Project Number: DE-FE0031863

Low-cost Retrofit Kit for Integral Reciprocating Compressors to Reduce Emissions and Enhance Efficiency

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Mid Continental Rentals

U.S. Department of Energy
National Energy Technology Laboratory
Carbon Management and Natural Gas & Oil Research Project Review Meeting
Virtual Meetings August 2 through August 31, 2021

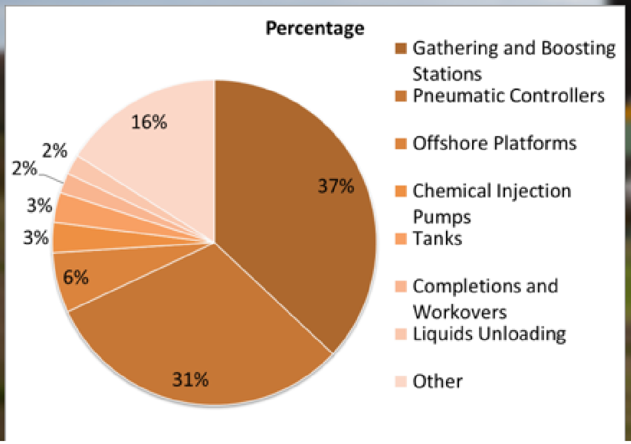
Presentation Outline

- Technical Status
- Accomplishments to Date
- Lessons Learned
- Project Summary

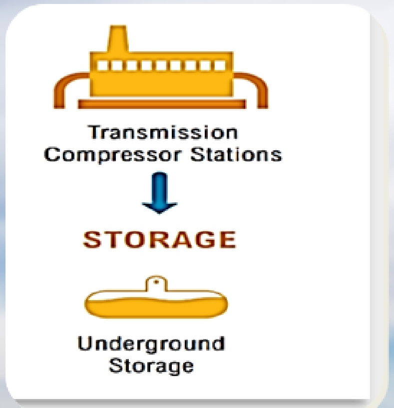
Emissions from O&G Production and Distribution Facilities

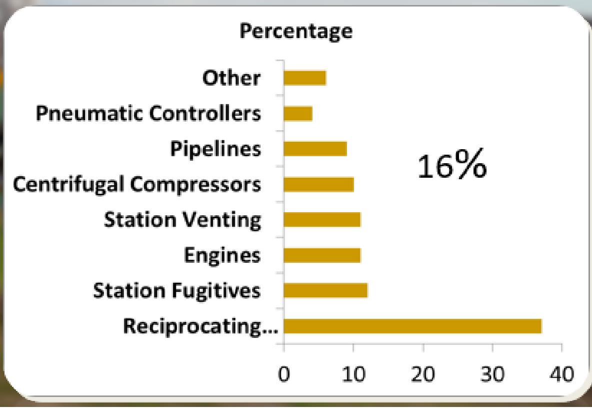
The oil and gas industry accounts for about a third of all methane emissions in the United States

Production and Processing

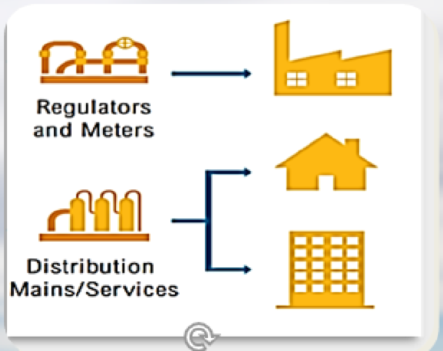


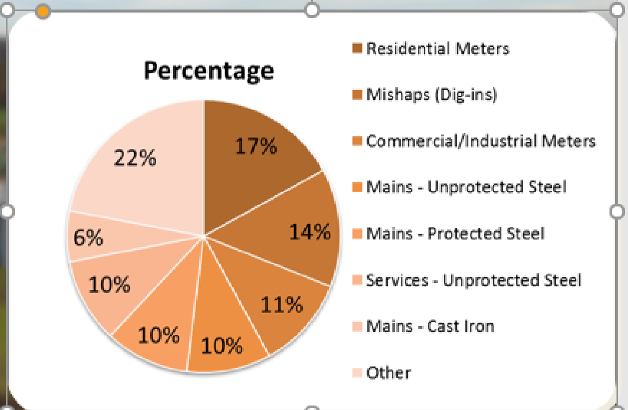
Transmission





Distribution

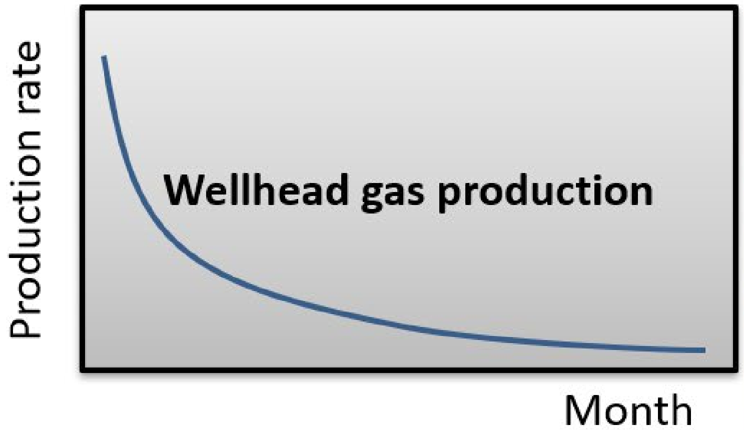




Problem Statement

EMISSIONS OVERVIEW

Requirement to meet the emissions standards at various operating conditions



Operational Limits

The majority of large industrial NG engines are designed to optimally work at their rated load and speed

VOC and Methane Emissions

Unburnt HC emissions generally at part load scenarios.

Regulations

Regulation on exhaust emissions require stricter control of RC engines operation especially at low loads

Project Objectives

Develop and validate a novel, low-cost ($50-$100/BHP), field-installable (installation time <3 hours), remotely controlled, retrofit kit with integrated sensors for Integral Reciprc

