THE UNIVERSITY OF GEORGIA Bioenergy

Development of a Method for Rapid Emissions Screening of Potential Alternative Diesel Fuels

Daniel Geller
Faculty Engineer
College of Engineering
The University of Georgia

UGA – Over 30 years in biofuels research

The University of Georgia

BIOENERGY SYSTEMS RESEARCH INSTITUTE

Harnessing Biology for a New Energy Economy

Vision: **Support alternative energy, fuel, and materials production through the use of biomass conversion strategies that are environmentally and economically sustainable**

- One of 3 DOE-Funded Research Centers
- Goal: Breakthroughs in Cellulosic Bioenergy
- Partnership with National Labs, Universities and Industry

UGA

UGA now officially has engineering college

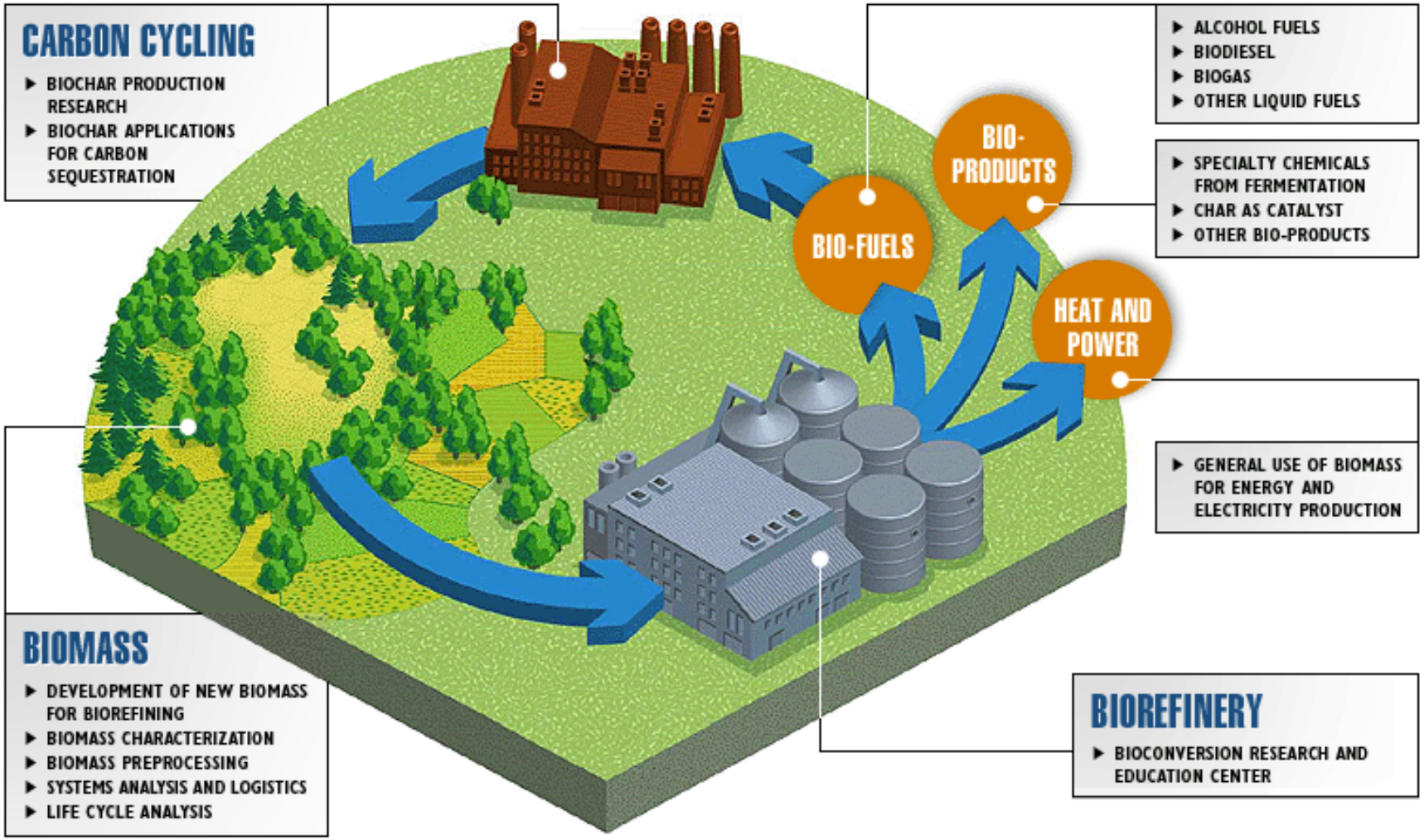
By LEE SHEARER updated Thursday, April 26, 2012 - 9:27pm

The University of Georgia will add a college of engineering on July 1, when the university's new fiscal year begins.

UGA's University Council made the move all but official Thursday, approving the new college in an unanimous voice vote, then applauding what they had done.

