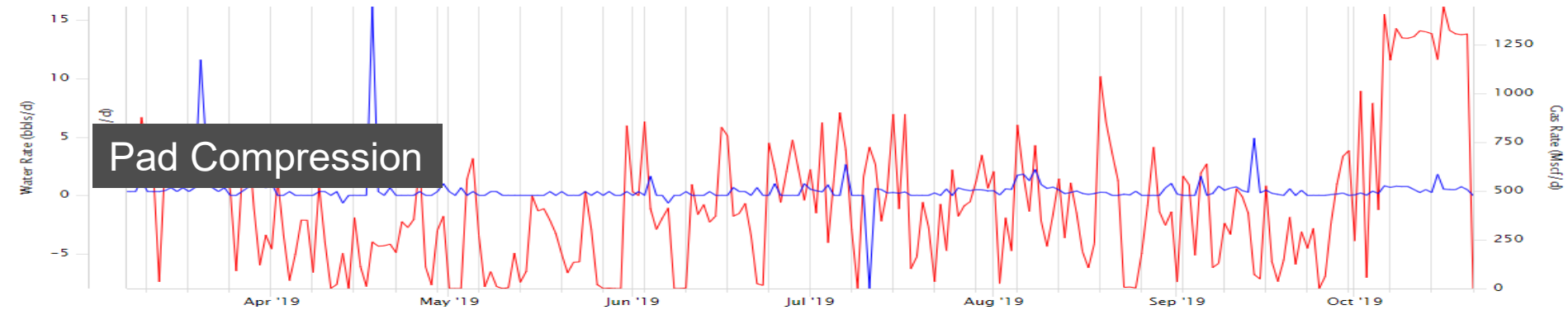
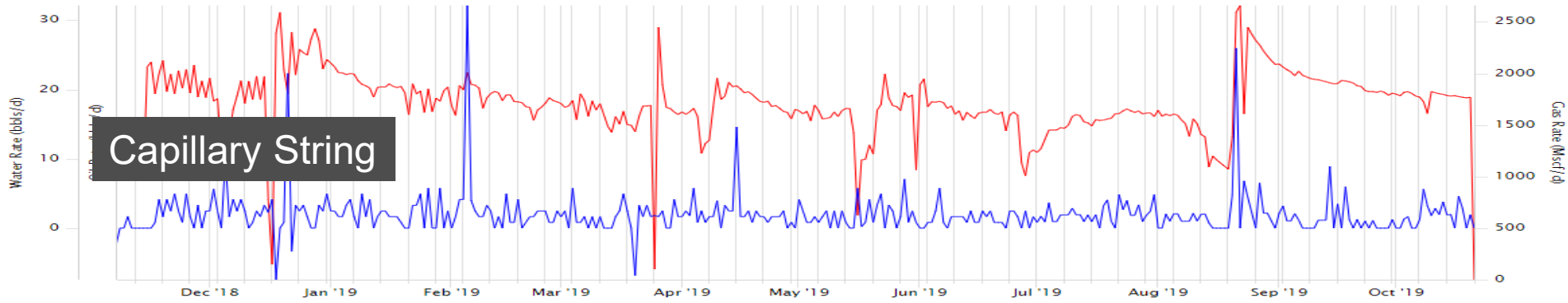
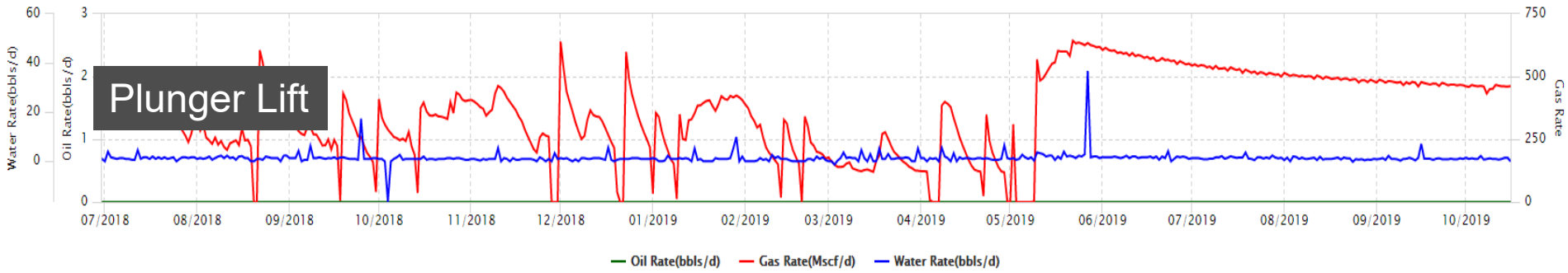
2018