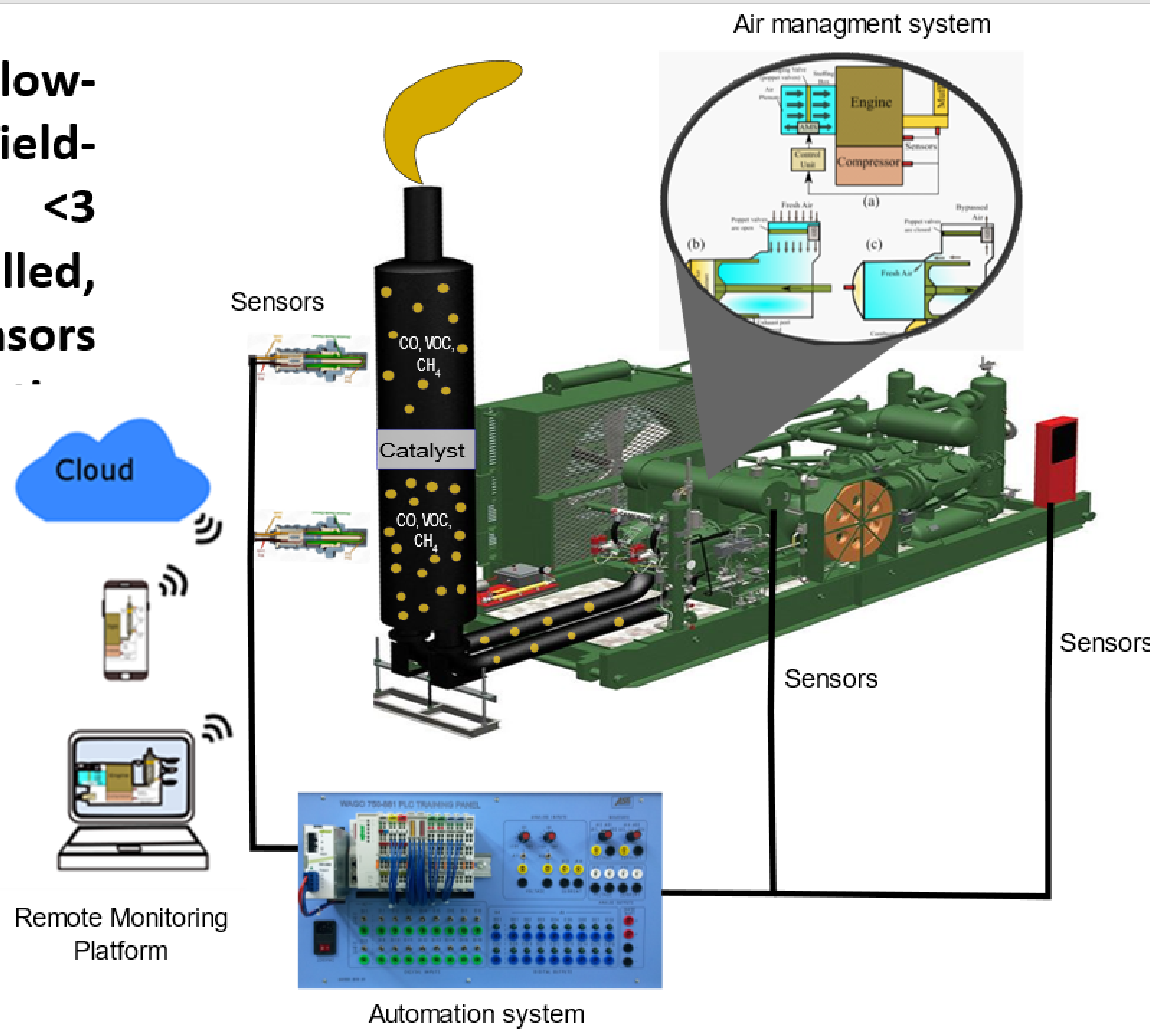
Compressors (IRCs).

This retrofit kit consists of:

1) an air management system;

2) integrated sensors to collect dat from the IRC; and

3) a cloud-connected control unit plus graphical user-interface (GUI) or HMI.



Project Team & Partners

The UNIVERSITY of OKLAHOMA
GALLOGLY
College of Engineering

Pejman Kazempoor, Assistant Professor, PI

Ramkumar Parthasarathy, Professor

Sridhar Radhakrishnan, Professor (Director Of Computer Science / Co-director, Data Science And Analytics)

Three graduate students & a lab technician and an undergraduate student

Mid Continental Rentals

Providing equipment, Technical support, Field support, Site access

WAGO

Providing automation equipment, Technical support, Field support,

Tasks- Summary

BUDGET PERIOD 1

Task 1.0 - Project Management and Planning

Task 2.0 – Installation of a full-size IRC at OU

Task 3.0 – Cost-effective and optimized air management system

Task 4.0 -Down-selection of the sensor systems (sensor+ sample line+ filtration)

BUDGET PERIOD 2

Task 5.0 –Integration of sensors and data acquisition

Task 6.0 – The first field deployment of the data acquisition system

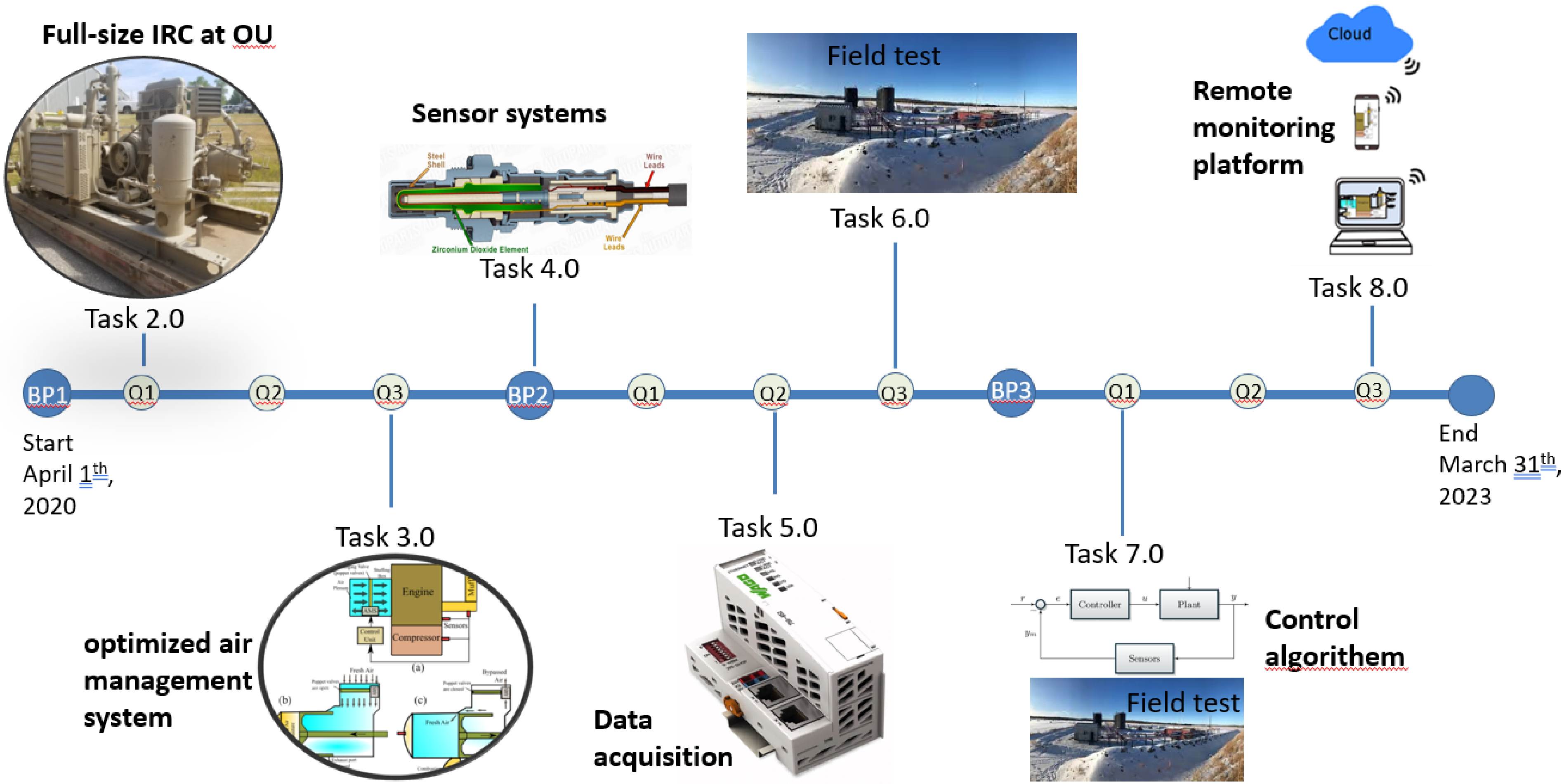
Task 7.0 – Feedback control algorithm to manage AMS

