

What Would Happen if We Ran our Engines on Alternative Fuels?

Engine Test Bed Project

Introduction

One facet of the Advanced Power and Energy Program (APEP) at UCI investigates the efficiency, performance, and pollutant emissions of various power systems. Until now, little research has been done within APEP on the emissions of reciprocating engines when using alternative gaseous fuels. Our senior design project involves the design and study of a natural gas reciprocating engine/generator test bed and its resulting exhaust composition and performance in order to shed new light on the impacts of running on conventional and alternative gaseous fuels. We hope that future research conducted with this test bed helps clarify the effects that these fuels have on particulate matter (PM_{2.5}) emissions since these particles (< 2.5 microns) can cause serious respiratory problems.

Purpose / Goals

1. Produce a reciprocating engine test bed that operates on natural gas to obtain a better understanding of pollutant formation mechanisms
2. Determine theoretical values for efficiency, optimal flow, and predicted emissions compositions for comparison to testing results.
3. Conduct performance testing of functioning test bed.

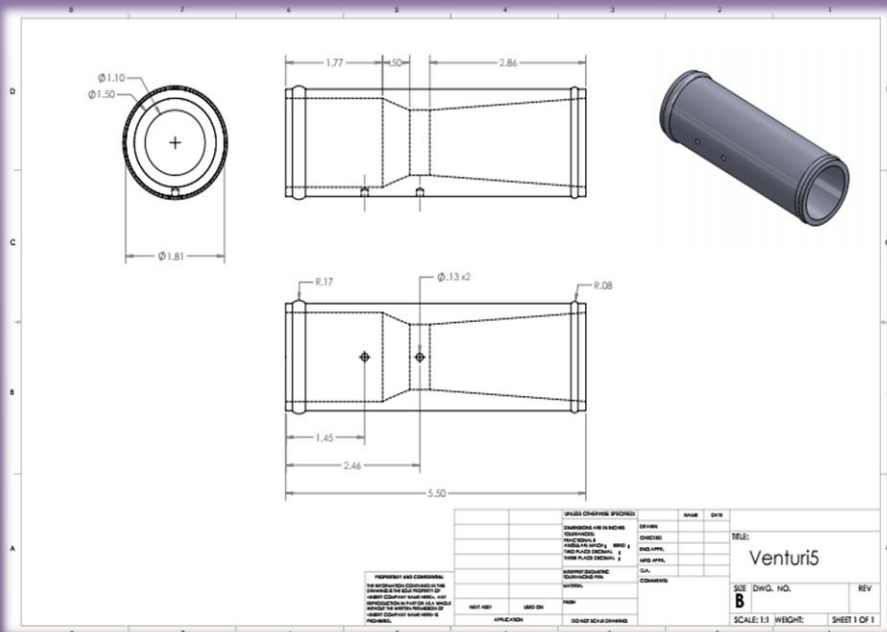
Cost Analysis

Resources	Amount	Costs	Amount
UROP Grant	\$2,200.00	Used 2002 Camaro 5.7L Engine + A/C Gen. (Value)	\$5,430.07
APEP Allowances	\$2,000.00	LC Towing	\$310.00
Resource Estimates		Pressure Regulator Replacement	\$132.65
Used Generac DG 50 Generator (Value)	\$8,950.00	12V Battery, Charger, and Switch	\$217.05
		Shell Rotella Oil	\$17.28
		Distributor Cap and Rotor	\$44.80
Resource Total	\$4,200.00	Fan Belt (1 - 49.5")	\$22.67
		Technician Visit 1	\$645
Costs Total	\$1,557.63	Flex Coupling + Nuts/Bolts	\$115.78
		3D-printed Venturi	\$24.00
Remaining Funds	\$2,642.37	Exhaust Piping	\$18.99

