DOE F 241.3
(2-01) p. 1 of 4

ANNOUNCEMENT

UNITED STATES DEPARTMENT OF ENERGY (DOE)
Scientific and Technical Information (STI) For Financial Assistance Recipients and Non-M&O/M&I Contractors

OMB Control No. 1910-1400

PART I: STI PRODUCT DESCRIPTION
(To be completed by Recipient/Contractor

A. STI Product Identifiers
1. REPORT/PRODUCT NUMBER(s)
None
2. DOE AWARD/CONTRACT NUMBER(s)
DE-FC26-08NT01928
3. OTHER IDENTIFYING NUMBER(s)
CDP # 139.10

B. Recipient/Contractor
Iowa Central Community College

C. STI Product Title
Iowa Central Quality Fuel Testing Laboratory

D. Author(s)
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E. STI Product Issue Date/Date of Publication
09/30/2013 (mm/dd/yyyy)

F. STI Product Type *(Select only one)*
☒ 1. TECHNICAL REPORT
☒ *Final* ☐ *Other (specify)*
☐ 2. CONFERENCE PAPER/PROCEEDINGS
Conference Information (title, location, dates)
☐ 3. JOURNAL ARTICLE
a. TYPE: ☐ *Announcement Citation Only* ☐ *Preprint* ☐ *Postprint*
b. JOURNAL NAME
c. VOLUME *d. ISSUE*
e. SERIAL IDENTIFIER (e.g. ISSN or CODEN)
☐ OTHER, SPECIFY

G. STI Product Reporting Period (mm/dd/yyyy)
09/02/2008 Thru *09/30/2013*

H. Sponsoring DOE Program Office
Energy Effcy & Renewable Energy

I. Subject Categories *(list primary one first)*
Fuel testing, Fuel quality, Fuel industry training
Keywords

J. Description/Abstract
See attached abstract

K. Intellectual Property/Distribution Limitations
(must select at least one; if uncertain contact your Contracting Officer (CO))
☒ 1. UNLIMITED ANNOUNCEMENT *(available to U.S. and non-U.S. public; the Government assumes no liability for disclosure of such data)*
☐ 2. COPYRIGHTED MATERIAL: *Are there any restrictions based on copyright?* ☐ *Yes* ☐ *No*
If yes, list the restrictions as retained in your contract
☐ 3. PATENTABLE MATERIAL: THERE IS PATENTABLE MATERIAL IN THE DOCUMENT
INVENTION DISLOSURE SUBMITTED TO DOE:
DOE Docket Number: S-
(Sections are marked as restricted distribution pursuant to 35 USC 205)
☐ 4. PROTECTED DATA: ☐ *CRADA* ☐ *Other*
If other, specify
Release date (mm/dd/yyyy)
☐ 5. SMALL BUSINESS INNOVATION RESEARCH (SBIR) DATA
Release date (Required,
(No more than 4 years from date listed in part 1.E above)
☐ 6. SMALL BUSINESS TRANSFER (STTR) DATA
Release date (Required,
No more than 4 years from date listed in part 1.E above)
☐ 7. OFFICE OF NUCLEAR ENERGY APPLIED TECHNOLOGY

L. Recipient/Contractor Point of Contact *Contact for additional information (contact or organization name to be included in published citations and who would receive any external questions about the content of the STI Product or the research contained therein)*
Dr. Don Heck
Name and/or Position
Heck@iowacentral.edu 515-574-1243
E-mail *Phone*
Iowa Central Community College
Organization

ANNOUNCEMENT

UNITED STATES DEPARTMENT OF ENERGY (DOE)
Scientific and Technical Information (STI) For Financial Assistance Recipients and Non-M&O/M&I Contractors

OMB Control No.
1910-1400

PART II: STI PRODUCT MEDIA/FORMAT and LOCATION/TRANSMISSION

(To be completed by Recipient/Contractor)