BUDGET PERIOD 3

Task 8.0 – Predictive and preventive maintenance platform

Task 9.0 – Final product at a field

Project Schedule – 2020-2023



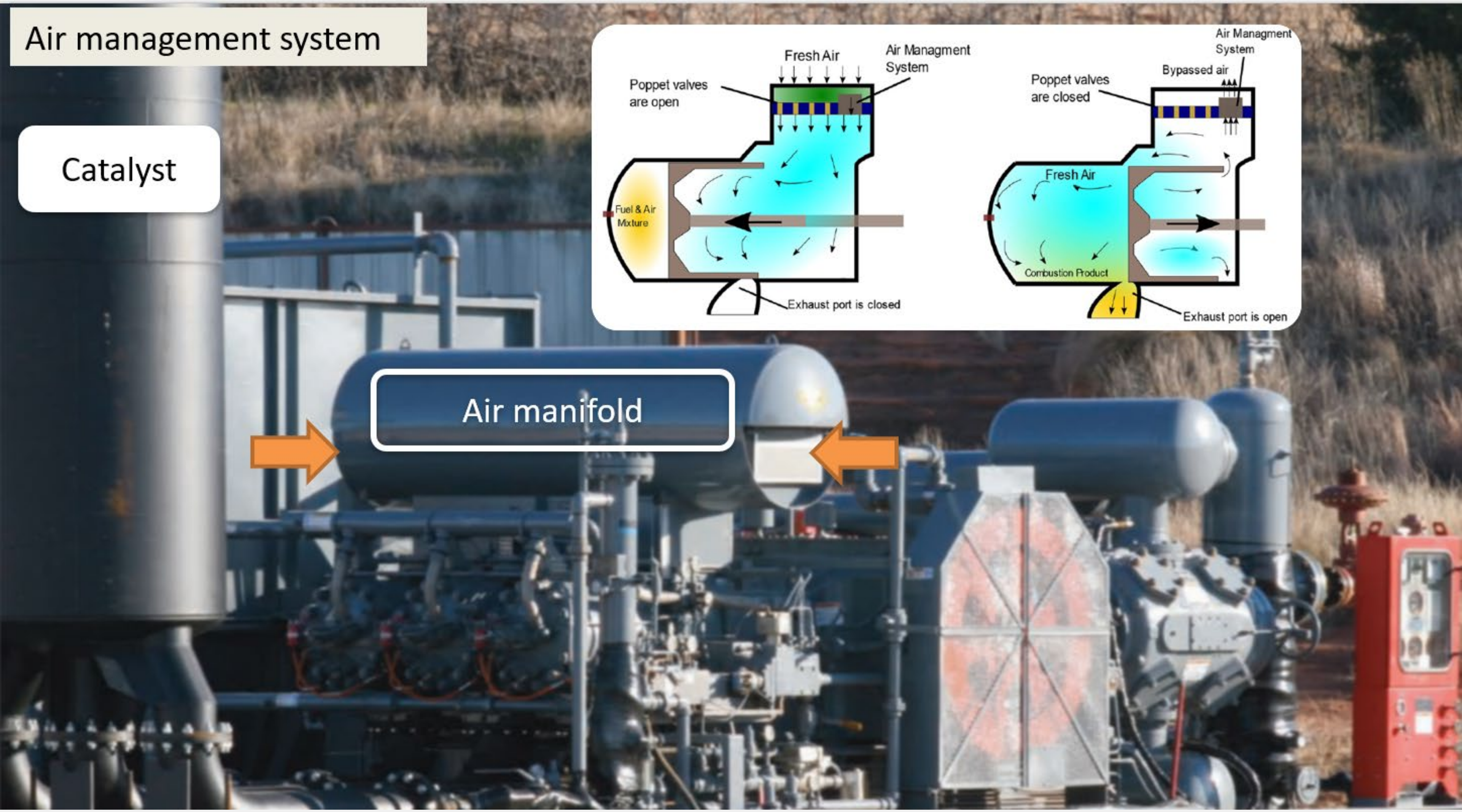
Accomplishments to Date



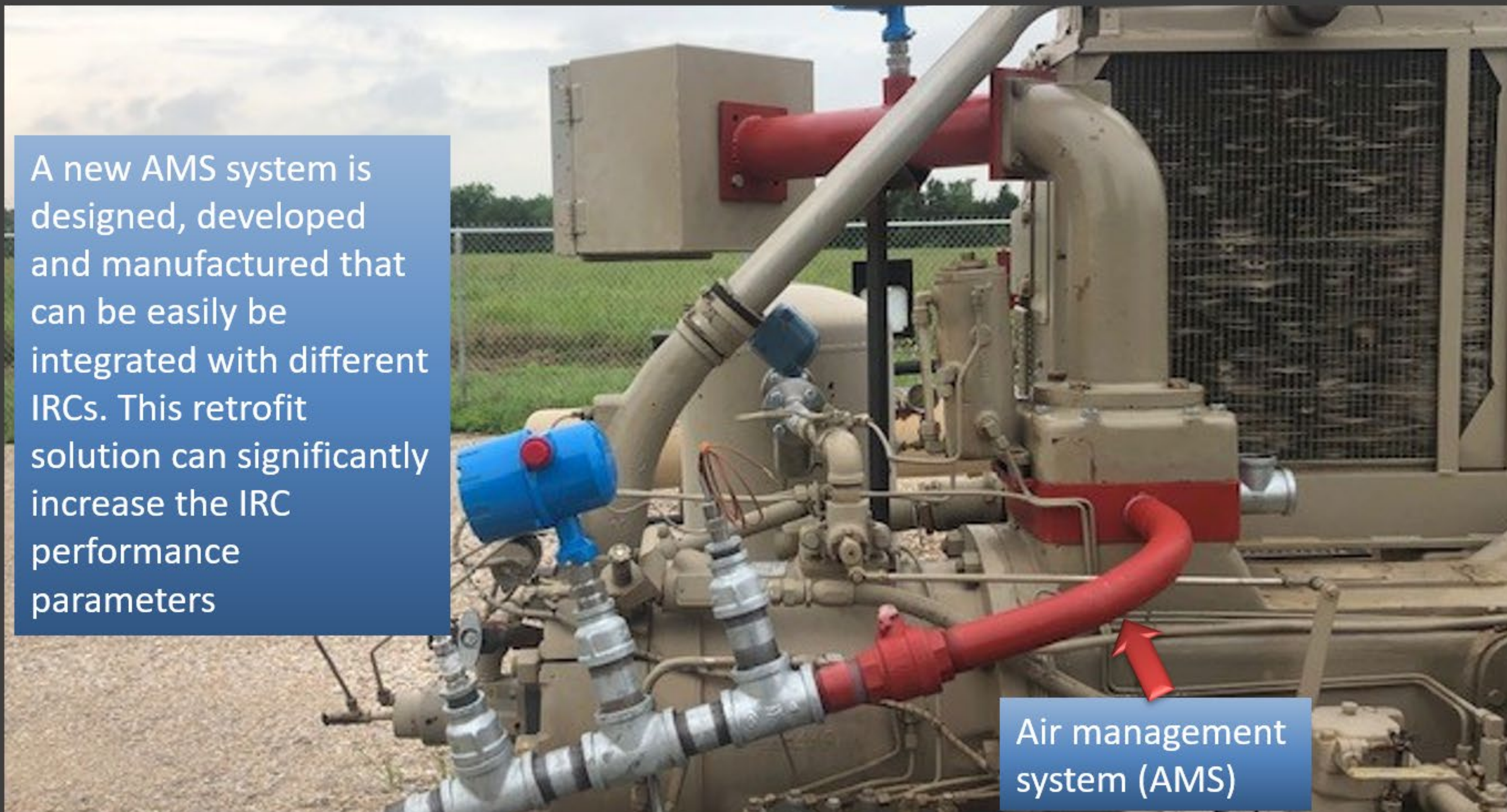



Task 2: Installation of a full-size IRC at OU

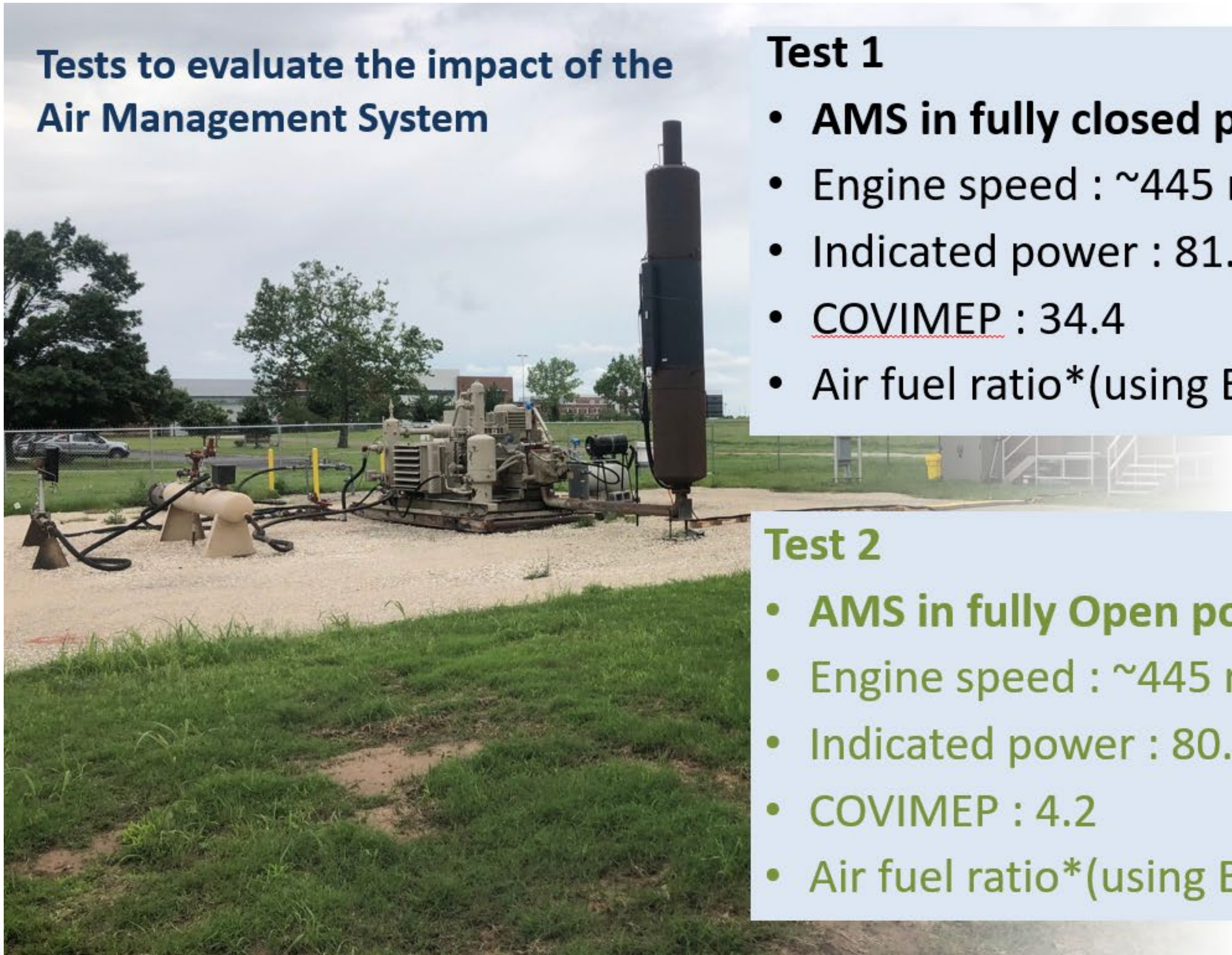
Task 3.0 – Cost-effective and optimized air management system



Task 3.0 – Cost-effective and optimized air management system



