Methane Mitigator

Development of a Scalable Vent Mitigation Strategy to Simultaneously Reduce Methane Emissions and Fuel Consumption from the Compression Industry

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Project Overview

- Funding – DOE: $1,498,405, Cost Share: $433,093
- Overall Project Performance Dates
  - Original: 3/20/20 to 3/19/23
  - Current: 3/20/20 to 3/19/24
- Project Participants
  - WVU – PI – Derek Johnson, Co-PI – Andrew Nix, Nigel Clark
  - Caterpillar – Michael Bardell
  - NEW – Energy Environmental Analytics (EEA)
- Overall Project Objective
  - Develop a stand-alone vent mitigation system and fuel delivery control system capable of consuming transient vent gas emissions in well site engines to reduce GHG and other pollutants.

Technology Background

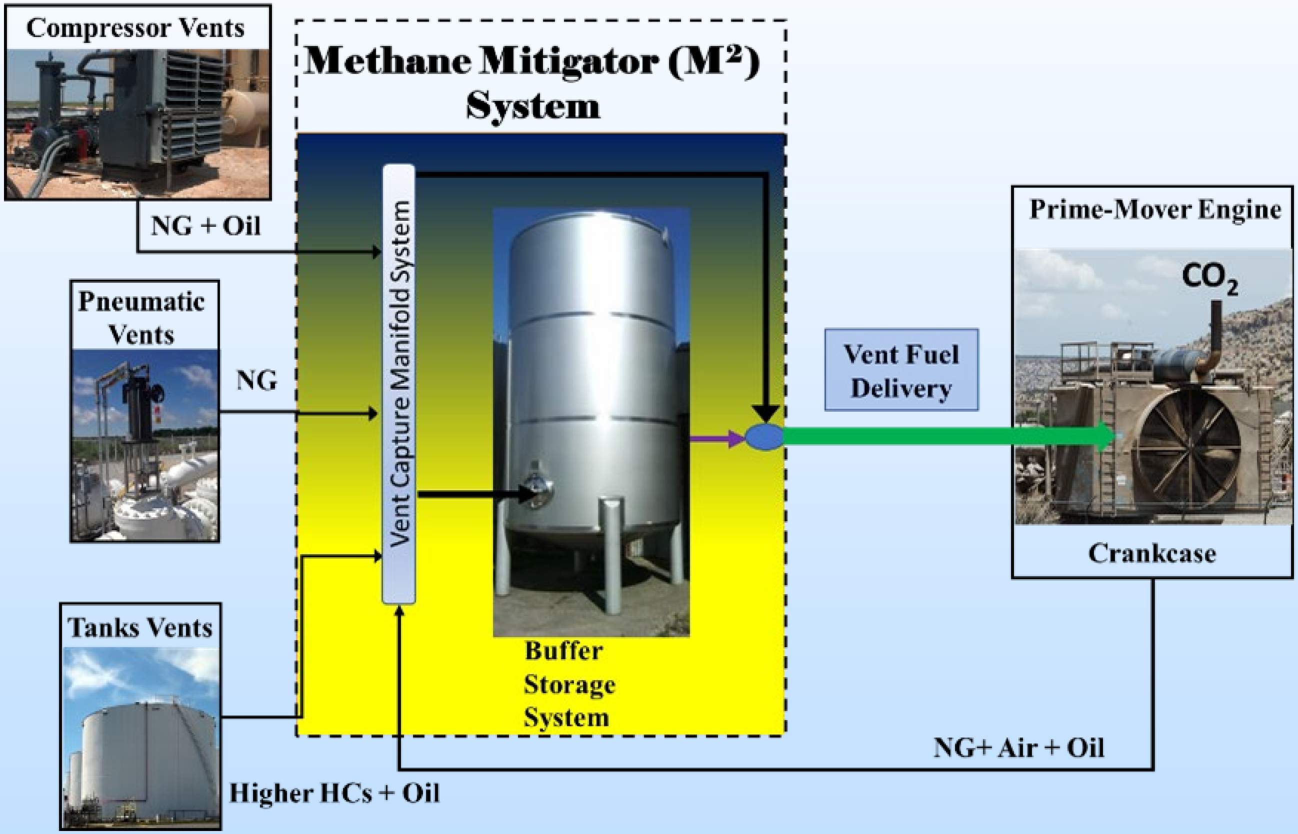
Commonly Vented Sources of Methane in Compression Industry

- Engine crankcases – vented to atmosphere
- Compressor vents – vented to atmosphere
- Pneumatic controllers (PCs) – vented to atmosphere
- Liquid storage tanks
  - Condensate tanks – vented to atmosphere, combustor, or VRU
  - Produced water tanks – primarily vented to atmosphere