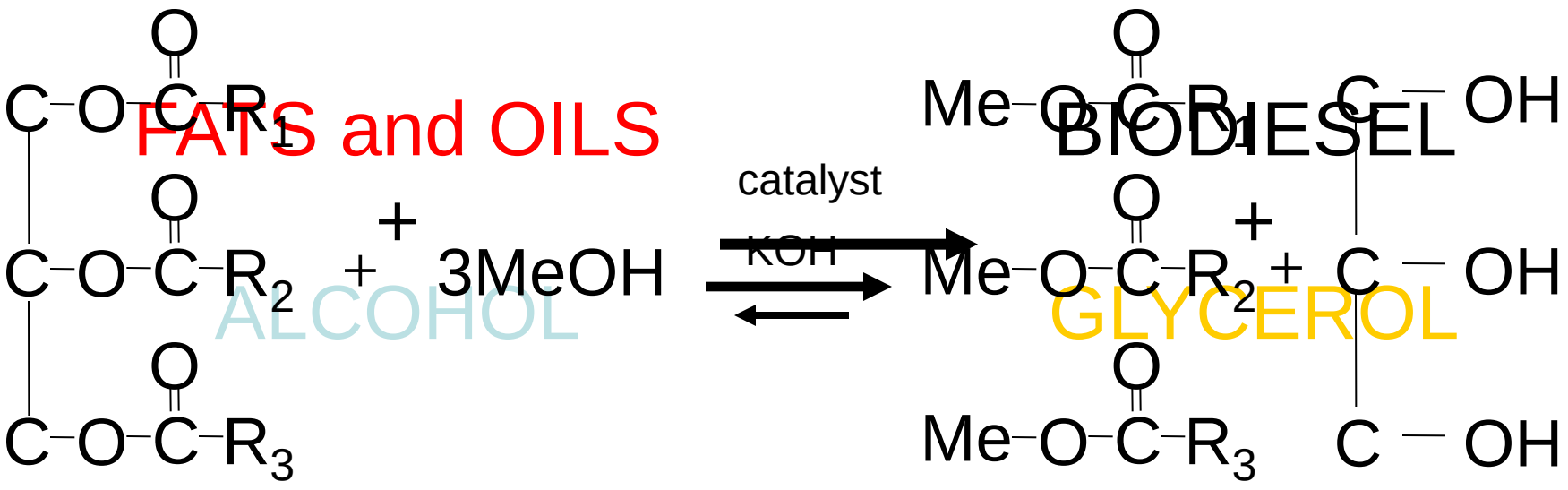
The group of about 200 faculty and administrators advises UGA President Michael Adams on academics and other university-wide policies.

The Integrated Biorefinery



Biodiesel Production

Difficult to make right - Biodiesel is made by the transesterification of vegetable oils



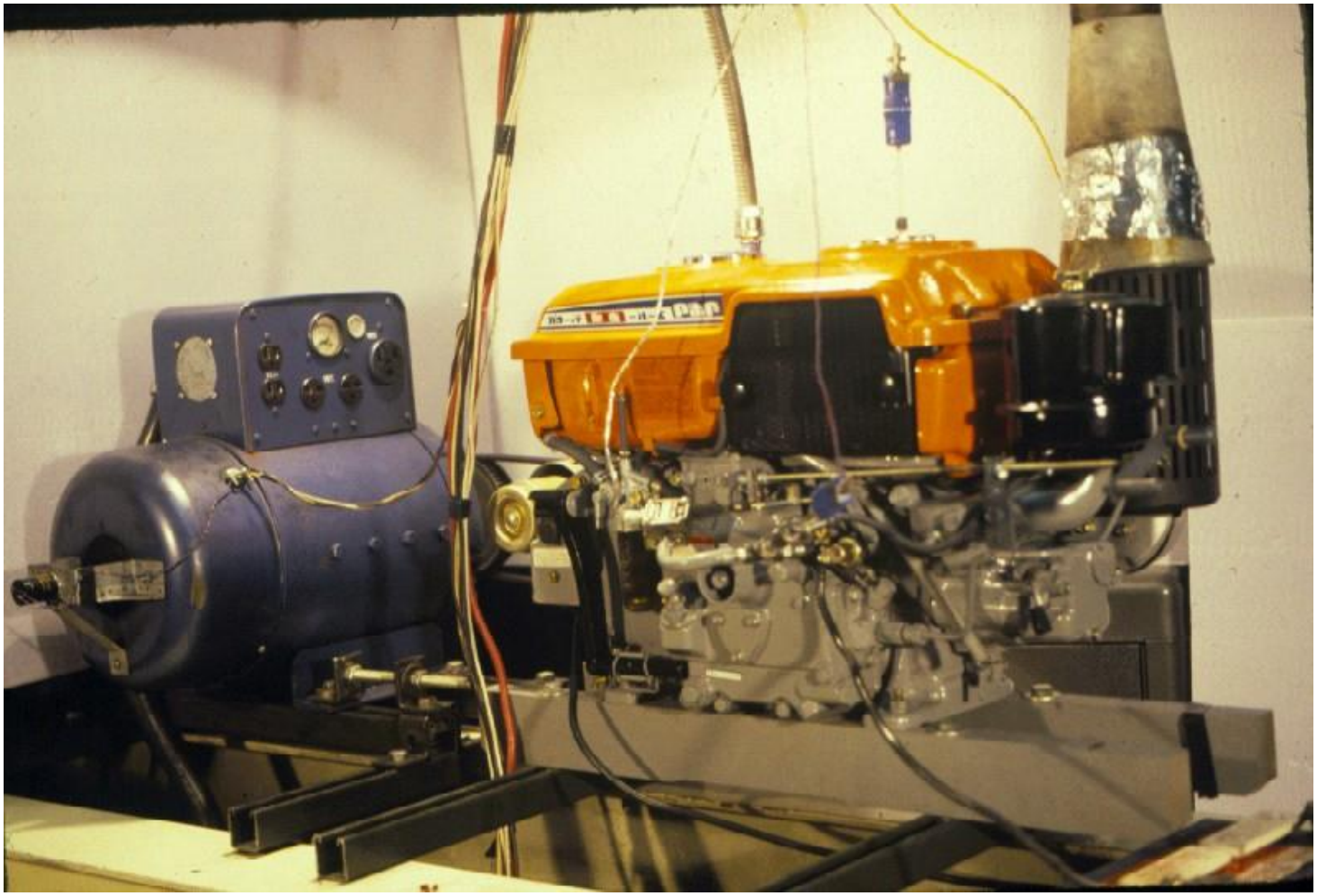
Triglyceride (fats and oils)