Task 3.0 – Cost-effective and optimized air management system



Tests to evaluate the impact of the Air Management System

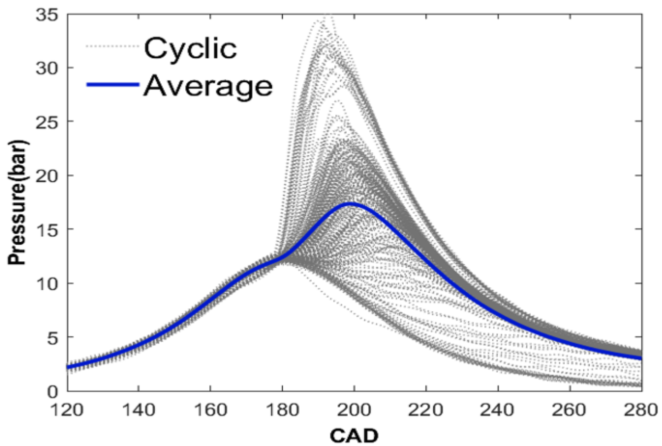
Test 1

- **AMS in fully closed position**
- Engine speed : ~445 rpm
- Indicated power : 81.5 Hp
- COVIMEP : 34.4
- Air fuel ratio*(using ECM sensor) : 40.8

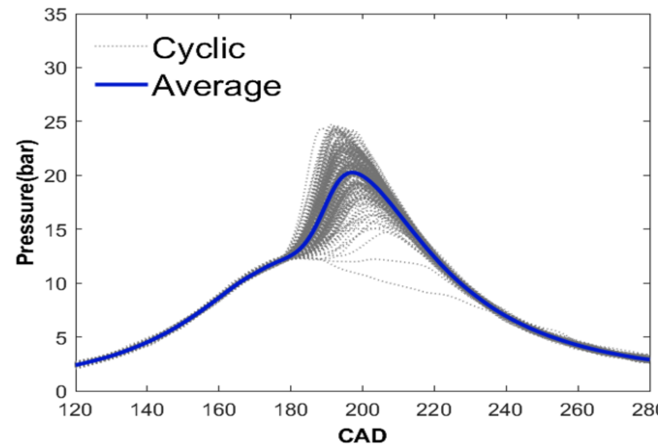
Test 2

- **AMS in fully Open position**
- Engine speed : ~445 rpm
- Indicated power : 80.5 Hp
- COVIMEP : 4.2
- Air fuel ratio*(using ECM sensor) : 24.4