Technology Background

Build On and Integrate Current Technologies

- Closed Crankcase Ventilation
- Dual fuel natural gas fumigation systems



Technical Approach/Project Scope

1) Literature review
   - Most recent data on sources

2) Filling gaps
   - New measurements
     - New activity data
     - Verification of "existing" data estimates

3) Laboratory R&D
   - Selection of representative engine technology – CAT G3508J
   - Baseline characterization
   - Evaluation of aftermarket CCV
   - Modification and redesign
     - Inclusion of other streams

4) Modeling
   - Current and new data
   - Estimation of "methane" recovery as potential fuel offset
   - Time varying volumes, compositions, heating values, MN
   - Sizing tool – scenario capabilities

5) Technology Demonstration
   - Mimic real-world scenarios in laboratory
   - Deployment in the field

Progress and Current Status of Project

Sources "Steady"

- **Engine crankcases**
  - Vary with engine load and age
  - Short term steady
  - Inerts, oil vapor, and methane

Engine	Blow-by Estimate
New Engine	Blow-by [dm^3/s] =rated power [kW]/180
	Blow-by [ft^3/min]=rated power [hp]/120
Worn Engine	Blow-by [dm^3/s] =rated power [kW]/90
	Blow-by [ft^3/min]=rated power [hp]/60

*Total flow

- **Compressor vents**
  - Vary with load and age
  - Short term steady
  - Gas with oil vapor

Compressor	Vent Estimates
New	5-10 SCFH
Worn	120-180 SCFH

*Per cylinder/throw

Progress and Current Status of Project

Progress and Current Status of Project

Crankcases

- Methane ~<5% by vol
- Total flow estimation

- 25 engines (current and previous programs)
  - 3306s, **3508**, 3512s, 3516s, 3612

- 22/25 – 88% follow conventional ranges
  - Questionable fuel/load for 3 cases outside range

Compressors

- Verified – high pressure = higher losses

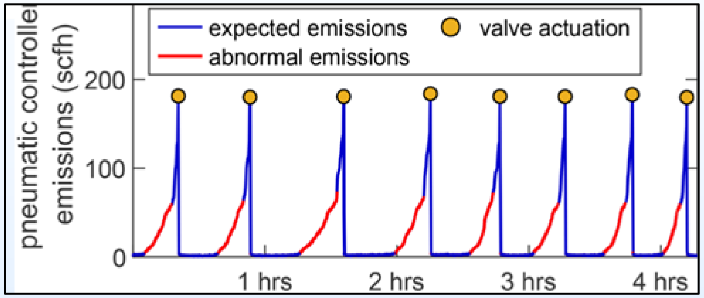
- High pressures
  - 4.8 to ~300 SCFH

- Low pressures
  - 6 to 34 SCFH

Progress and Current Status of Project

Sources "Un-Steady"

- **PCs**
  - GPUs and other separators – collocated
  - Short term variable
    - Stovern, et al. - 4.9 PC per well
    - CPC up to 9.9 SCFH (time average)
    - IPC 0.1 up to 31.3 SCFH (time average)
    - Luck, et al. – 12 SCFH (time average)
    - Peak rates up to 200 SCFH (3 SCFM) (instantaneous emissions for actuations)
    - EF – 13.5 SCFH



*Hours at best

- **Tanks**
  - Variable composition – high VOCs
  - Short term variable
  - Variable based on gas, condensate and water production

Condensate
- 33.3±24.3 lb/bbl (VOC) (Hendler, et al.)
- 0.01 lb/bbl (Environ)

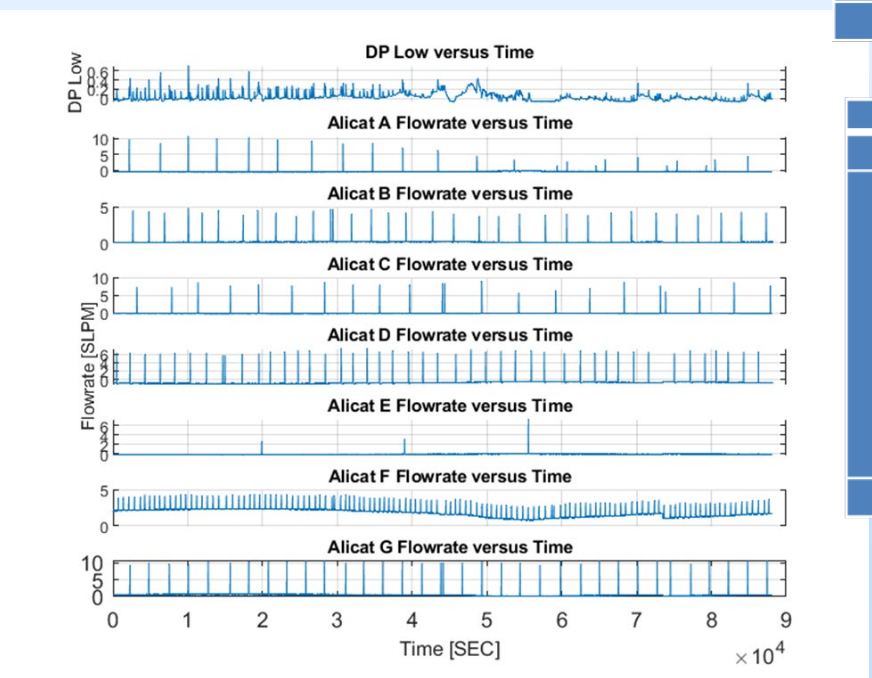
Water
- Previously no VOC/CH_4 reported
- Newly included in GHGRP EFs