- Built on the success of 2017 and identified several other pads where manual unloads were a frequent requirement for flow.
- Observed uplift in production and reduction in manual unloading events.
- Total Systems Installed = 46, Total Systems = 62

2019

- Installed 60 more systems in Q1 2019
- Total Active Systems 108
- In addition to plunger lift systems, other means of emission reduction artificial lift systems were installed:
 - 4 Total Capillary strings by YE 2019
 - 3 pad compressors installed and operating by YE 2019 servicing 14 wells

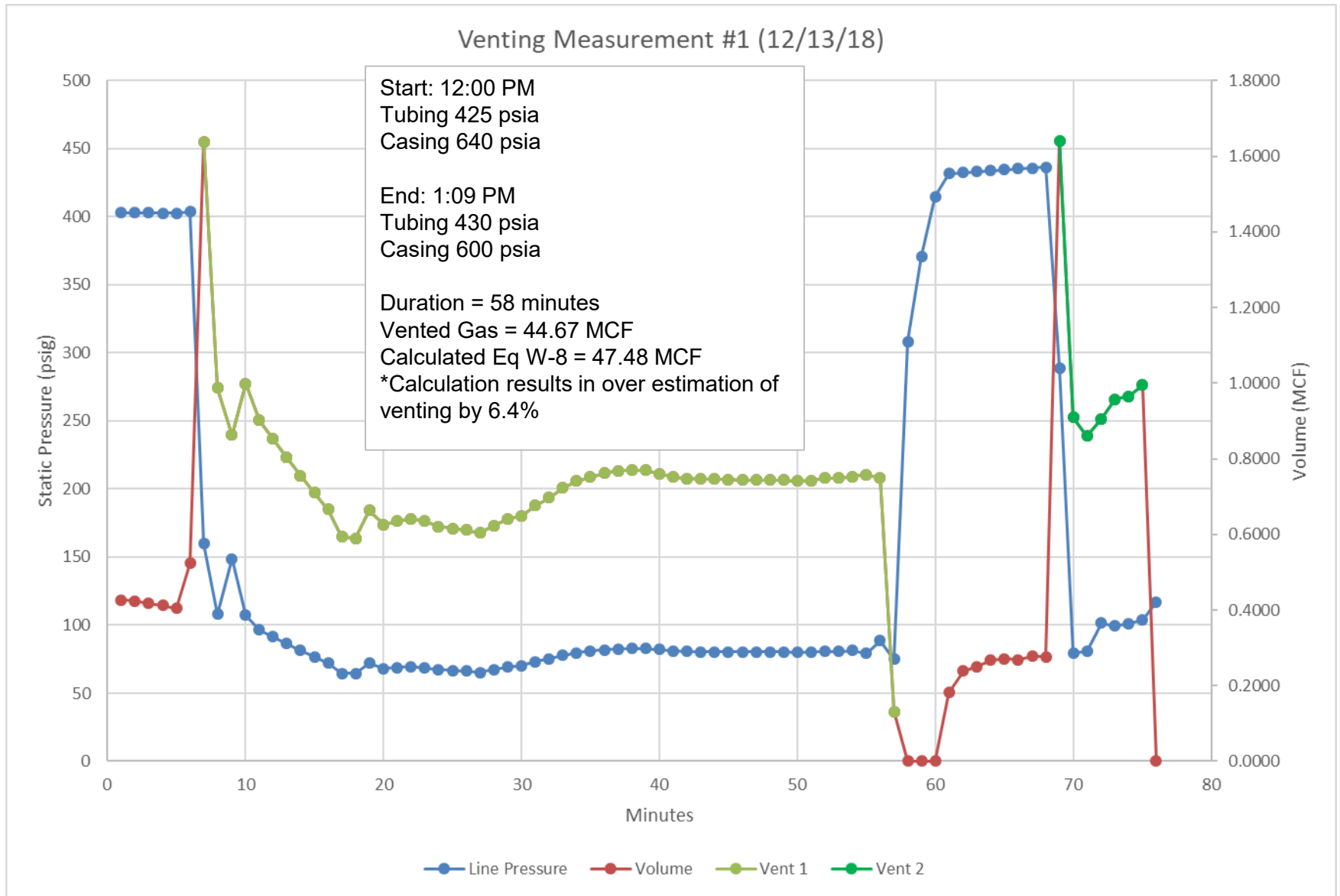
Artificial Lift Success - Examples



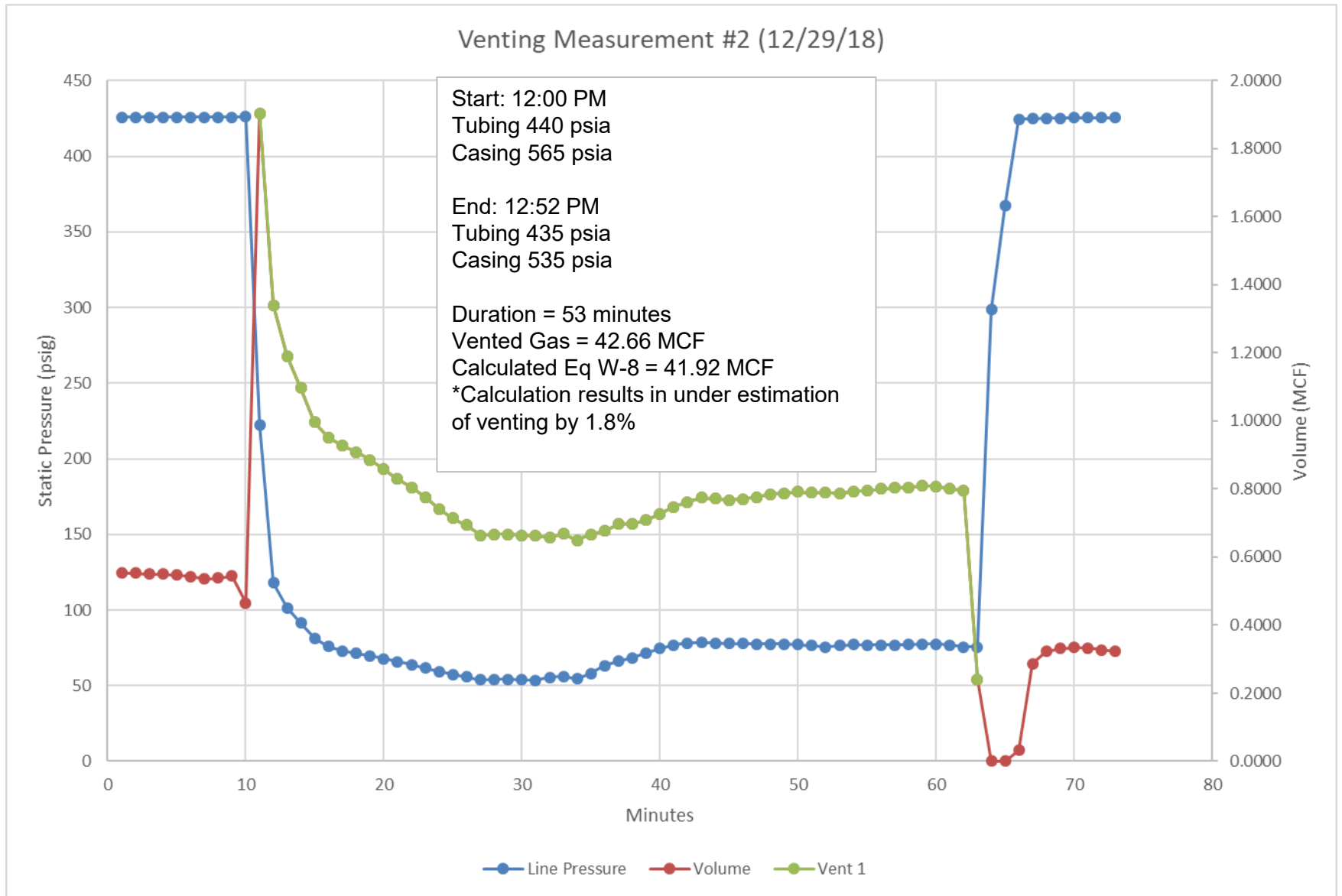
Liquid Unloading Calculation Verification

- **40 CFR Part 98 Subpart W lists 3 different calculation methods**
 - Calculation Method 1 – Equation W-7 using measured values
 - Calculation Method 2 – Equation W-8 for non plunger lift assist
 - Calculation Method 3 – Equation W-9 for plunger lift assist
- **Range Resources – Appalachia made piping changes to a Marcellus well in order to measure the vented gas during liquids unloading events in December 2018 to test the differences between Eq W-8 and W-7**
- **Two measurements were recorded**
 - Measurement 1 – Completed 12/13/18 resulting in Eq W-8 over estimating the emissions by 6.4%
 - Measurement 2 – Completed 12/29/18 resulting in Eq W-8 under estimating the emissions by 1.8%
 - Average of these two measurements results in a difference of 2.3% between calculated and measured.
- **Based on this confirmation it was decided that we would continue to use Eq W-8**