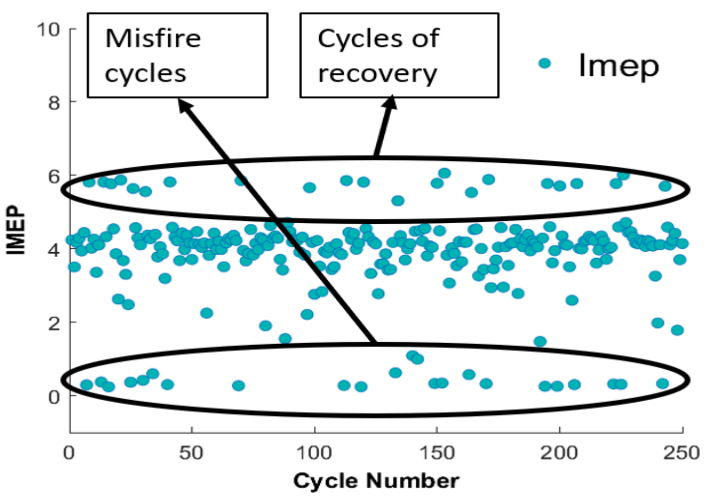
Task 3.0 – Cost-effective and optimized air management system-Test results



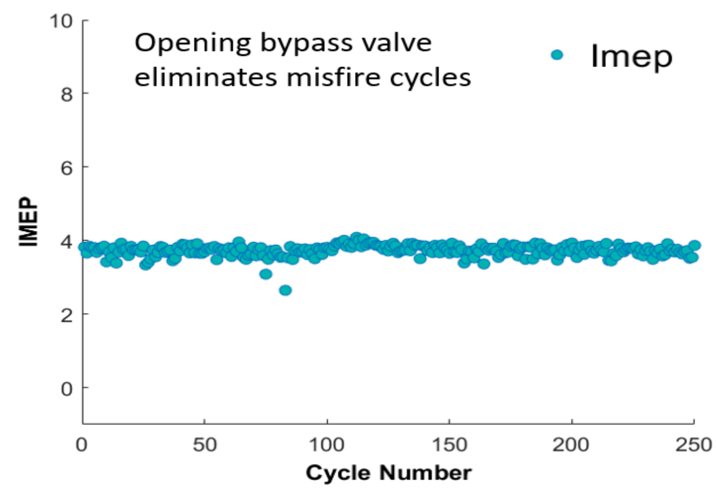
Test 1: AMS in fully closed position



Test 2: AMS in fully open position

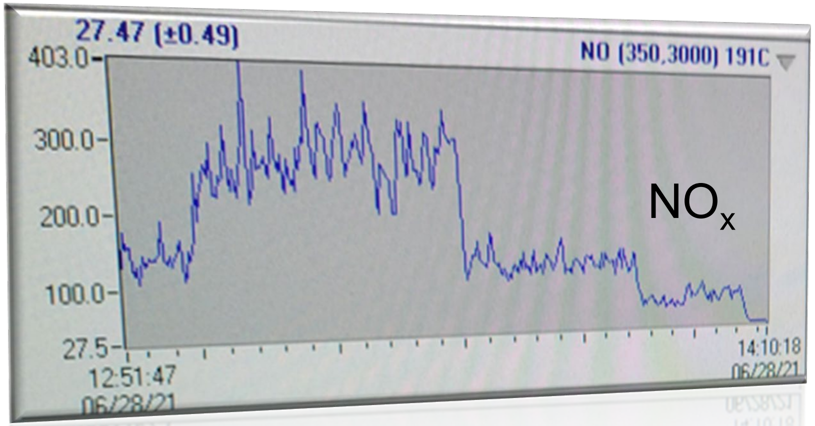


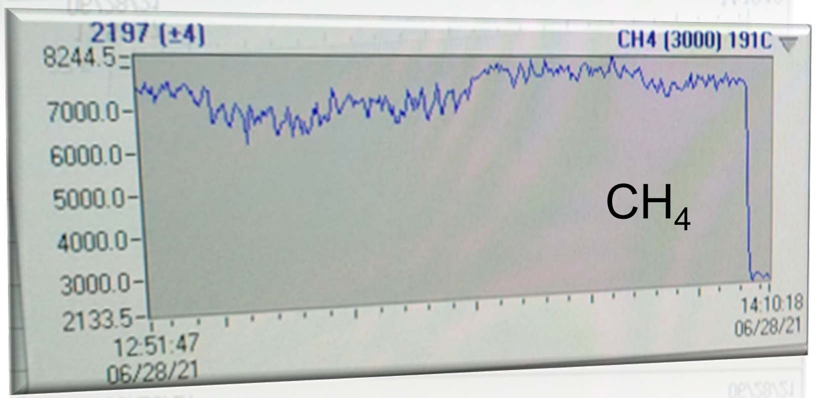
Test 1: AMS in fully closed position

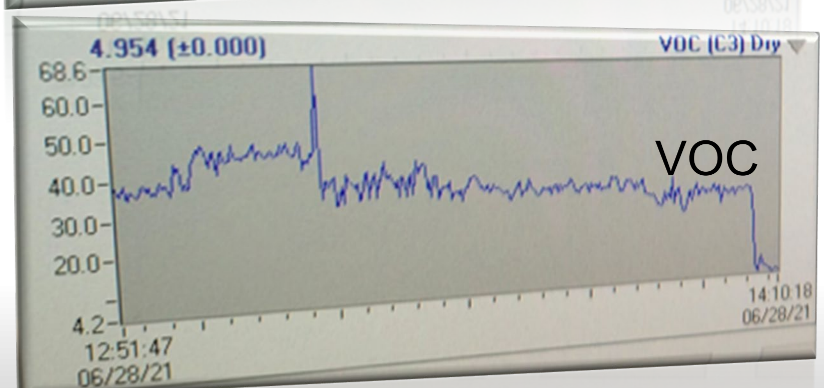


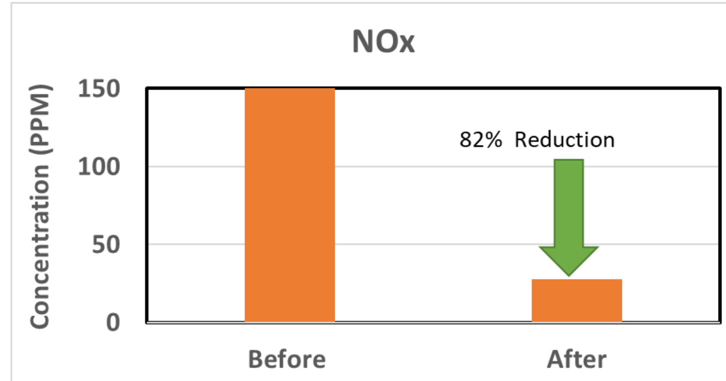
Test 2: AMS in fully open position

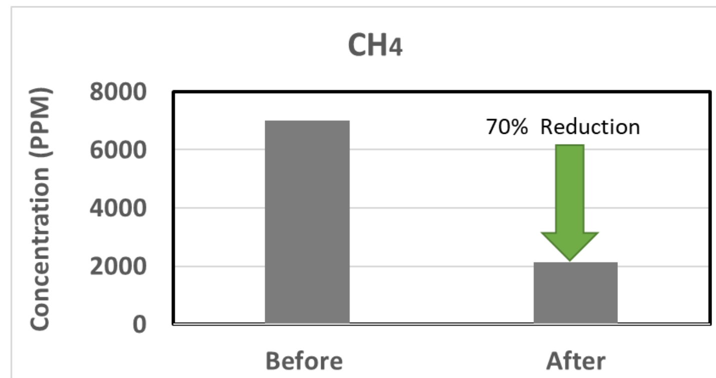
Task 3.0 – Cost-effective and optimized air management system-Test results