Progress and Current Status of Project

Progress and Current Status of Project

PCs

- **Highly variable**
  - Below and above current EF of 13.5 SCFH



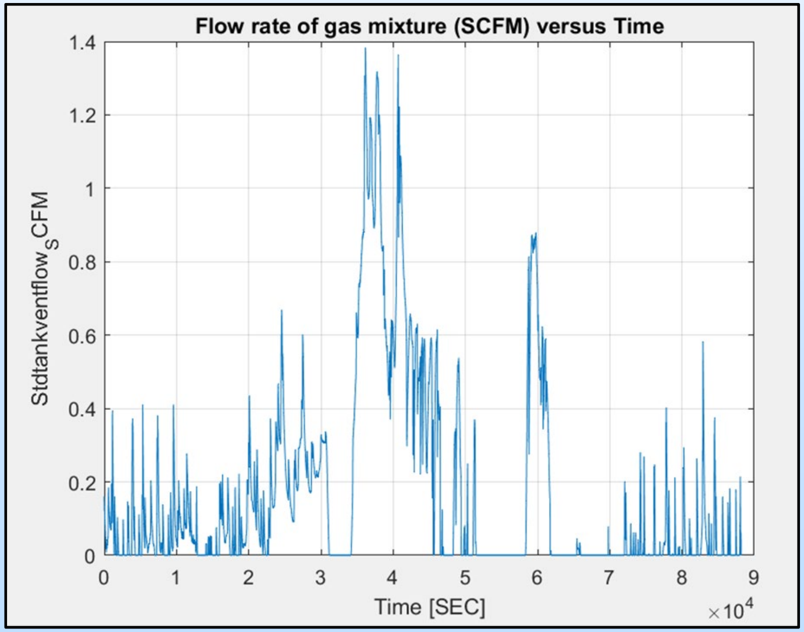
Site 1 PC Flow Rates (SCFH)								
	Dates	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun	29-Jun
PC 1	2H (MFM F)	0.329	0.453	0.385	0.392	0.407	0.498	0.434
	4H (MFM E)	0.002	0.007	0.012	0.003	0.011	0.031	0.022
	6H (MFM D)	0.022	0.036	0.034	0.036	0.030	0.028	0.022
	8H (MFM G)	0.033	0.057	0.056	0.067	0.058	0.063	0.043
	10H (MFM C)	0.009	0.020	0.016	0.018	0.019	0.017	0.013
	14H (MFM A)	0.011	0.012	0.015	0.014	0.016	0.007	0.009
	18H (MFM B)	0.021	0.034	0.037	0.043	0.033	0.035	0.037
	Total per Day	0.425	0.621	0.554	0.573	0.575	0.680	0.580

Site 2 PC Flow Rates (SCFH)							
	Dates	29-Jul	30-Jul	31-Jul	1-Aug	2-Aug	3-Aug
PC 2	2H (MFM G)	2.045	1.930	2.365	2.135	1.898	1.775
	2H (MFM H)	0.855	0.908	0.945	0.898	0.902	0.874
	4H (MFM E)	0.065	0.051	0.052	0.058	0.050	0.049
	4H (MFM F)	3.399	2.970	2.813	5.960	2.354	2.406
	6H (MFM B)	2.867	2.624	2.676	2.606	2.397	2.237
	6H (MFM D)	0.055	0.051	0.053	0.032	0.061	0.065
	10H (MFM A)	NA					
	10H (MFM C)	18.282	15.630	14.337	14.337	15.366	14.171
	Total per Day	22.656	19.610	18.200	21.285	18.734	17.565