Methanol (alcohol)

Methyl Ester (Biodiesel)

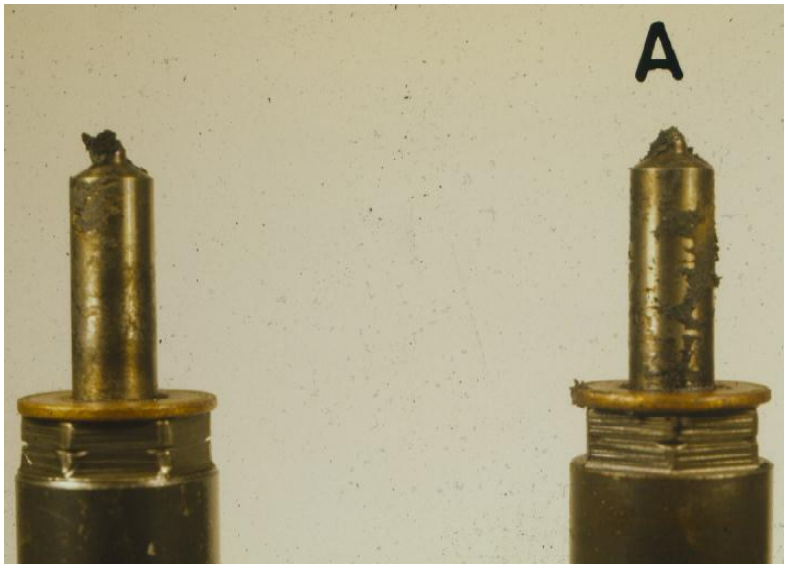
Glycerol

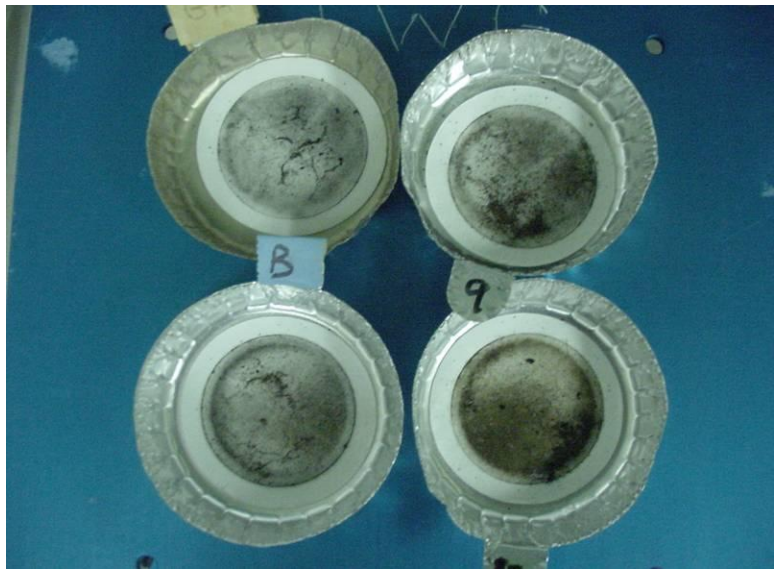
Engine Testing Facility



Function of analysis: Screen for potential diesel fuel additives, extenders and replacements. – Not for EPA certification!