A. Media/Format Information:

1. MEDIUM OF STI PRODUCT IS:
   - ☒ Electronic Document ☐ Computer medium
   - ☐ Audiovisual material ☐ Paper ☐ No full-text
2. SIZE OF STI PRODUCT 2 MB
3. SPECIFY FILE FORMAT OF ELECTRONIC DOCUMENT BEING TRANSMITTED, INDICATE:
   - ☐ SGML ☐ HTML ☐ XML ☒ PDF Normal ☐ PDF Image
   - ☐ WP-Indicate Version *(5.0 or greater)* _____
     Platform/operating system _____
   - ☐ MS-Indicate Version *(5.0 or greater)* _____
     Platform/operating system _____
   - ☐ Postscript _____
4. IF COMPUTER MEDIUM OR AUDIOVISUAL
   - a. Quantity/type *(specify)* _____
   - b. Machine compatibility *(specify)* _____
   - c. Other information about product format a user needs to know: _____

B. Transmission Information:

STI PRODUCT IS BEING TRANSMITTED:

- ☒ 1. Electronic via Elink
- ☐ 2. Via mail or shipment to address indicated in award document *(Paper products, CD-ROM, diskettes, videocassettes, et.)*

_____

- ☐ 2a. Information product file name *(of transmitted electronic format)*

_____

PART III: STI PRODUCT REVIEW/RELEASE INFORMATION

(To be completed by DOE)

A. STI Product Reporting Requirement Review:

- ☒ 1. THIS DELIVERABLE COMPLETES ALL REQUIRED DELIVERABLES FOR THIS AWARD
- ☐ 2. THIS DELIVERABLE FULFILLS A TECHNICAL REPORTING REQUIREMENT, BUT SHOULD NOT BE DISSEMINATED BEYOND DOE.

B. DOE Releasing Official

- ☐ 1. I VERIFY THAT ALL NECESSARY REVIEWS HAVE BEEN COMPLETED AS DESCRIBED IN DOE G 241.1-1A, PART II, SECTION 3.0 AND THAT THE STI PRODUCT SHOULD BE RELEASED IN ACCORDANCE WITH THE INTELLECTUAL PROPERTY/DISTRIBUTION LIMITATION ABOVE.

Released by *(name)* _____

Date _____
(mm/dd/yyyy)

E-mail _____

Phone _____

Award No.: DE-FC26-08NT01928
Recipient: Iowa Central Community College

Response to DOE F 241.3 Item J. Description / Abstract

ABSTRACT

The objective of this project is to finalize the creation of an independent quality fuel testing laboratory on the campus of Iowa Central Community College in Fort Dodge, Iowa that shall provide the exploding biofuels industry a timely and cost-effective centrally located laboratory to complete all state and federal fuel and related tests that are required. The recipient shall work with various state regulatory agencies, biofuel companies and state and national industry associations to ensure that training and testing needs of their members and American consumers are met. The recipient shall work with the Iowa Department of Ag and Land Stewardship on the development of an Iowa Biofuel Quality Standard along with the Development of a standard that can be used throughout industry.

B. Scientific/Technical Reports

Final Scientific/Technical Report

1. DOE Award No. DE-FC26-08NT01928 awarded to Iowa Central Community College. Title of Project: Iowa Central Quality Fuel Testing Laboratory. Principal Investigator: Dr. Don Heck. Team members: Iowa Department of Agriculture and Land Stewardship (IDALS), Iowa Central Diesel Technology Program, Iowa Central Process Technology Program.

2. No patented material or protected data was generated with this award.

3. Executive Summary:

Iowa is a leader in renewable fuels production with the capacity to produce over 4 billion gallons of ethanol and biodiesel annually. Testing of renewable fuels can be costly and time-consuming, but is essential to gain consumer confidence and support for renewable fuels. The mission of the Iowa Central Fuels Testing Laboratory is to provide low-cost, rapid fuel testing for the renewable fuels industry. These services are especially important for the smaller producers and start-ups that would otherwise have limited means for quality testing. Lack of testing can be detrimental as it then becomes more likely that off-spec fuel will reach the consumer. In addition, the Laboratory offers one-on-one personal service with the ability to work with clients on special projects including consultations and report generations when requested, typically free of charge. This level of service is not readily available at larger businesses and contributes to the success of our clients in the renewable fuels industry. Because the Laboratory is located on the campus of Iowa Central Community College, the Laboratory offers educational opportunities for the students of Iowa Central. In addition, the Laboratory is in a position to sponsor and conduct research projects that will benefit the renewable fuels industry. These projects can employ the use of Iowa Central student interns greatly enhancing their academic experiences.