Progress and Current Status of Project

Tanks

- **Highly variable**
  - Variable compositions



Day		LFE Size	Initial Vent Volume Estimates (CF)	New Vent Volume Estimates Total Flow (CF)	H2O Produced (CF)	Composition Data
0	Site 1	2"			121.21	June 27th GC analysis
1	Site 1	2"	405.05	923.23	102.4	June 27th GC analysis
2	Site 1	2"	270.66	196.37	141.53	June 27th GC analysis
3	Site 1	2"	876.53	742.48	127.61	June 27th GC analysis
4	Site 1	2"	863.31	1239.3	115.48	GC analysis
5	Site 1	2"	291.09	600.68	102.12	Interpolated
6	Site 1	2"	961.52	1482.8	97.01	Interpolated
0	Site 2	1"	242.98	247.9	109.37	GC analysis
1	Site 2	1"	250.32	255.07	103.47	Interpolated
2	Site 2	1"	157.5	153	97.91	Interpolated
3	Site 2	1"	250.78	338.88	101.13	GC analysis
4	Site 2	1"	183.83	188.22	107.06	GC analysis August 1st
5	Site 2	1"	212.58	215.83	108.41	GC analysis August 1st

NOTE: DATA ANALYSIS NOT FINAL – EXAMPLE ONLY

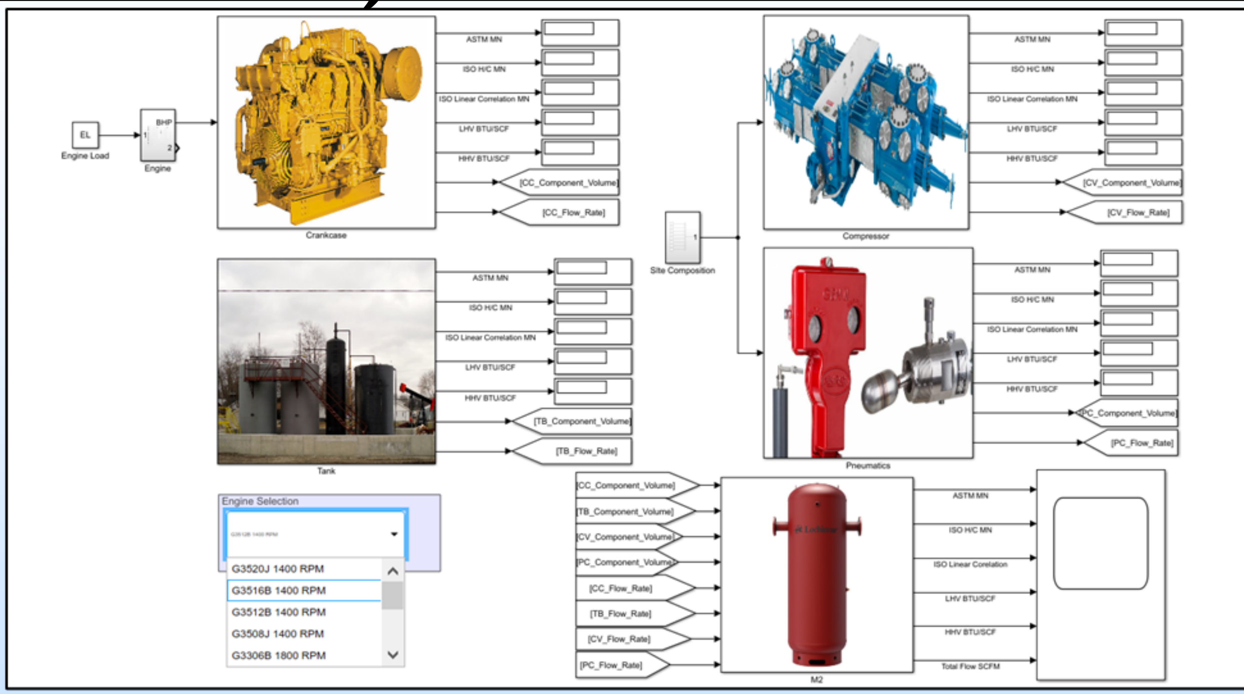
Progress and Current Status of Project

Modeling

- **Design and analysis tool**
  - MATLAB and Simulink

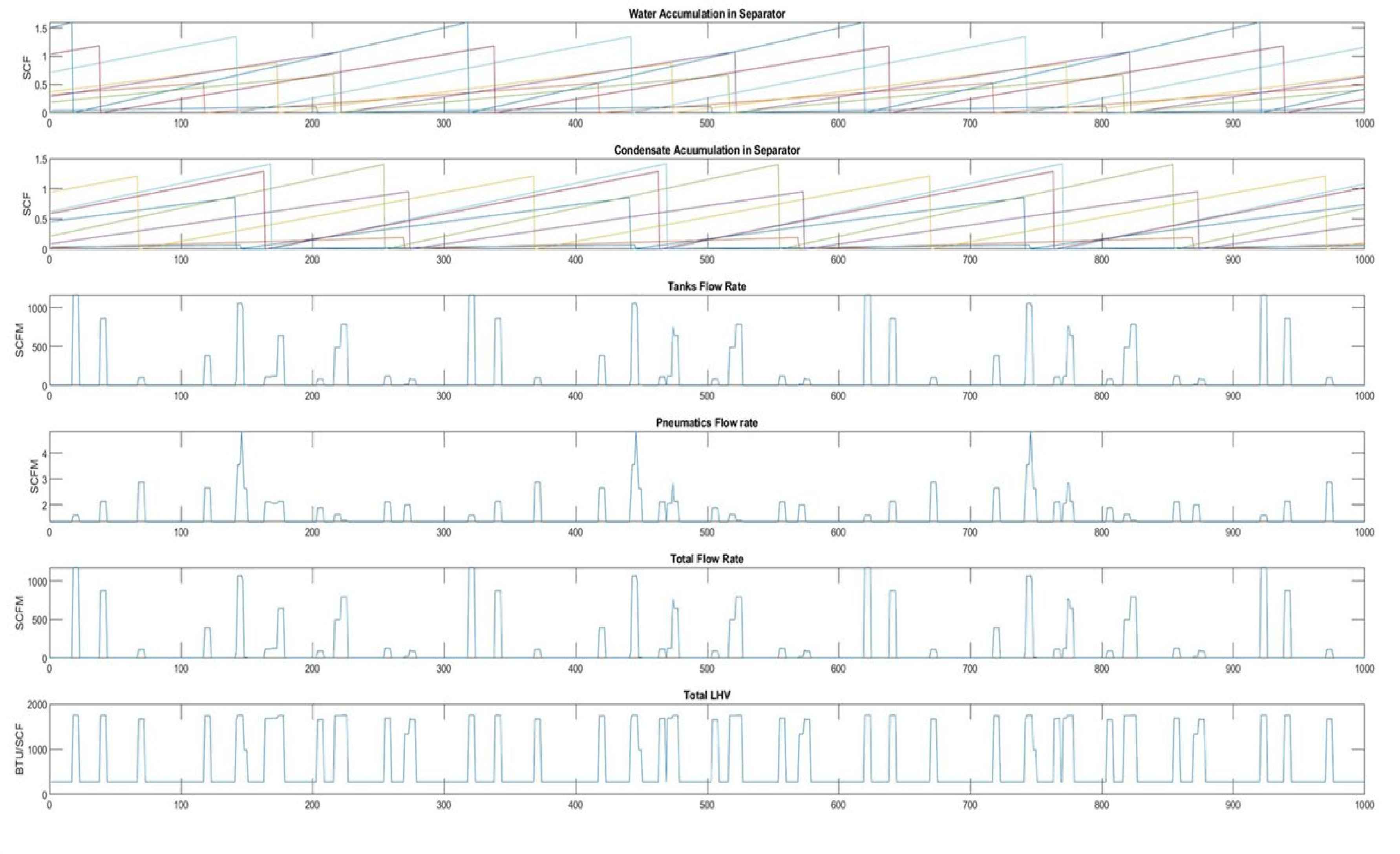
- **Using literature and new data**
  - Time based emissions
  - Compositions
  - Total flow
  - Energy content
  - MN