Injector Tip Coking Analysis



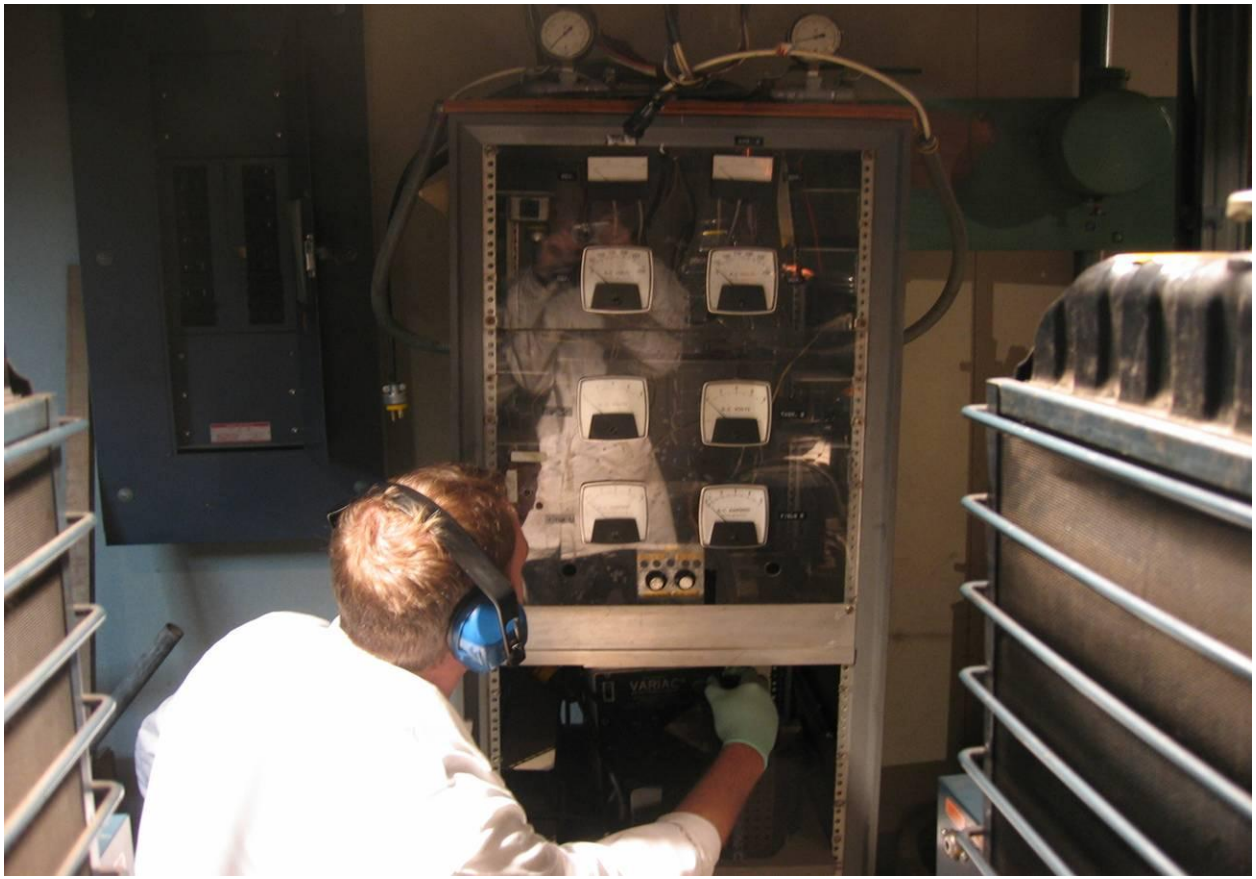


Alternative fuel coking is normalized to #2 diesel fuel
Diesel Fuel Coking Index = 1
Lower Index = Better Performance

Cold-Start Ignition

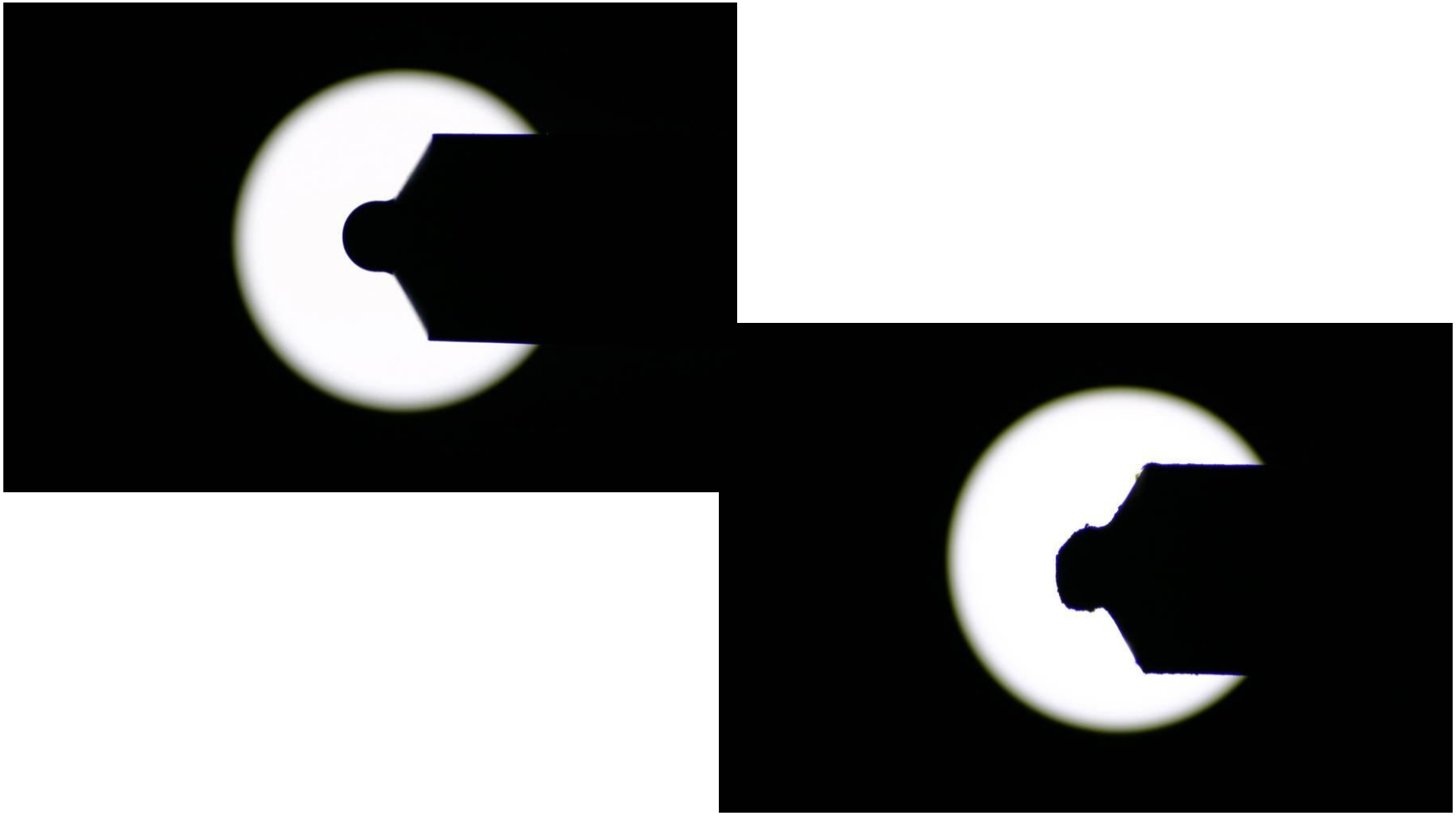
Engines are equipped with dual-fuel system, fuel feed is switched from diesel to test fuel during starting sequence