Iowa Central dedicated some of the funding for this project to enhance the College's ability to provide valuable and timely training for students and for the employees of area biotechnology and biofuels industries. Iowa Central has created numerous strong partnerships with local industries; these partnerships have allowed for the development of the Process Technology Program in addition to several custom-designed and delivered training modules. These relationships continue and will likely grow with the anticipated expansion of the agricultural biotechnology sector in the Fort Dodge area.

4. Comparison of Actual Accomplishments with Stated Goals:

Task 1.1. Design of Laboratory

The Laboratory has been successfully designed and is equipped to handle testing needs complying with ASTM D6751 (biodiesel), D975 (diesel), D7467 (biodiesel blends), D396 (fuel oils), D4806 (denatured fuel

ethanol), and D5798 (ethanol blends). Tests that require outsourcing include ASTM D613 (cetane), D 6079 (lubricity), and D2624 (conductivity).

Task 1.2. Research and Procurement of Laboratory Equipment

All major equipment has been purchased and installed and is currently functioning in the laboratory, with the exception of the High Frequency Reciprocating Rig for lubricity testing, the Ignition Quality Tester for cetane, and the Supercritical Fluid Chromatograph for olefin content. A cost/benefit analysis for these instruments did not justify their purchase and these tests are currently being provided by our out-sourced laboratory (Southwest Research Institute, San Antonio, Texas). Additional instruments procured beyond the initial equipment list include a gas chromatograph appropriate for measuring low levels of ethanol, a gas chromatograph for performing the EN 14103 FAME Content test, a coulometric Karl Fischer titrator for detecting very low levels of moisture, a vapor pressure tester, an FT-IR for measuring percent biodiesel, and an additional flash point tester and rancimat tester to increase our throughput with these tests.

The Laboratory purchased three 2011 Ford F-250 Super Duty pick-up trucks with the Power Stroke B20 diesel engine designed to run up to 20% biodiesel blends. Fuel Inspectors for the State of Iowa drove these trucks during a two-year period during which the Laboratory monitored fuel economy and engine performance. The results of this study are summarized in section 5 below.

Task 1.3. Equipment Set-up and Validation

All equipment has been successfully set up and validated for use. On-going validations of equipment performance are accomplished through routine Quality Control sample testing and charting, routine calibrations and reference material checks where available and appropriate, and on-going participation in the ASTM Laboratory Crosscheck programs. The details of these activities and requirements are outlined in the Laboratory's Quality Manual for the BQ-9000 and ISO-9001 accreditation programs.

Task 1.4. Fuel Testing Services

The Laboratory is currently self-funded and employs two full-time technicians, one part-time technician, one part-time office assistant, one full-time business manager and one full-time director. Our client list is currently over 200 and represents 38 states and 3 foreign countries. The Laboratory currently serves major biodiesel and ethanol producers, the State of Iowa Bureau of Weights and Measures, fleet managers, smaller producers, academic institutions, new start-ups, private citizens, and several other entities. A full-panel ASTM D6751 biodiesel slate costs $730 including the out-sourced cetane test or $495 without cetane. A full-panel ASTM D4806 ethanol slate costs $260. The Laboratory offers ale carte tests and custom packages; rush service is available for an additional fee. The Laboratory hosts a web site with information, pricing and services performed at www.iowafuellab.com.

Task 2.1. Industry Validation

Significant growth in the biofuels industry exists within the Fort Dodge area. In order to keep up with the required skills that the industry demands, Iowa Central has connected with these businesses on numerous occasions. Meetings have taken place both on-site of the particular facility as well as on the Iowa Central campus. These meetings have allowed Iowa Central to gain insight for the skills and equipment requirements important to the industry. Industry participants include Koch Fertilizer, Louis Dreyfus, Poet, Cargill (former Tate & Lyle facility), Corn LP, and Renewable Energy Group (formerly West Central Cooperative). We were not able to complete a training program with Maple River Energy due to several considerations.