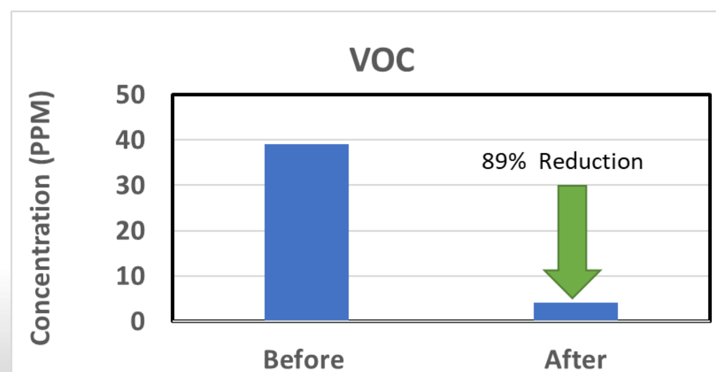










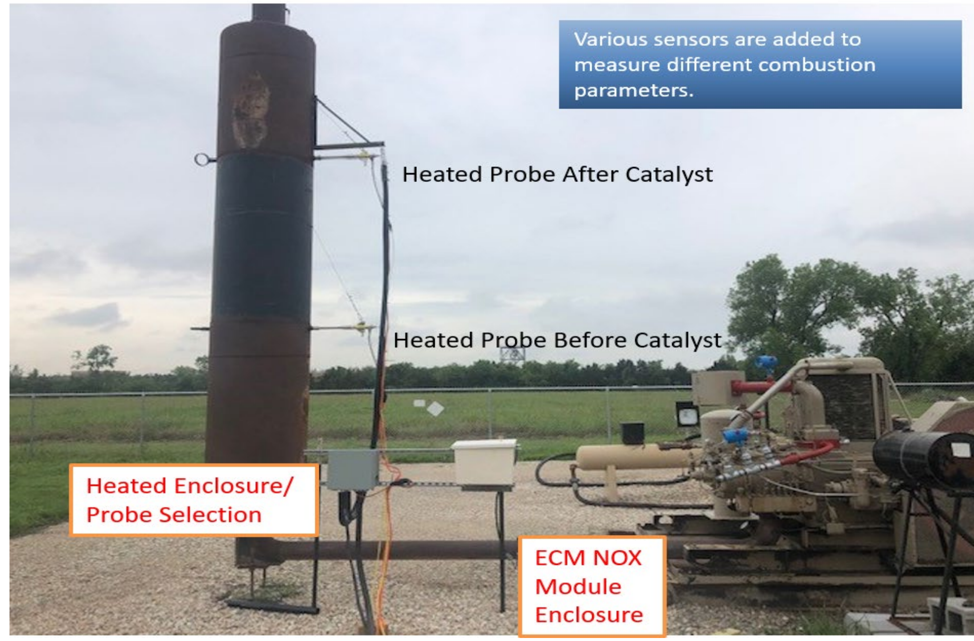


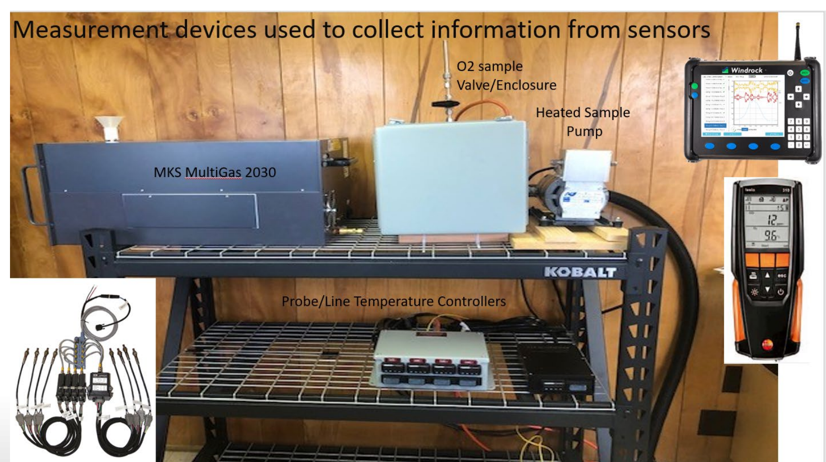
Task 4.0 -Down-selection of the sensors (sensor+ sample line+ filtration)