Engine Loading – Power, Durability, Efficiency



Engines are loaded by dumping current from generator into resistor bank. Increased resistance = increased power output
Peterson Test leads to accelerated engine wear

Computer Vision for Engine Durability



Original testing protocol

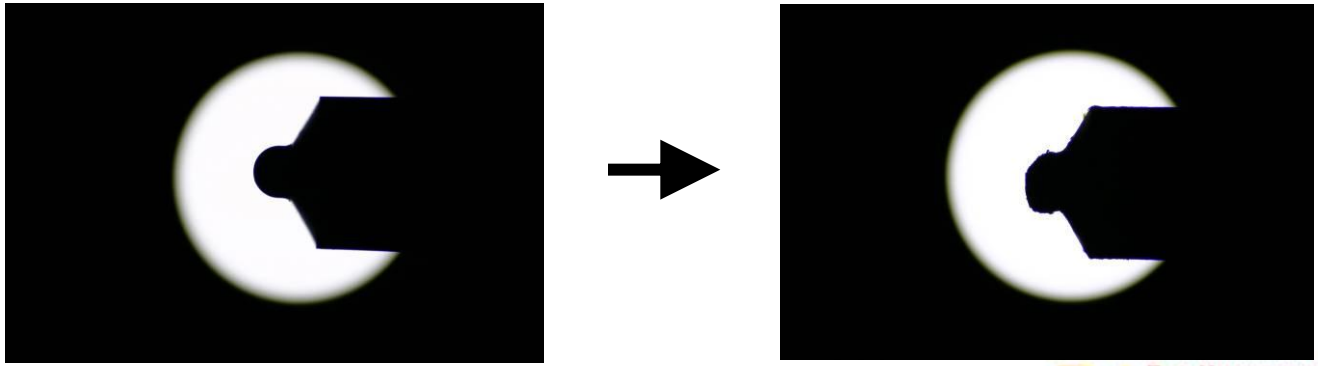
- Peterson torque test developed 1983
- Used projections of injector tips on walls with tracing paper
- Weighed actual cut out paper to determine injector coking

Second generation testing protocol

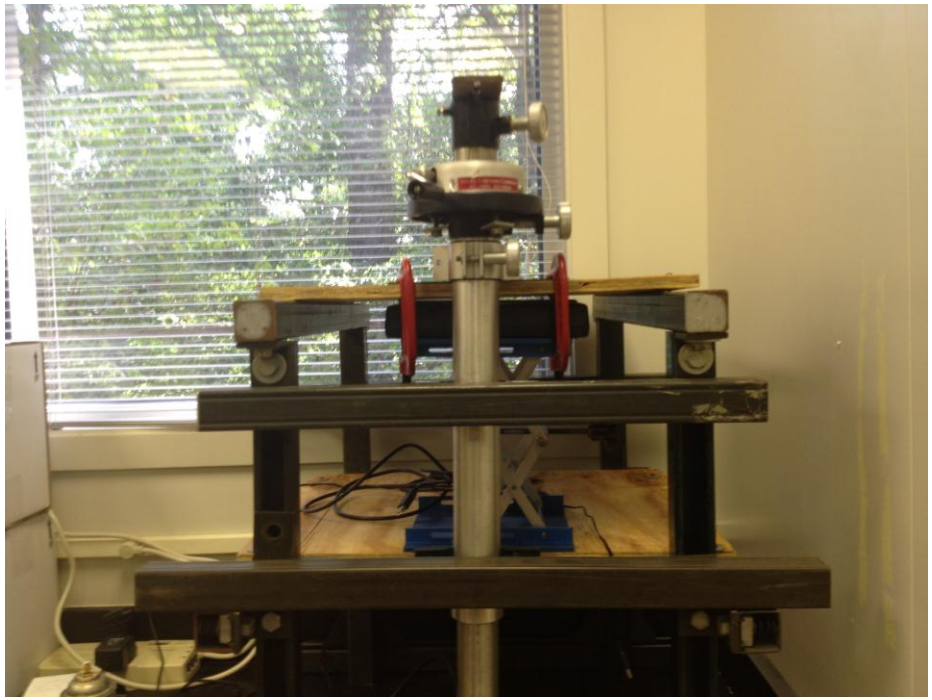
- Protocol developed by Goodrum, et al. 1993
- Used 800 pixel camera and 286PC to take digital photos of injectors
- Captured card w/ analog video camera and translated to 800 pixel image
- Counted pixels using FORTRAN program

Third Generation testing protocol

- New method developed by Geller, 2004
- Upgrade existing of 800 pixel camera and 286PC to modern 4MP digital camera with instant imaging capability
- Development of new engine durability testing protocol
- Fuel economy analysis infrastructure added



New Protocols Made Testing Easier



- Streamlined 90 minute testing protocol
  - Technician has time to collect more data
- Desire to introduce new data collection capability
- Desired integration of emissions testing capability