Task 2.2. Curriculum Development

One result of Iowa Central's relationships with area industries is the creation of the Process Technology Program, offered for the fall of 2013. Industry participants provided input and guidance for the development of this program. Several new courses have been either created or significantly modified for this program, including Introduction to Process Technology (BPT-300), Applied Chemistry (CHT-105), Process Steam and Heating Systems (BPT-315), Process Cooling Systems (BPT-320), Material Balance (BPT-310), Basic Fermentation (BPT-335), and Biomanufacturing (BPT-211).

Task 2.3. Equip Training Laboratories to Supplement Hands-on Training

Several pieces of equipment have been purchased, installed and utilized by the Iowa Central Diesel Technology Program. In several instances, the equipment was purchased used and refurbished by Iowa Central students.

A Mustang MD 1000 Chassis Dynamometer was purchased and installed in a new building specially designed for this particular instrument. The dynamometer is used to make horsepower and torque comparisons between engines running on petroleum diesel and on biodiesel. Students are instructed on how the dynamometer works and how to interpret results. The dynamometer also allows students to observe a diesel engine up close as it runs under a full load. The dynamometer also contains an exhaust opacity meter for exhaust analysis; 5 portable opacity meters have been purchased as well.

Three diesel units containing 2009 emissions equipment were purchased. Two of these units were purchased wrecked, with Iowa Central students performing refurbishments on these units. The first unit is a 2009 Freightliner Cascadia tractor trailer that had been wrecked beyond reasonable use. The Diesel Technology Program students modified this unit to serve as an in-class working unit for demonstrating diesel technology, including the function and servicing of the Diesel Particulate Filter (DPF) and Exhaust Gas Recirculation (EGR) systems. The second unit is a 2009 International Dura Star that the students were able to repair back to road-worthiness. This unit is also used for instruction in diesel and emissions technology, and is also used by the Iowa Central Transportation Technology Program students to obtain their CDL licenses for over-the-road trucking. The third unit is a 2009 Peterbilt that originally served as

an experimental production unit for Peterbilt. This unit is a road-ready unit and, in addition to providing instructional and training opportunities, is also taken to local parades and county fairs to be used as a recruiting tool for Iowa Central.

The last unit purchased is an off-road Caterpillar IT28G articulated loader. This unit was refurbished by Iowa Central students and is used for moving large items into and out of the classroom, hoisting engines, and any other heavy-duty task. This unit provides a comparison between over-the-road and off-road diesel systems and is also used to teach hydraulics, HVAC and electrical systems.

Task 2.4. Industrial Training

Iowa Central provides industry training across the 9-county region that we serve. The majority of this training is contract training which means it is custom designed and delivered for the specific production facility that requests it. Examples of industry training that have been delivered include fermentation, quality control, motors and controls, PLCs, instrumentation, pumps, blowers, conveyors, plant air systems, tanks, vessels and valves, preventive and predictive maintenance, computers, leadership training, and safety training. These training modules have seen over 2100 individual registrations by students and employee participants (some participants sign up for more than one module). In addition, Iowa Central participated in the Biodiesel for Diesel Technicians workshops sponsored by the Iowa Biodiesel Board and National Biodiesel Board. In addition to conducting and participating in the workshops, the curriculum has been incorporated into other courses on campus including Diesel Fuel Systems (DSL 445) and Diesel Automatic Systems (DSL 838).

Task 2.5. Enhancement of Industry Training

Iowa Central is continuously working on enhancing our industry partnerships. As a requirement, Iowa Central program leaders are required to meet twice a year with industry representatives to discuss curriculum updates and other industry needs that may have developed. Additional benefits of our industry partnerships include possible equipment donations to equip student laboratories, and numerous opportunities for Iowa Central personnel to participate in employee training sponsored by local production facilities. This helps to ensure that Iowa Central employees are up-to-date with current technology and practices, and therefore better equipped to share this with our students.

