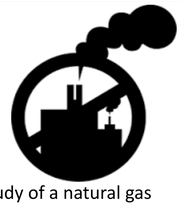
What Would Happen if We Ran our Engines on Alternative Fuels?
Engine Test Bed Project

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.

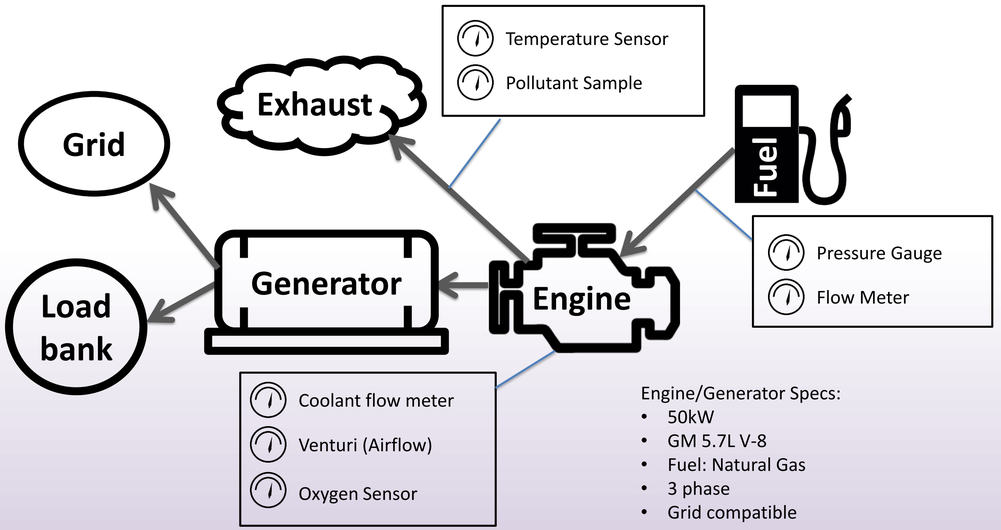
Cost Analysis

Resources	Amount
UROP Grant	$2,200.00
APEP Allowances	$2,000.00
Resource Estimates	
Used Generac DG 50 Generator **(Value)**	$8,950.00
Resource Total	**$4,200.00**
Costs Total	**$1,557.63**
Remaining Funds	**$2,642.37**

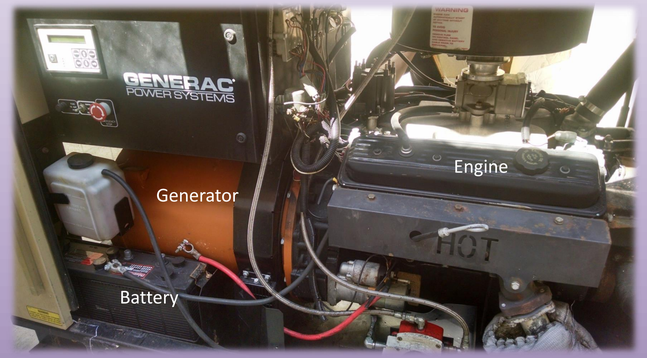
Costs	Amount
Used 2002 Camaro 5.7L Engine + A/C Gen. **(Value)**	$5,430.07
LC Towing	$310.00
Pressure Regulator Replacement	$132.65
12V Battery, Charger, and Switch	$217.05
Shell Rotella Oil	$17.28
Distributor Cap and Rotor	$44.80
Fan Belt (1 - 49.5")	$22.67
Technician Visit 1	$645
Flex Coupling + Nuts/Bolts	$115.78
3D-printed Venturi	$24.00
Exhaust Piping	$18.99

The Setup

Block schematics of test bed with measurement and analyzing equipment attached



Engine/Generator Specs:
- 50kW
- GM 5.7L V-8
- Fuel: Natural Gas
- 3 phase
- Grid compatible



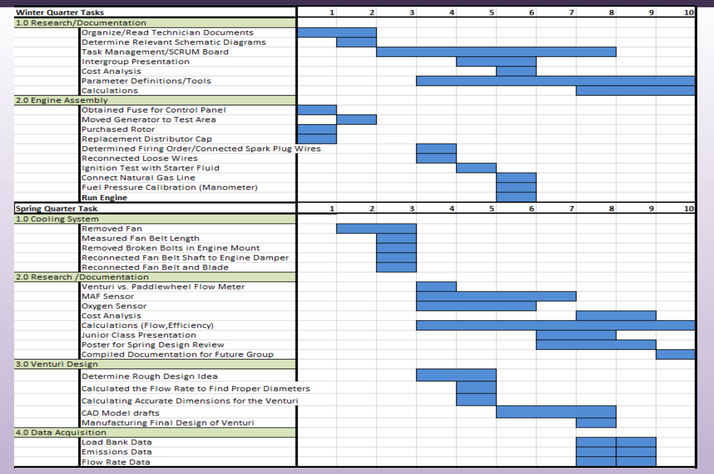
View of engine and generator from side

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

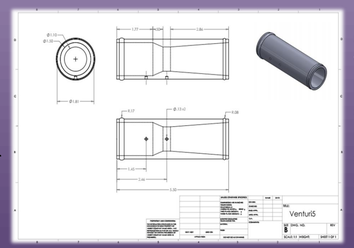


Looking Towards the Future

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.

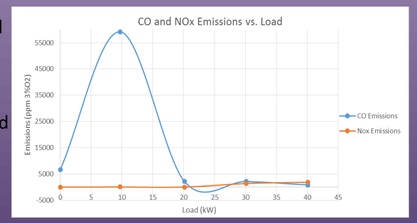
Progress

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.



Project participants

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

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