Existing EPA methods prohibitive

- In-line GC
- Dynamometer
- Long testing periods
- Complicated
- EXPENSIVE

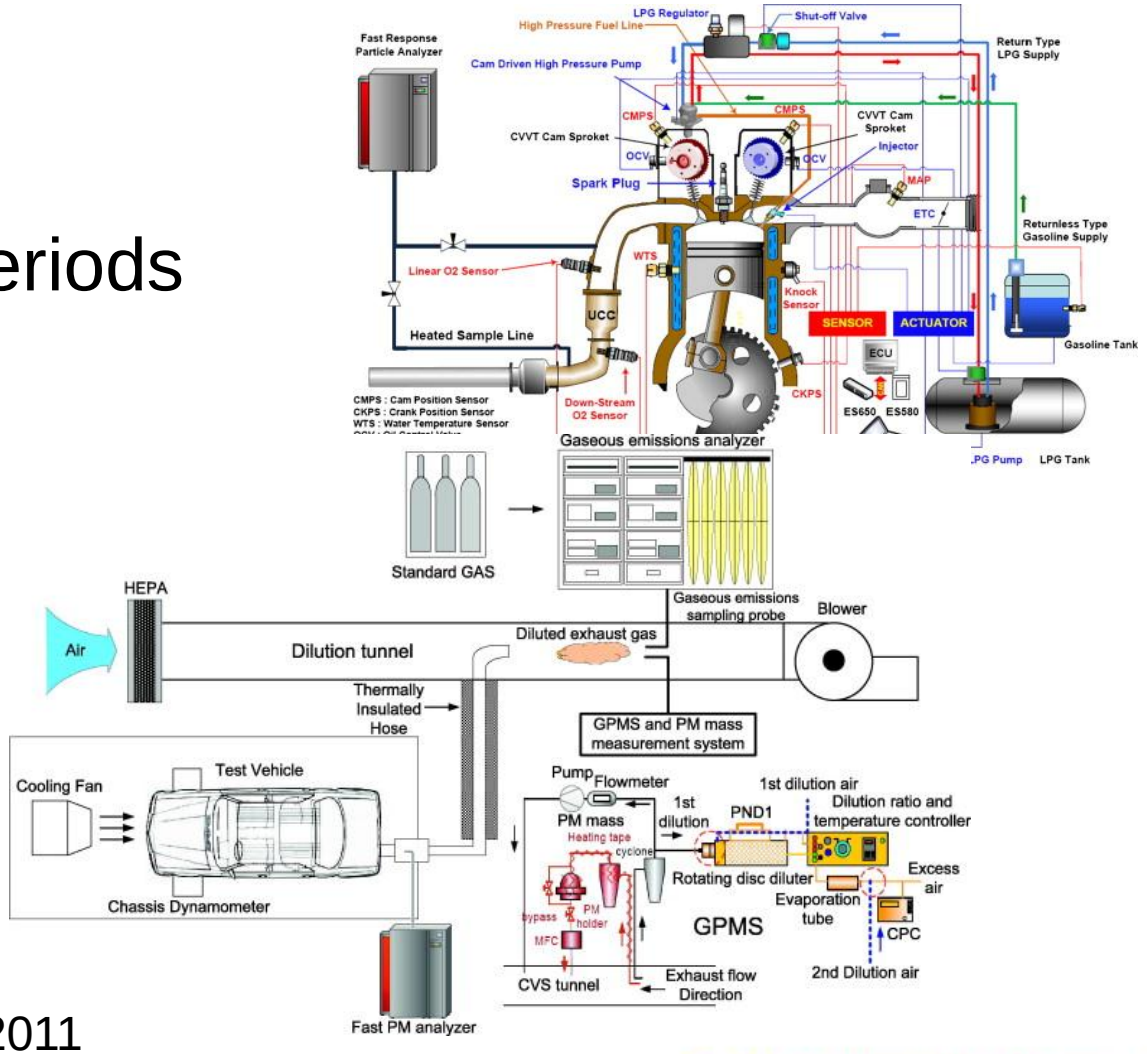


Figure from Myung, et al., 2011

Species of Interest

- **NOx: Contributor to ground level ozone, levels linked to traffic/freight/rail especially diesel**
- **SOx: New ULSD (Ultra-low sulfur diesel) standards require less than 15ppm for diesel. In most cases biofuels have ~0ppm sulfur**
- **PM: High health risk pollutant associated with diesel evaluated by smoke test incorporated on some portable emissions analyzers**
- **$CO/CO_2/O_2$: Indicators of combustion efficiency**

Goal: Develop Streamlined Emissions Testing w/ diesel fuel as a baseline

- **Must be low maintenance – technician has several other duties during testing protocol**
- **Must be low cost – trying to provide low cost screening of fuels and fuel additives**
- **SOLUTION: Must be accurate as a comparison to baseline fuel does not need to provide absolute data for EPA regulation.**
- **This is simply a screening procedure, allows identification of promising candidates for further, more extensive (and expensive) analysis**

First method used Enerac 3000E

- **Real-Time analysis of CO, CO_2, SOx, NOx, and Combustibles**
- **Required manual recording or use of PC with serial port adapter (fragile)**
- **Difficult to calibrate**

Upgrade to ECOM AC

- **Real-Time analysis of CO, CO_2, SOx, NOx, and Combustibles**
- **USB interface**
- **Simple Calibration**