Indicator Port Engine Pressure

Indicator Port 2nd Stage Compressor Pressure

Indicator Port 1st Stage Compressor Pressure

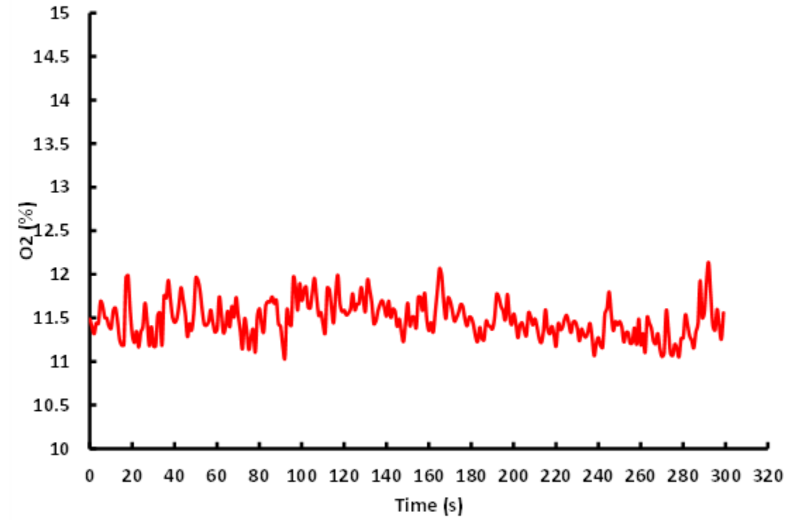


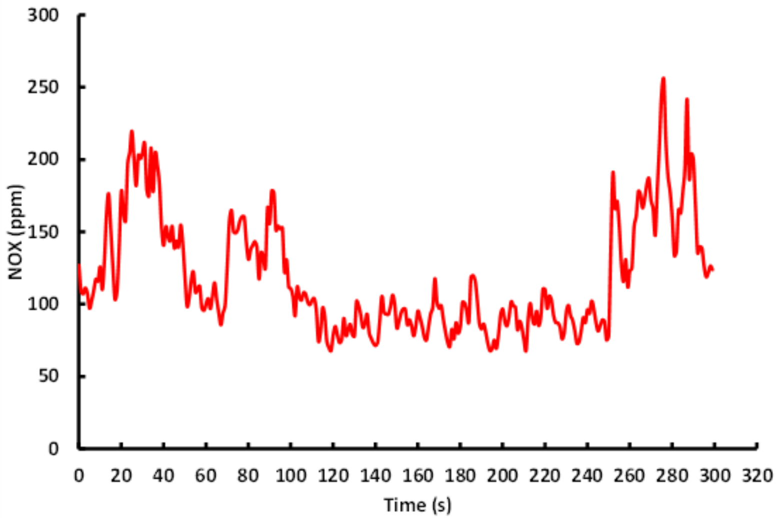


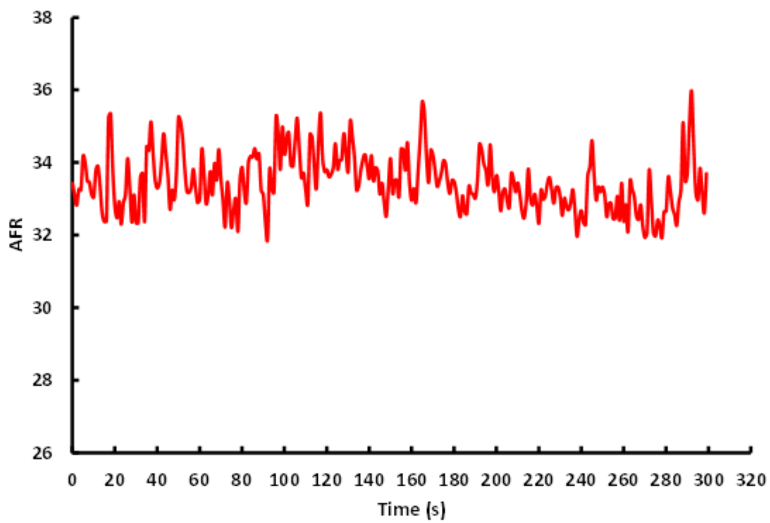
Task 4.0 -Down-selection of the sensors (sensor+ sample line+ filtration)

Emission results (ECM)

	NOx(ppm)	O2 (%)	AFR
Min	68	11.0	31.9
Max	256	12.1	36.0
AVG	119	11.5	33.4







Summary of milestones and updated completion dates

Task/ Subtask	Milestone Title & Description	Planned Completion Date	Actual Completion Date	Verification method	Comments
Task 1	Project management plan	Duration of project	ongoing	PMP file	None
Task 2	IRC at OU site is fully functional	06/30/2020	Completed	Lab test verification, report	Finished July 13, 2020
Task 3	Manually operated AMS reduces the IRC emissions (methane, CO, VOCs) to the standard level at partial loads (loads >40% and Speed >300 rpm).	12/31/2020 (Has changed)	ongoing	Lab test verification, report	11/30/2021
Task 4	The sensors system selected are all suitable to work under harsh two-stroke operation	03/31/2021	ongoing	Lab test verification, report	05/03/2021

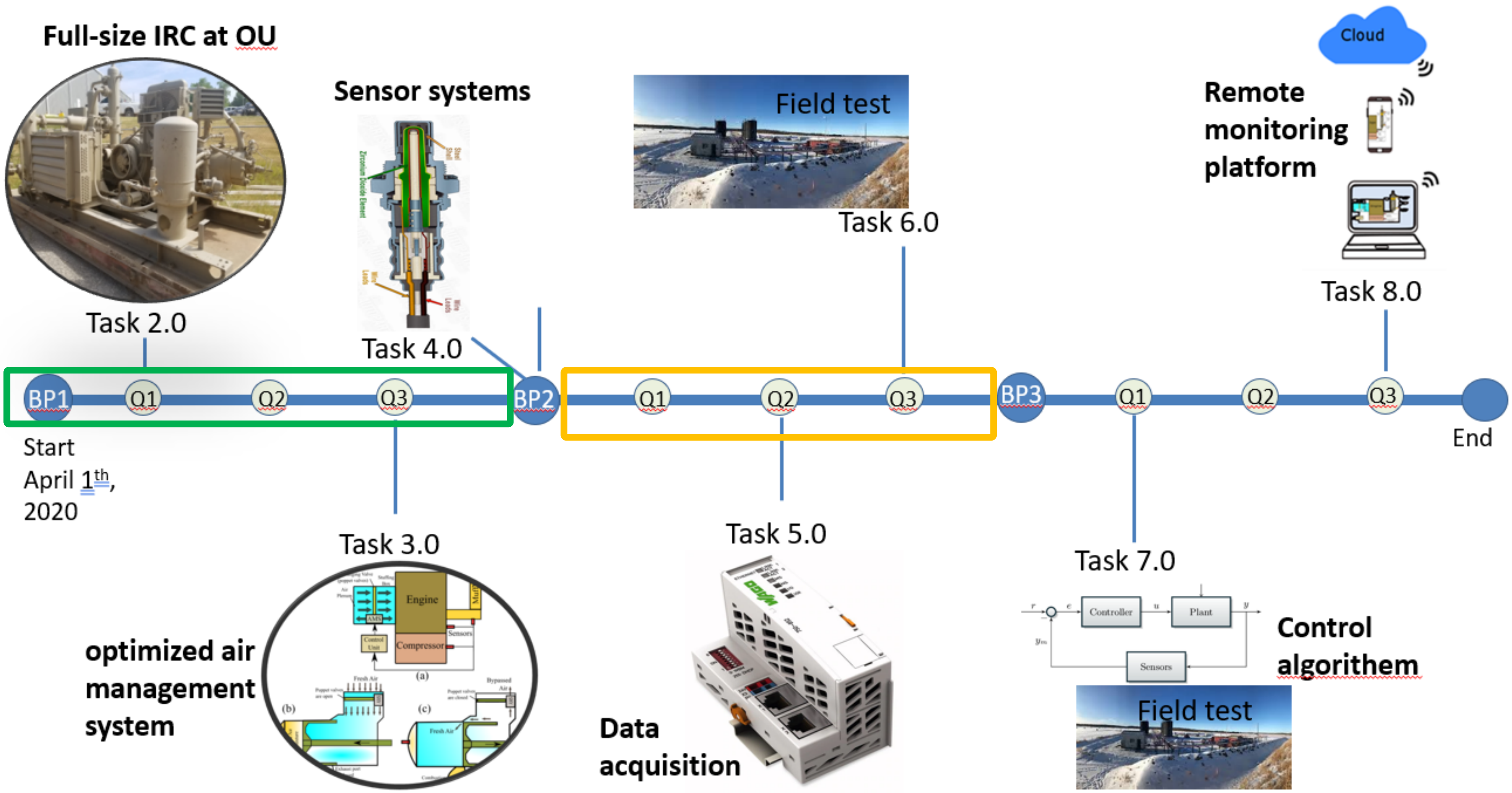
Lessons Learned

- Open space laboratory assists the development process of new technology. However, it brings some challenges and limitations.
- The new air management system developed can effectively enhance the engine operation and emissions. Additional tests should be performed to validate the concept at all operating conditions.
- The AMS should also be equipped with smart algorithms that can effectively manage the technology performance (BP2).
- Various technical challenges should be resolved to generalize the concept and used it for other IRC sizes.

Project Summary

- A comprehensive test facility has been established at OU. The facility comprises a full-size IRC, state-of-the-art performance and emissions measurement tools and devices.
- A cost-effective, field-installable technology is designed and manufactured to manage the IRC performance and emissions at various load and speeds
- Sensors for automation and remote monitoring of IRC are selected and tested. Steady-state data has been recorded.
- An automation system is under development.
- Field tests will be conducted in BP2.