- **Using literature and new data**
  - Scenarios

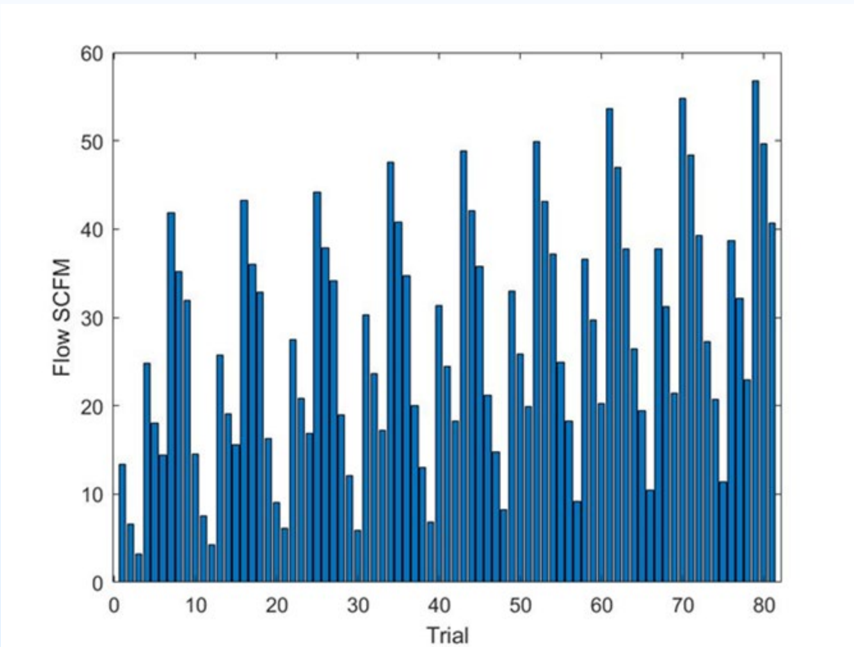


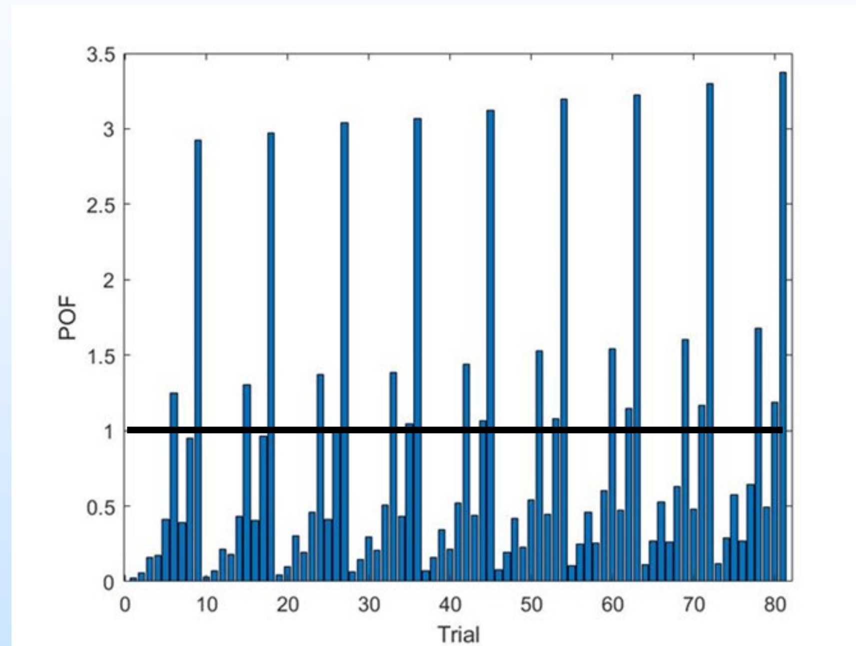
Inputs	Outputs
Engine Size	Engine BHP
Engine Load	Engine Fuel Consumption
Gas Production Rate	LHV, HHV, MN of Fugitive Gasses
Condensate Production Rate	Emissions Flow Rates
Water Production Rate	Fuel Offset Factor
Site Composition	
Wells Per Site	
Piston Ring Wear	
Packing Seal Ring Wear	

Progress and Current Status of Project



Progress and Current Status of Project





- Potential recover limited by "condensate" tank emissions
  - MN/heating value – not necessarily total flow limited
- Uncertainty on EFS
  - New condensate data is required

Progress and Current Status of Project

M^2 R&D

- Platform – donated CAT G3508J
- Representative – 35** series – 3508, 3512, 3516, 3520

- Delayed – laboratory issues
- WVU sale of VETL

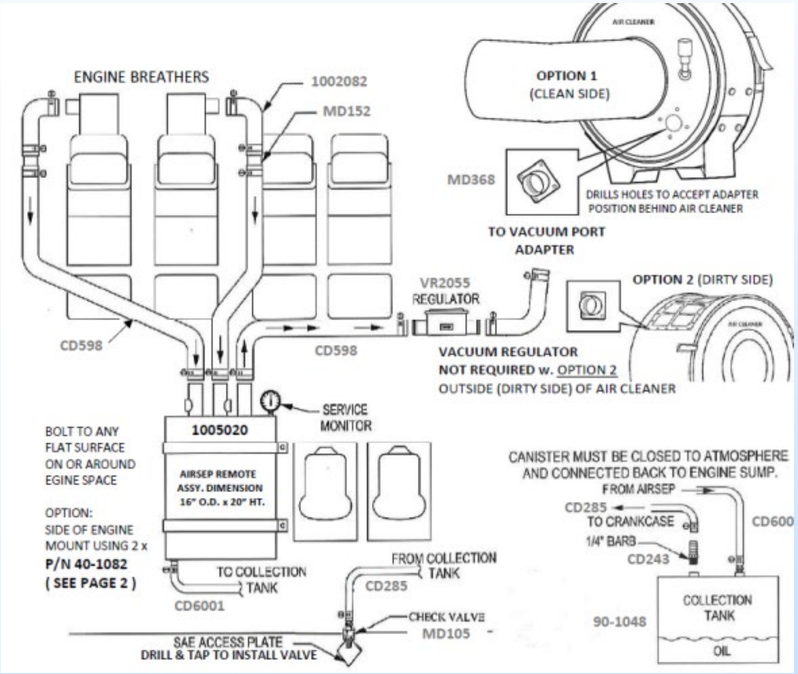
- Energy Environmental Analytics (E2A)
- Providing services – dedicated R&D test cell