Subtask 2.6. Industrial Training for Biofuels and Diesel Mechanics

Procurement and use of the training equipment for Subtask 2.6 is addressed above in Task 2.3. Collection of fuel samples state-wide by the Iowa Department of Agriculture is on-going; these samples are brought to the Laboratory for analysis.

Task 3.1. Accreditation Process

The Laboratory completed the BQ-9000 Laboratory Program administered by the National Biodiesel Accreditation Commission in June 2010, and was the first laboratory in the nation to do so. This

accreditation was successfully renewed in June 2013 and is valid until June 2016. The Laboratory also successfully completed the requirements for the ISO-9001:2008 program administered by the United Registrar of Systems in April 2012. This certificate is valid until April 2015.

Task 3.2. Identify Key Aspects of Fuel Filter Fouling

The Laboratory has purchased and installed a GC/MS capable of identifying contaminant materials. This instrument is used routinely for analysis of fuel, fuel filters and biodiesel feedstock materials. Analysis of fuel filters to-date reveals that the majority of issues are related to either microbial action or biodiesel contaminants such as monoglycerides. Work with this aspect of the project is on-going.

Task 3.3. Create New and/or Modify Existing Biofuels Standards

The Iowa Department of Agriculture has adopted ASTM D6751 as the standard for fuel quality. With the excess revenue currently being generated, the Laboratory is in a position to consider partnering with other organizations such as the National Biodiesel Board, the Iowa Biodiesel Board or the Iowa Renewable Fuels Association to determine what research projects can be undertaken by the Laboratory that would be useful for the renewable fuels industry as a whole. Rather than focus on a specific task, this approach will allow the Laboratory some flexibility to meet the current needs of the industry; any research findings will then be presented at venues hosted by these organizations.

Subtask 3.4. Certification of the Biofuels Laboratory

This section has been addressed above in Task 3.1.

5. Summary of Project Activities.

Iowa Central Fuel Testing Laboratory:

Equipment and casework purchases for the Laboratory began in the fall of 2008. The equipment and casework initially had to be installed in a temporary location while we waited on the construction of the Biosciences and Health Sciences Building which currently houses the facility. The Laboratory moved into the new (current) facility late in the summer of 2009. At this time, we began working with an outside consultant to create a BQ-9000 Laboratory quality management system. We received this accreditation in June 2010 and we were the first in the nation to do so.

Initial plans for the Laboratory were to offer full-slate testing for biodiesel and ethanol, with a ramping up of capabilities to offer diesel and gasoline testing as well. The rationale for this was to serve the needs of the Iowa Department of Agriculture with "one-stop shopping" for all their fuel testing needs. At issue were the requirements for cetane and octane test engines to allow us to provide full service testing. These two requirements alone would have added over $500,000 in additional funds needed, plus a dedicated technician to operate the equipment. We did not have the funds available for this and

have worked out arrangements to out-source these tests to other laboratories. The Laboratory investigated the possibility of obtaining an Ignition Quality Tester that would provide a cetane value, but did not feel that the revenue generated from this instrument would be sufficient to make it cost-effective. The Laboratory also decided against purchasing a high-frequency reciprocating rig for lubricity measurements for the same reason. The funds that would have been spent on these instruments were used instead to purchase additional equipment to expand our throughput and also to expand our capabilities in diesel and gasoline.

The Laboratory "officially" opened for business in June 2010 after receiving the BQ-9000 accreditation. In February 2011 the Laboratory hired a full-time business manager who was instrumental in implementing a full-scale marketing campaign including print, newsprint, internet and radio advertising, in addition to creating increased visibility through display booths at trade show venues. By the summer of 2011 the Laboratory was able to offer a full ASTM D4806 ethanol panel of tests; this happened in conjunction with bringing our part-time technician (an Iowa Central graduate) to full-time status. With the BQ-9000 program completed, the Laboratory also started work on the ISO-9001 program to cover all other aspects of the laboratory (the BQ program only applies to the biodiesel testing). The Laboratory completed this program in April 2012. In December of the same year, the Laboratory brought on a second full-time technician, a graduate of the Iowa Central Biofuels Technology Program who had previously completed an internship with the Laboratory. The Laboratory also employs a part-time office assistant and a part-time laboratory assistant. The Laboratory currently offers services to over 200 clients representing 38 states and three foreign countries.