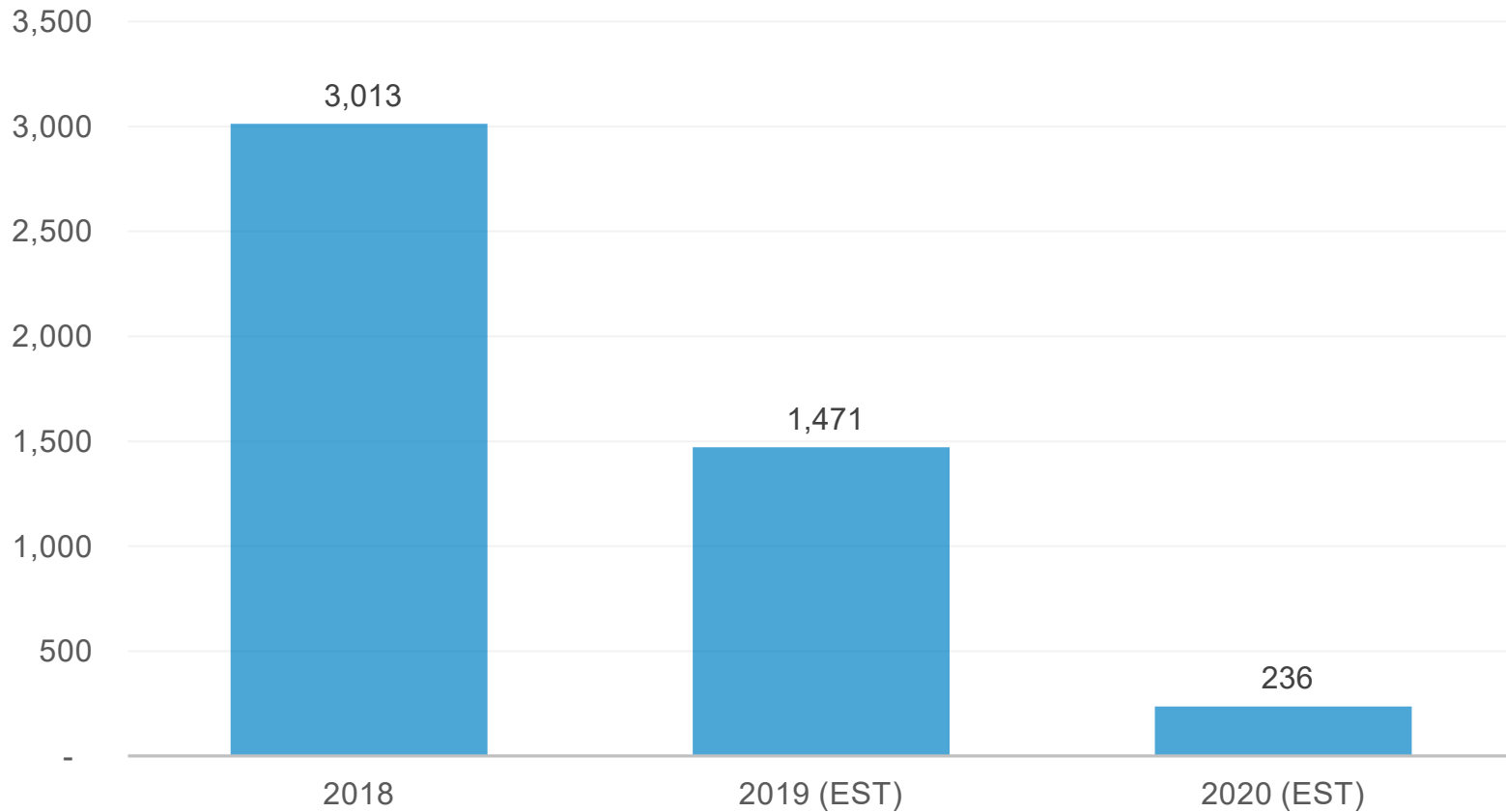
Identification - First Liquids Unloading Emissions Measurement



Identification - Second Liquids Unloading Emissions Measurement



Range Resources CH₄ Emission Reduction Trend for Basin 160A (Metric Tons /Year)



Summary

- **RRC identified a series of opportunities to improve upon liquid unloading events throughout our NEPA asset.**
 - Installed 108 active plunger lift systems following 2017 GHG report
 - 4 total capillary strings installed by YE 2019
 - 3 pad compressors set and servicing 14 wells.
- **Confirmed to continue to use Eq W-8 to estimate emissions based upon verification through on-site piping changes.**
- **Throughout the last 3 years with initiative to reduce emissions based upon unloading events, we have seen a steady decline in emission numbers.**
 - 2017 – as reporting period initiated the program to reduce our emissions based upon liquid unloading events.
 - 2018 – built upon the success and creativity of the team to increase production, all the while reducing emissions through artificial lift alterations.
 - 2019 – addressed 90% of all the wells listed as having unloading events with with Plunger Lift, Capillary Strings, or pad compression, accounting for nearly 98% of our reportable emission calculations.



QUESTIONS?