ENERGY ENVIRONMENTAL ANALYTICS

Progress and Current Status of Project

M^2 R&D

- Test cell and control room nearly completed
- Major equipment installed
  - Engine/generator
  - Load bank
  - Radiator
- Ongoing
  - NG line upgrade
  - DAQ instrumentation
- Future
  - Baseline testing
  - Evaluation of AIRSEP



Plans for future testing/development/ commercialization

a. In this project
   - Laboratory R&D
   - Laboratory demonstration – CAT G3508J
   - Field demonstration*** (time and funding permitting)

b. iM4 and other funding for continued R&D – refinement
   - Focus on only CCV and closed compressor vents (CCV^2)
   - STEAQ – better understanding of tanks for future systems

c. Scale-up potential, if applicable
   - Current/future modeling to highlight savings
   - https://netl.doe.gov/sites/default/files/netl-file/Brun.pdf
     - +15,000 upstream prime movers (small to large engines and compressors)
       - Most units 4SLB < 2000 hp
     - 800-900 boosting stations
     - 850 – 900 mainline compressor stations

Summary Slide

Methane Mitigator

- Verified industry rules of thumb
  - Engine crankcase total vent rates – including compositions
  - Total compressor vent emissions – including compositions

- Verified and expanded on PC vent rates and behavior (6-7 continuous days)

- Tanks
  - Atmospheric tanks complex – due to breathing and operations
  - PW data lacking – working through development of EFs from real world data
  - Condensate – even higher variability and complexity identified with modeling
    - Need new data and understanding

- High potential – 95% reduction in engine crankcase and compressor vents
- With buffer storage
  - High potential to consume PC emissions
  - Tanks – dependent on dry/wet gas and “real emissions” produced

Appendix

– These slides will not be discussed during the presentation but are mandatory.