Iowa Central Process Technology and Diesel Technology Programs:

Several meetings have taken place between Iowa Central personnel and representatives from area industries. These meetings have led to the design, development and implementation of the Process Technology Program which was rolled out for the fall of 2013. Additionally, these collaborations have led to the development of several training modules custom-designed for individual companies. These modules have been taught either on-site or on campus and so far have seen over 2100 registrants. This relationship continues with existing companies and is expected to expand as the biotech industry expands in the Fort Dodge region. Much of this expansion is anticipated to come through the agricultural park west of town known as Iowa's Crossroads of Global Innovation.

Benefits to the Diesel Technology Program include the purchase and installation of the chassis dynamometer to give students a hands-on look at diesel engine operation. Several units containing 2009 emissions systems were purchased and refurbished for student use. Iowa Central's participation in the "Biodiesel for Diesel Technicians" workshop sponsored by the Iowa Biodiesel Board and National Biodiesel Board has given our instructors additional material to incorporate into their curricula.

Ford F-250 Super Duty Pickup Demonstration Project:

The Laboratory conducted a 24-month demonstration project with the three Ford F-250 Super Duty diesel pickup trucks purchased for the Iowa Department of Agriculture. The study compared the use of petroleum diesel with 20% biodiesel, and utilized a truck running on 100% petroleum diesel (the ULSD truck), one truck running on a blend of 20% soy biodiesel with petroleum diesel (the Soy truck), and one truck running on a blend of 20% tallow biodiesel with petroleum diesel (the Tallow truck). All three units were driven by employees of the Iowa Bureau of Weights and Measures assigned to carry out the duties of monitoring the accuracy of retail pump delivery systems and collecting fuel samples from both production facilities and retail locations for quality analysis. The routes driven by the employees included a northern route (Mason City area), central route (Carroll area) and a central/southern route (Des Moines area), all within the state of Iowa.

The Ford F-250 Super Duty Power Stroke B20 turbo diesel is approved for use with up to 20% biodiesel and so this blend level was chosen for the study. Fueling for the ULSD unit occurred at a retail station known to sell B0 (straight ULSD). The biodiesel units fueled from a 500 gallon storage tank placed at a convenient location for each driver. Fuel for these tanks was prepared twice a year at the terminal where biodiesel was splash-blended into the ULSD and delivered to the 500-gallon tank. The winter delivery included the addition of winter additive and a mix of #1 and #2 ULSD for the biodiesel blends, and a winter additive only for the ULSD.

Data collection for the study began the first week of July 2011 and continued through the last week of June 2013. Data collection from the recorders was sometimes sporadic resulting in the collection of data for roughly half of the miles driven. The sporadic nature of data collection appeared to be random and therefore is not believed to have introduced any bias into the study. Data recorded includes speed, fuel consumption, ambient temperature, engine load, exhaust pressure, fuel pressure and distance travelled. After the initial start, the recorders were programmed to capture data for regeneration of the Diesel Particulate Filter (DPF) systems. Fuel samples were routinely taken for analysis in addition to several samples of engine lube oil collected during scheduled oil changes.

The performance of all three units was remarkably similar. Fuel economy for the B20 units was slightly higher with fuel economy for the Soy unit at 19.77 mpg (3.3% higher than ULSD unit), and the Tallow unit at 19.55 mpg (2.2% higher than the ULSD unit). These values were statistically different from the average ULSD fuel economy (19.12 mpg) when using a paired *t*-test. Fuel economy for all three units trended slightly lower over the course of the study, with the trend-line for the ULSD and Soy units showing a decreasing slope that was significantly different than zero. Average weekly temperatures exhibited a seasonal pattern as expected; however, this pattern was not readily evident in any of the three units. When plotted against temperature, fuel economy for the ULSD unit did show a positive correlation.