Progress



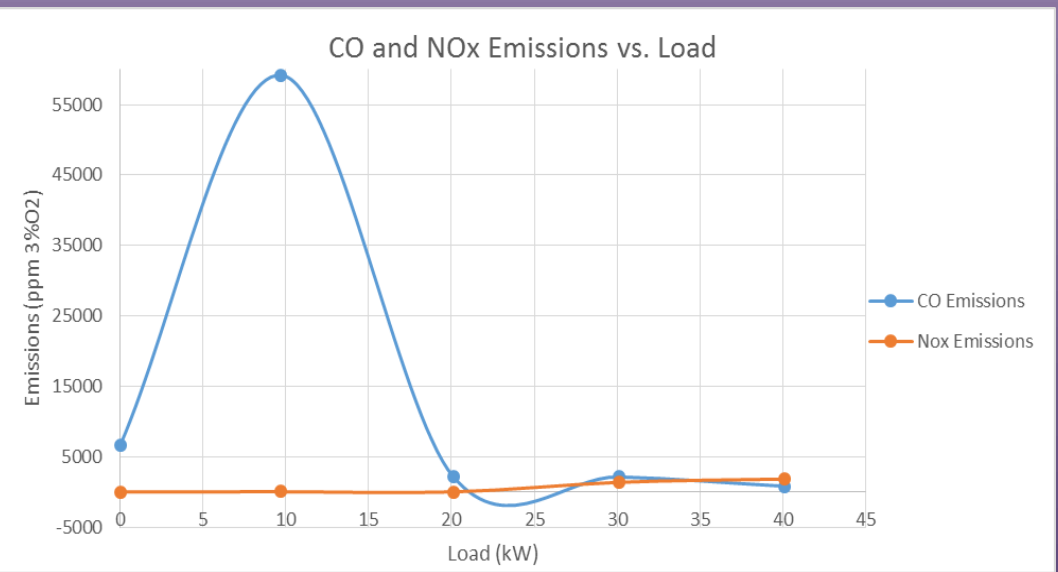
Replaced the fan belt to have a running cooling system which would allow us to run the system for a long period of time for data acquisition.