Project Summary-Next Steps



Acknowledgment

- DOE project Manager (Joseph Renk)
- Mid Continental Rentals
- WAGO Automation
- Windrock Inc.

Appendix

- –Benefit to the Program
- –Project Overview
- –Organization Chart
- –Gantt Chart
- –Project Schedule

Benefit to the Program

- Aligned with the program objectives, the research team proposes to develop a novel, low-cost, field-installable, remotely controlled retrofit kit with integrated sensors for Integral Reciprocating Compressors. This integrated solution improves operating efficiencies and significantly reduces emissions of IRCs used in different sections of the natural gas industry.

Project Overview

Goals and Objectives

- The objective is to develop and validate a novel, low-cost, field-installable, remotely controlled, retrofit kit with integrated sensors for Integral Reciprocating Compressors (IRCs) used in production, gathering, transmission, and processing sections of the natural gas industry.
- The proposed technology helps to reduce emissions and improves operating efficiencies, combustion stability, and operational envelope of IRCs.
- This retrofit kit consists of 1) an air management system; 2) integrated sensors to collect data from the IRC; and 3) a cloud-connected control unit plus a graphical user-interface (GUI) or HMI.
- Since the parameters measured to control the AMS constitute true evidence of the IRC's healthy operation, the cloud-connected feature facilitates remote monitoring of the IRC for preventative and predictive maintenance as an additional benefit to operators.

Organization Chart

Pejman Kazempoor, Assistant Professor, PI

Ramkumar Parthasarathy, Professor

Sridhar Radhakrishnan, Professor (Director Of Computer Science / Co-director, Data Science And Analytics)

Three graduate students & a lab technician and an undergraduate student

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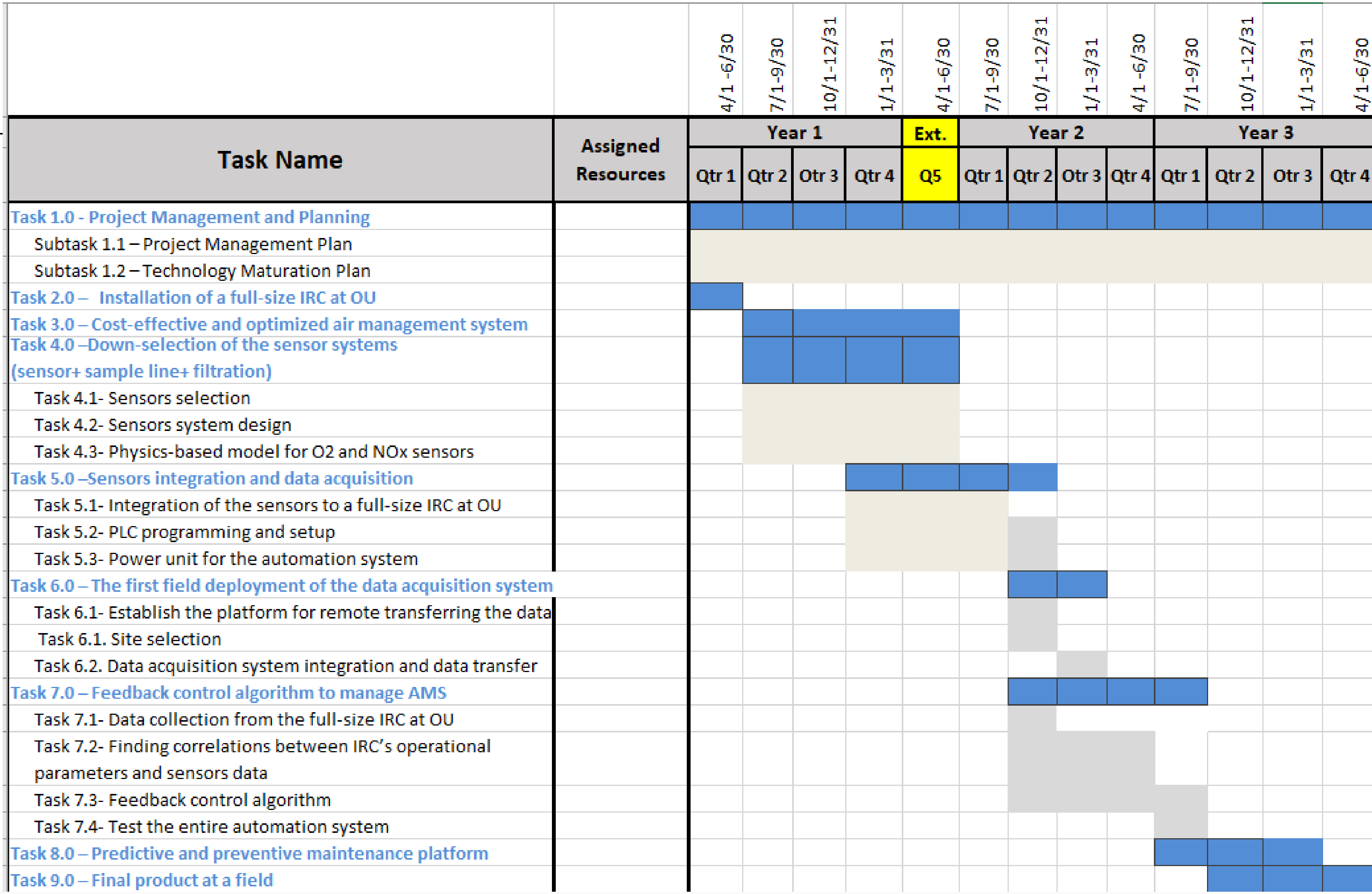
Gantt Chart



4/1 -6/30
7/1-9/30
10/1-12/31
1/1-3/31
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1/1-3/31
4/1 -6/30
7/1-9/30
10/1-12/31
1/1-3/31
4/1-6/30
Task Name
Assigned Resources
Year 1
Ext.
Year 2
Year 3
Qtr 1
Qtr 2
Otr 3
Qtr 4
Q5
Qtr 1
Qtr 2
Otr 3
Qtr 4
Qtr 1
Qtr 2
Otr 3
Qtr 4
Task 1.0 - Project Management and Planning
Subtask 1.1 – Project Management Plan
Subtask 1.2 – Technology Maturation Plan
Task 2.0 – Installation of a full-size IRC at OU
Task 3.0 – Cost-effective and optimized air management system
Task 4.0 –Down-selection of the sensor systems (sensor+ sample line+ filtration)
Task 4.1- Sensors selection
Task 4.2- Sensors system design
Task 4.3- Physics-based model for O2 and NOx sensors
Task 5.0 –Sensors integration and data acquisition
Task 5.1- Integration of the sensors to a full-size IRC at OU
Task 5.2- PLC programming and setup
Task 5.3- Power unit for the automation system
Task 6.0 – The first field deployment of the data acquisition system
Task 6.1- Establish the platform for remote transferring the data
Task 6.1. Site selection
Task 6.2. Data acquisition system integration and data transfer
Task 7.0 – Feedback control algorithm to manage AMS
Task 7.1- Data collection from the full-size IRC at OU
Task 7.2- Finding correlations between IRC's operational parameters and sensors data
Task 7.3- Feedback control algorithm
Task 7.4- Test the entire automation system
Task 8.0 – Predictive and preventive maintenance platform
Task 9.0 – Final product at a field

Project Schedule