Current system: ECOM J2KN

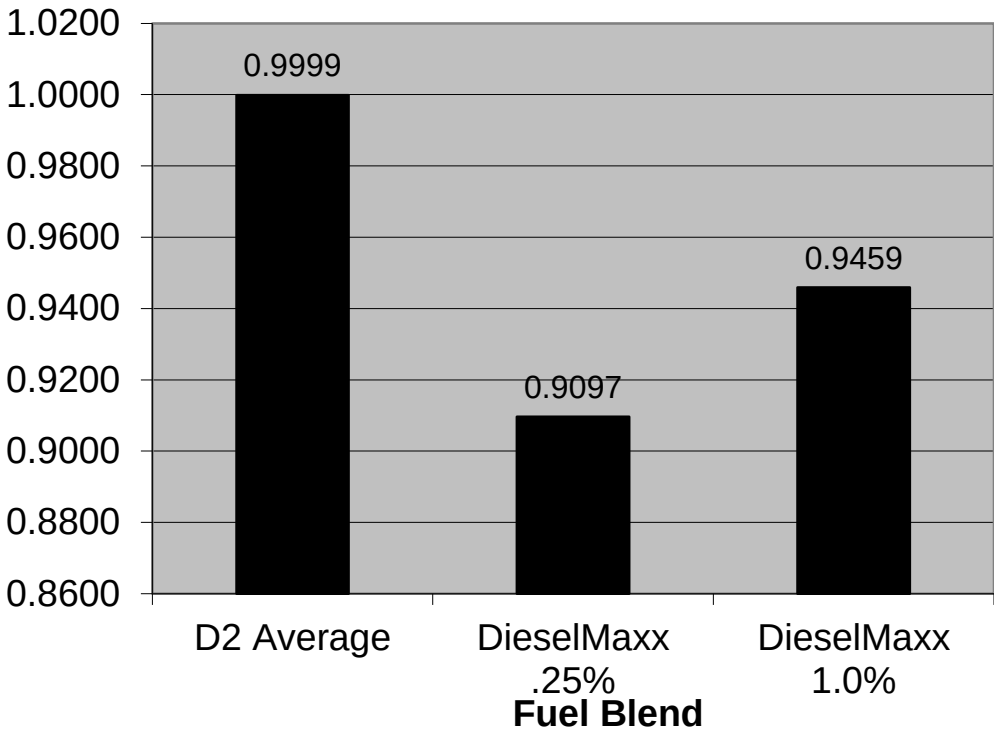
- **Real-Time analysis of CO, CO_2, O_2, NOx, efficiency and Combustibles**
- **SD Card data collection – NO COMPUTER!!!**
- **Simple Calibration**
- **Remote data collection**

Use of performance indices

- **Indices comparing fuel of interest to petroleum based diesel used to baseline and normalize data**
- **Initially used to evaluate coking, allowed statistically valid replication of engine durability**
- **Applied to emissions factors**
- **Index value greater than 1 suggests more emissions than straight diesel less than 1 suggests improvement**