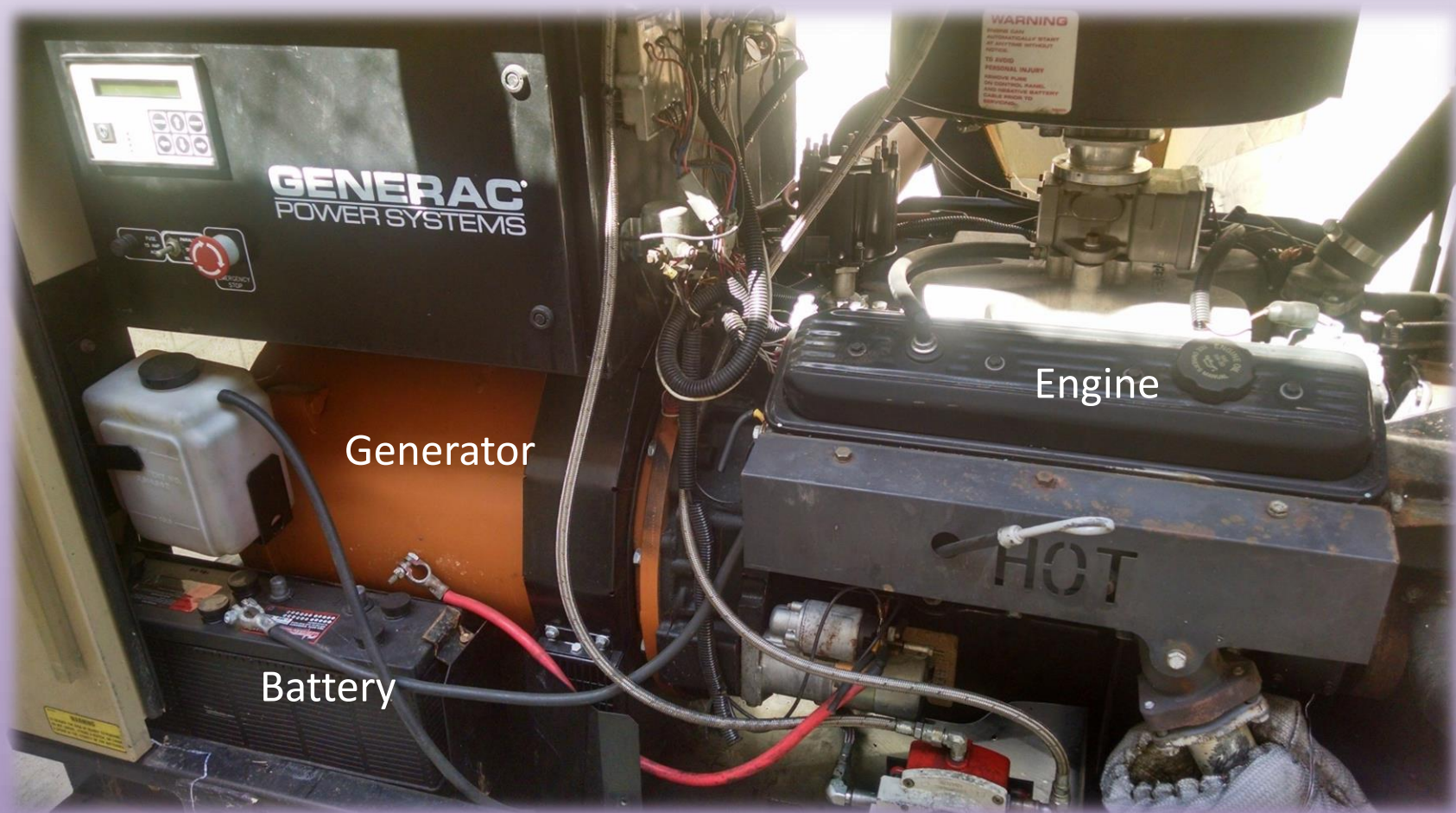
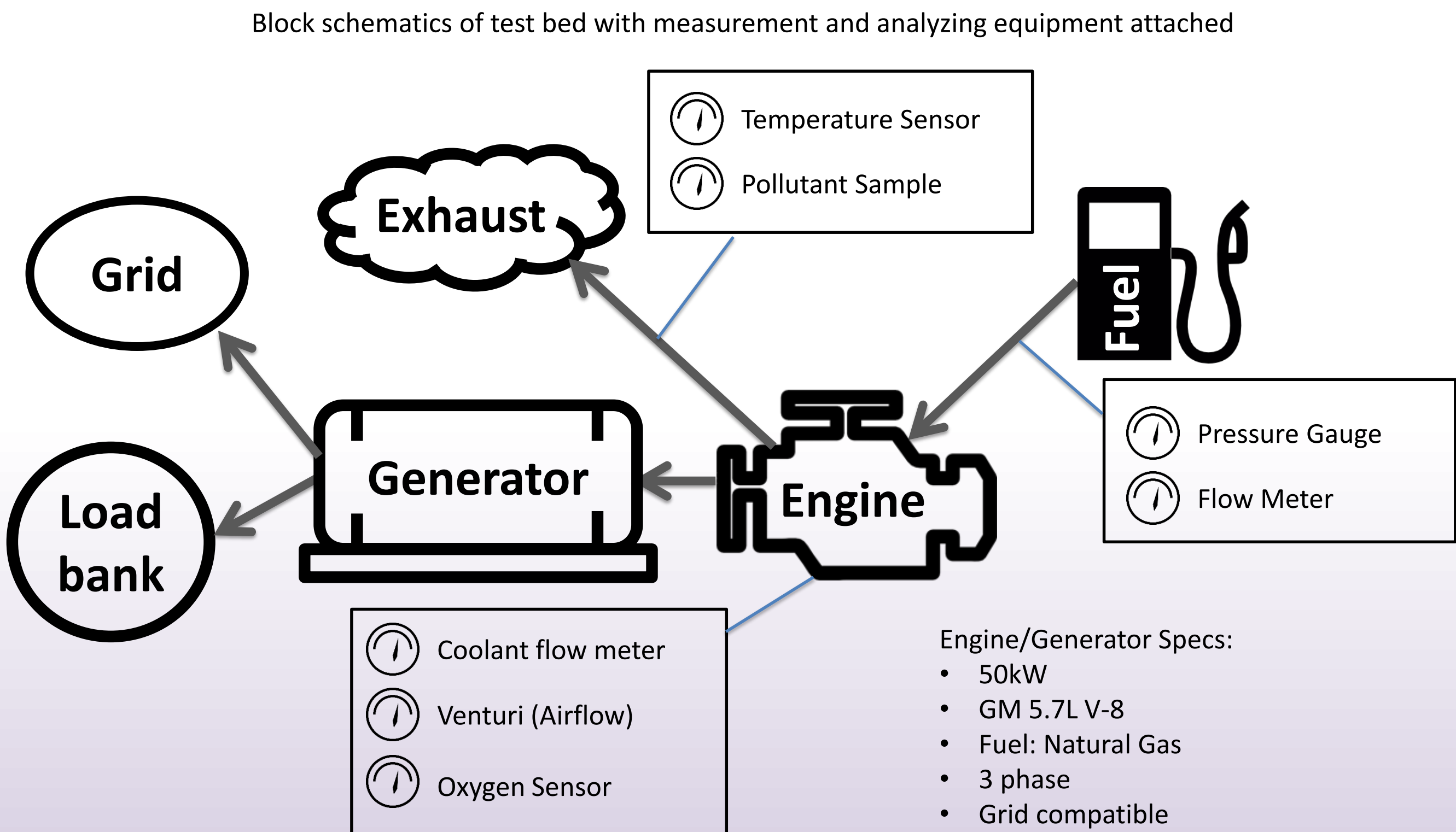
CAD design of the Venturi flow meter. Made with the help of the ASME Fluid Meters standards and designed to our specific flow conditions.