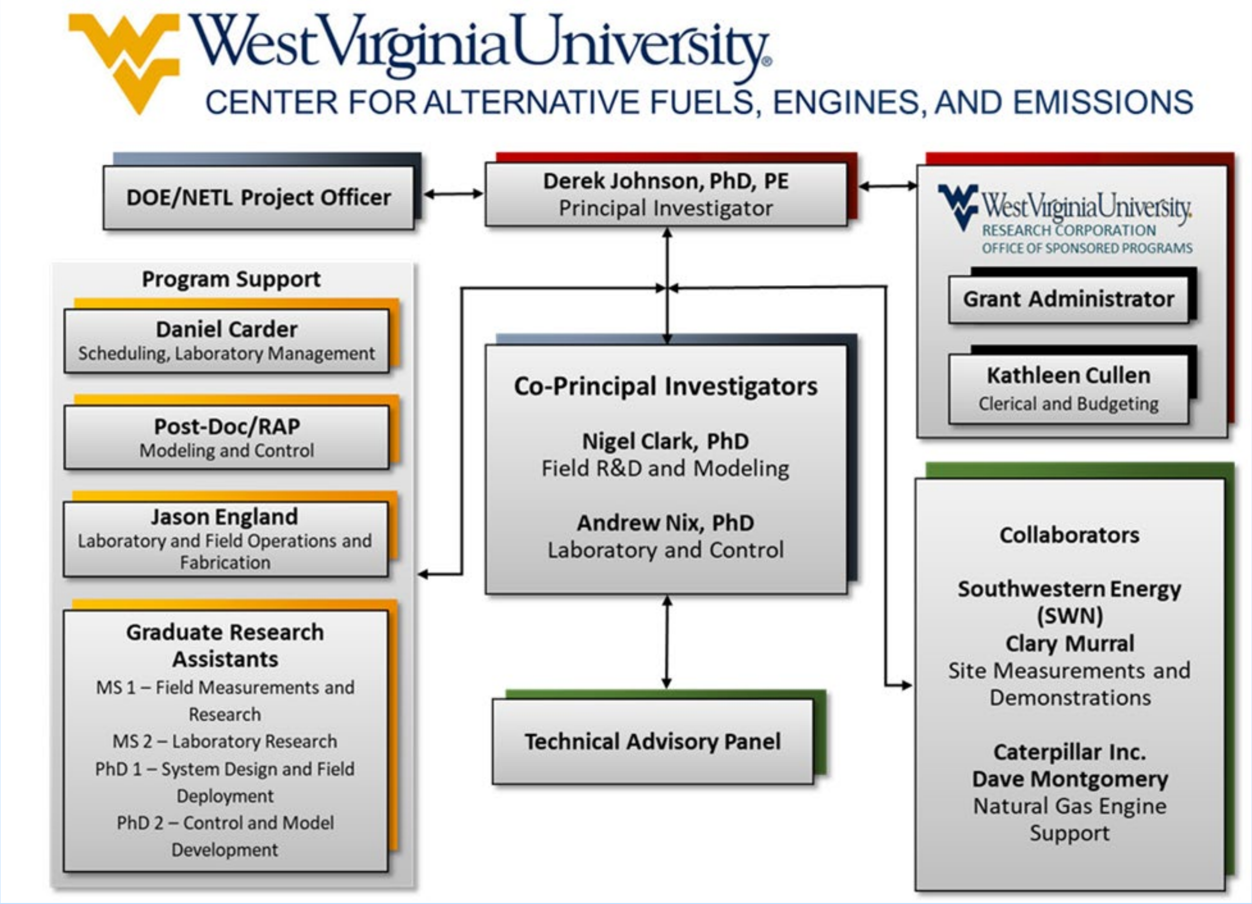
Organization Chart

Primary R&D – WVU G3508J – Setup and control modifications – CAT

SWN – Site Measurements

New***- Northeast Natural Energy – Multiple Dry Gas Sites with Compression

New***- Energy Environmental Analytics – Laboratory Services

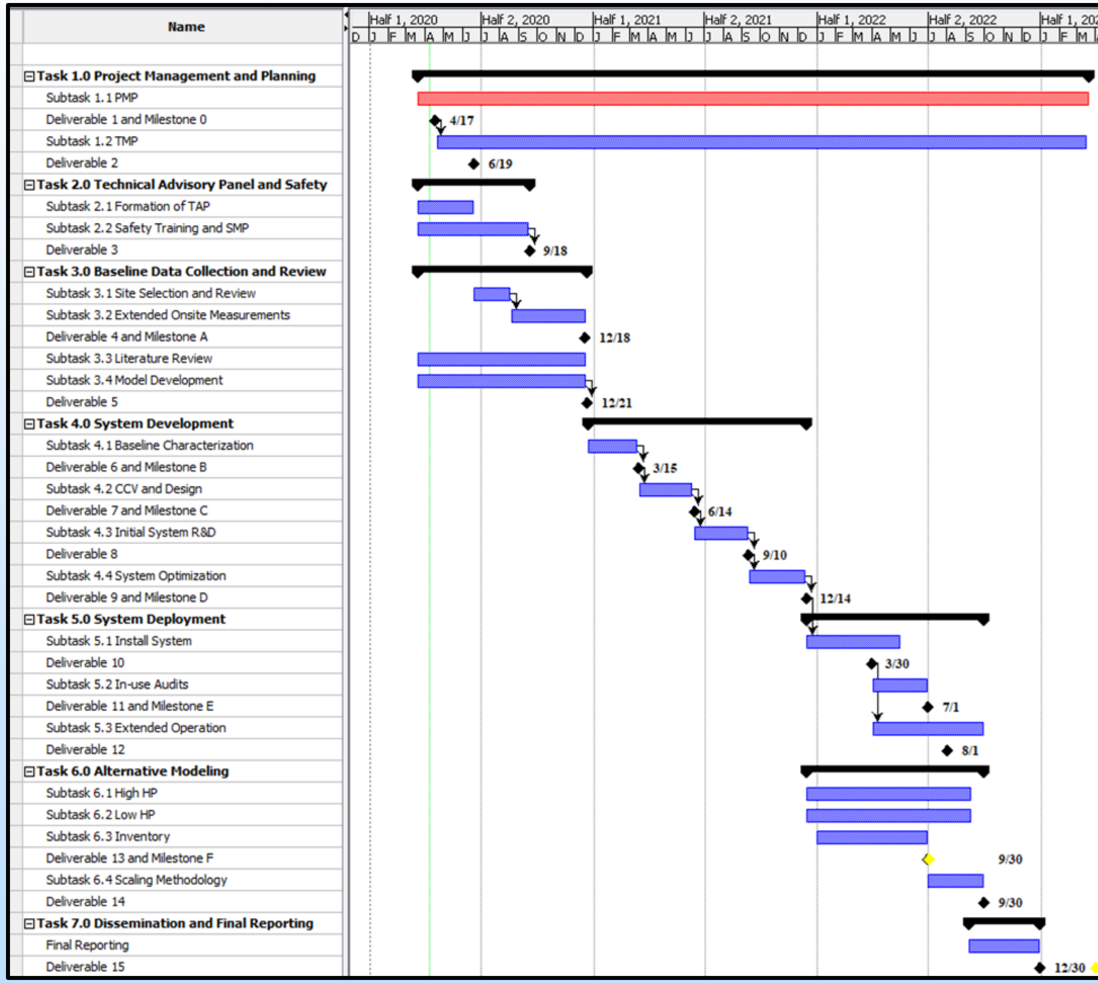


TAP –

- **WVU, CAT, Bryan Marlow – Ariel, Tracey Footer – ERG, Nathan Fowler – Baughner, Richard Atkinson - Consultant**

Gantt Chart

- Original Gantt Chart
- 1st 6-month NCTE – overcome pandemic delays
- 2nd 6-month NCTE – overcome laboratory delays



Gantt Chart

- New Gantt Chart