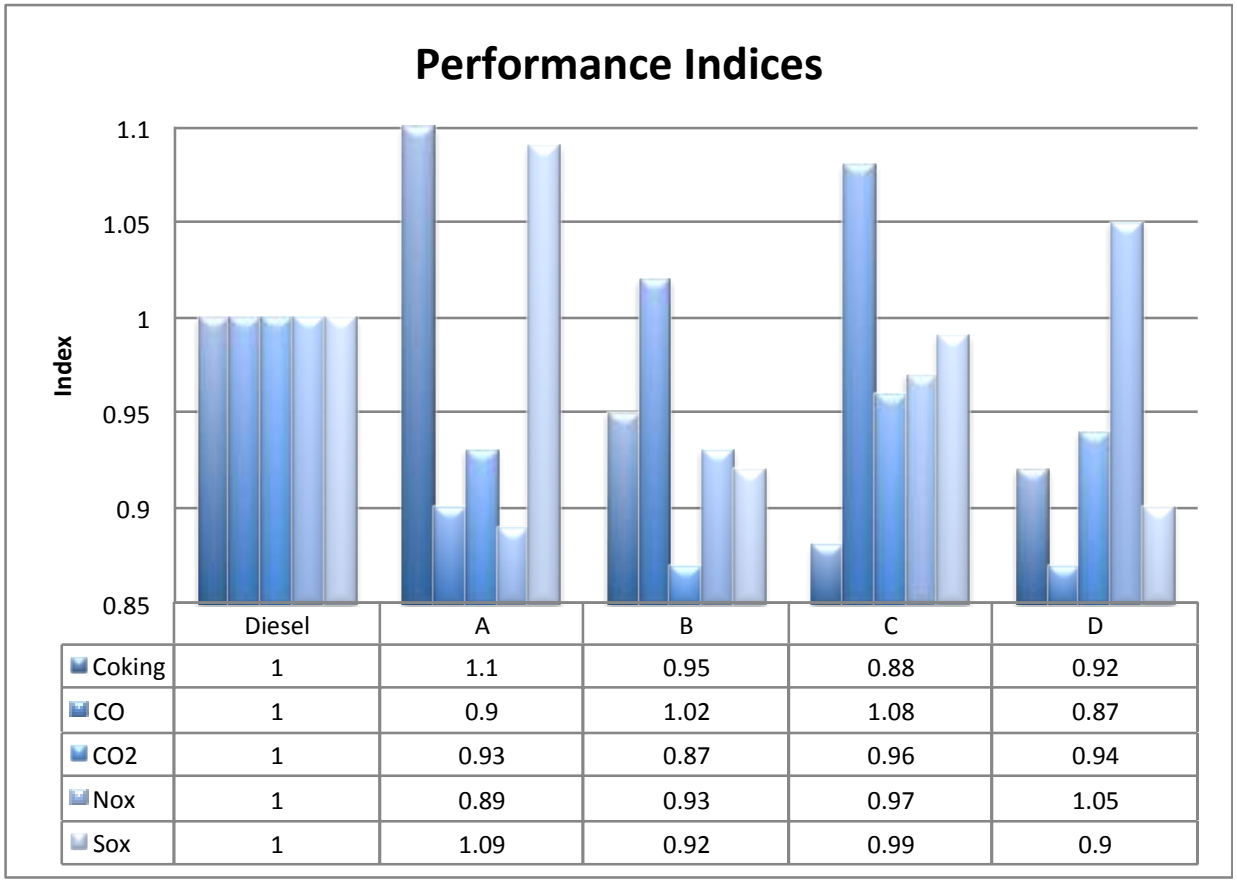
The data

- **Data can be reported as indices or reduction/increase**
- **Statistically valid replication ±1.0%**
- **Provides useful data for marketing/PR and identifies candidates for further testing**



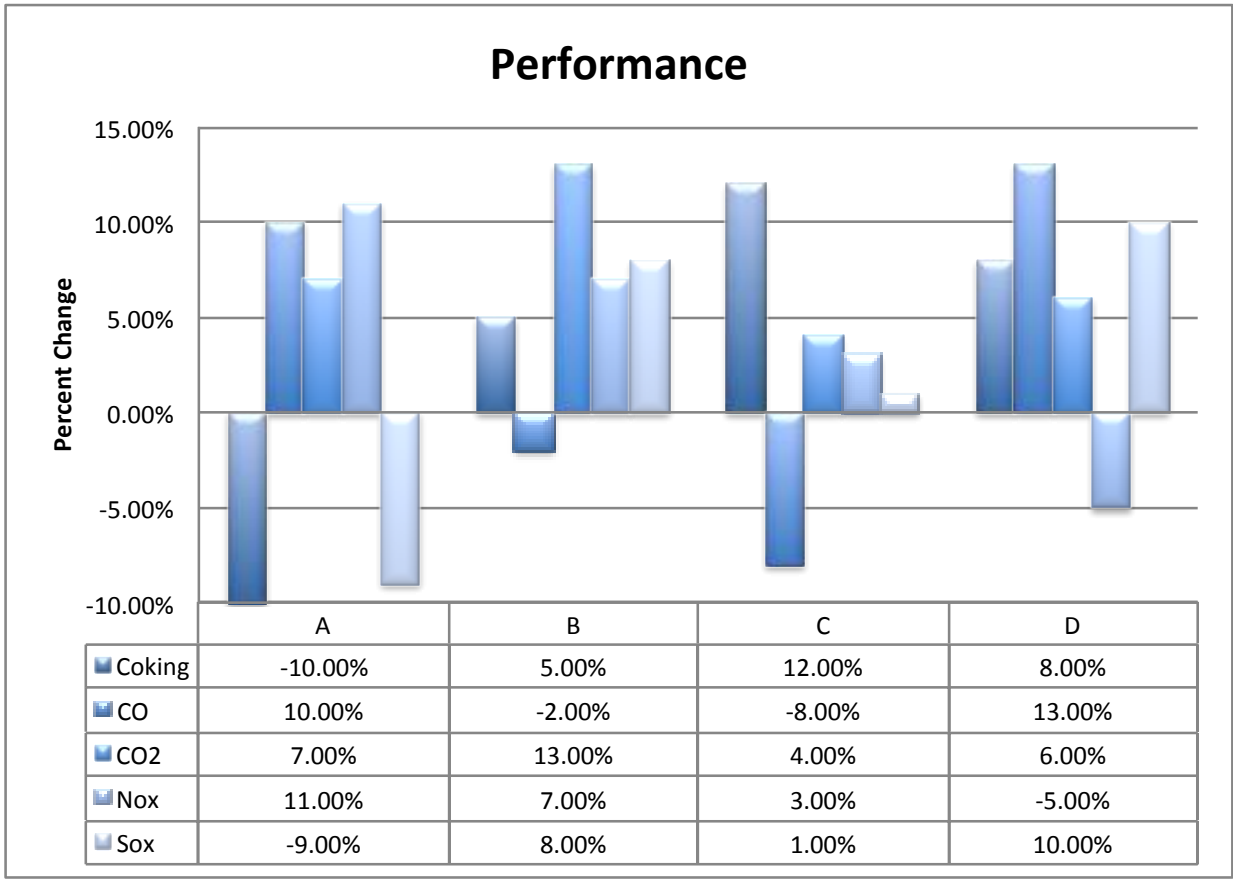
	NOx (ppm)	Reduction (ppm)
D2	1088.00	
DieselMaxx .25%	1040.00	4.41%
DieselMaxx 1.0%	1027.00	5.61%
DieselMaxx 2.5%	1029.00	5.42%

Indices used in published data



	Diesel	A	B	C	D
Coking	1	1.1	0.95	0.88	0.92
CO	1	0.9	1.02	1.08	0.87
CO2	1	0.93	0.87	0.96	0.94
Nox	1	0.89	0.93	0.97	1.05
Sox	1	1.09	0.92	0.99	0.9

Percent change used for product Selection



	A	B	C	D
Coking	-10.00%	5.00%	12.00%	8.00%
CO	10.00%	-2.00%	-8.00%	13.00%
CO2	7.00%	13.00%	4.00%	6.00%
Nox	11.00%	7.00%	3.00%	-5.00%
Sox	-9.00%	8.00%	1.00%	10.00%

The University of Georgia

Daniel Geller
dgeller@uga.edu

http://engineering.uga.edu/outreach