Data was acquired after applying different loads on the system. Emissions data and fuel flow input were recorded.



The Setup



View of engine and generator from side

Performance Mapping Results

The flow meter we used measured 540 pulses per actual cubic foot. This was converted to standard conditions and the energy input to the system was found using the fuel flow rate and a natural gas heating value of 1,000 Btu/ft³. Dividing the given load condition at each test point by the fuel energy input gave us the following efficiencies.

Pulse	Actual ft3	Standard ft3	Flow Rate (ft3/hr)	P abs	Temp (K)	Fuel Input (kW)	Efficiency (%)
4918	9.11	28.84	325.4577946	47.7	305.37	95.382	10.19%
5297	9.81	31.06	370.2711422	47.7	305.37	108.516	18.55%
7183	13.30	41.24	506.6797918	46.7	305.37	148.493	20.28%
9396	17.40	51.63	609.4374648	44.7	305.37	178.608	22.46%

Timeline

Winter Quarter Tasks	1	2	3	4	5	6	7	8	9	10
1.0 Research/Documentation										
Organize/Read Technician Documents										
Determine Relevant Schematic Diagrams										
Task Management/SCRUM Board										
Intergroup Presentation										
Cost Analysis										
Parameter Definitions/Tools										
Calculations										
2.0 Engine Assembly										
Obtained Fuse for Control Panel										
Moved Generator to Test Area										
Purchased Rotor										
Replacement Distributor Cap										
Determined Firing Order/Connected Spark Plug Wires										
Reconnected Loose Wires										
Ignition Test with Starter Fluid										
Connect Natural Gas Line										
Fuel Pressure Calibration (Manometer)										
Run Engine										
Spring Quarter Task										
1.0 Cooling System										
Removed Fan										
Measured Fan Belt Length										
Removed Broken Bolts in Engine Mount										
Reconnected Fan Belt Shaft to Engine Damper										
Reconnected Fan Belt and Blade										
2.0 Research/Documentation										
Venturi vs. Paddlewheel Flow Meter										
MAF Sensor										
Oxygen Sensor										
Cost Analysis										
Calculations (Flow, Efficiency)										
Junior Class Presentation										
Poster for Spring Design Review										
Compiled Documentation for Future Group										
3.0 Venturi Design										
Determine Rough Design Idea										
Calculated the Flow Rate to Find Proper Diameters										
Calculating Accurate Dimensions for the Venturi										
CAD Model drafts										
Manufacturing Final Design of Venturi										
4.0 Data Acquisition										
Load Bank Data										
Emissions Data										
Flow Rate Data										

Looking Towards the Future

This reciprocating engine test bed was initially influenced by a previous project that involved the monitoring of emissions from a natural-gas fired micro-turbine. From that project, it was discovered that emissions such as PM_{2.5} (previously assumed negligible) were being produced. Due to the extensive use of reciprocating engine applications, we hope that future researchers will shed new light on emissions trends in criteria pollutants (especially PM_{2.5}) that result from reciprocating engines powered by gaseous fuels.

Project participants



From left to right: Vince McDonell – Advisor, Katie Leong –Team Lead, Daniella Lopez, Richard Hack - Chief Engineer, Ivan Anagrus West, Christopher Ferro