Engine load for all three units showed seasonal variation, with the colder months generally equating to lower load values. The Soy unit had the lowest overall load averages, and these values were statistically different than the ULSD and Tallow load values. All three units exhibited a similar trend where engine load increased steadily as the ambient temperature increased. This trend was evident up to around 5 degrees Celsius for the ULSD and soy units; beyond 5 degrees Celsius load and temperature did not correlate. Load continued to increase for the Tallow unit beyond 5 degrees Celsius, but this increase was not as steep.

Exhaust pressure showed mild seasonal variations as well, with the ULSD unit exhibiting the highest overall exhaust pressure. This may be significant because an increase in exhaust pressure may correlate with a decrease in fuel economy as more energy is required to expel the exhaust gasses. This is evident for the ULSD unit when exhaust pressure is plotted against fuel economy, but not for the two biodiesel units.

All three units are equipped with current emissions requirements including a diesel particulate filter (DPF) which traps and removes particulate matter from the exhaust. This filter requires periodic regeneration which is accomplished by injecting diesel fuel into the unit to burn off the accumulated matter. All three units exhibited seasonal variation in the frequency of regeneration, with the warmer months correlating to more frequent regenerations (shorter distance interval between regenerations). The ULSD unit exhibited the shortest distance intervals overall, and this difference was statistically different than the two biodiesel units.

Engine lube oil analysis did not reveal any significant differences among the three units. Metals concentrations trended slightly higher in the biodiesel units, but this trend was not statistically significant. Soot and fuel dilution were not a significant concern, and the acid and base numbers for the used oil samples were similar with the exception of a statistically significant lower base number for the Tallow B20 unit. The fuel system contained a primary and secondary fuel filter, with the primary filter also serving as the water-in-fuel (WIF) filter. The WIF filter assemblies did not reveal any separated water, and the fuel filters did not reveal any contaminants. No filter fouling was experienced by any of the units during the two-year study period.

In summary, overall fuel economy was comparable among all three units; however, a paired *t*-test revealed that fuel economy for the ULSD unit was statistically different (and lower) than the B20 units. Because only a single ULSD unit was used for the demonstration, it is not possible to determine if this difference was the result of fuel choice or some other variable such as driver habits, driving cycle, or engine variation. Two factors could have contributed to reduced fuel economy in the ULSD unit; an increased exhaust pressure (which is negatively correlated with fuel economy) and an increase in the number of DPF regenerations per distance travelled (causing more fuel to be consumed for the regeneration cycles). Overall, this study demonstrates that B20 performance is comparable to ULSD and is a viable alternative to using ULSD alone.

6. Identity of Products Developed Under the Award.

No publications, technologies, patents, or products were developed with this project. The Laboratory hosts a website found at www.iowafuellab.com.

7. Projects Involving Computer Modeling.

This project did not involve any computer modeling.

C. Financial Reporting

The cost status comparing budget and actual costs incurred as of September 30, 2013 is shown in the table below as prepared for final report dated January 29, 2014.

	Budget Period 1 2008-2009		Budget Period 2 2009-2010		Budget Period 3 2010-2013		TOTALS	
	Budget	Cost	Budget	Cost	Budget	Cost	Budget	Cost
Personnel	211,500	187,303	115,000	130,209	225,550	236,320	552,050	553,832
Fringe Benefits	67,680	51,318	32,000	35,958	90,220	77,429	189,900	164,705
Travel	17,550	605	5,000	0	2,400	2,285	24,950	2,890
Equipment	874,762	904,753	338,938	320,077	359,009	217,502	1,572,709	1,442,332
Supplies	329,508	362,755	21,710	47,079	45,621	79,546	396,839	489,380
Contractual	0	0	0	0	300,000	413,807	300,000	413,807
Other Direct costs	29,000	23,266	35,000	14,102	30,000	41,532	94,000	78,900
Total Direct Charges	1,530,000	1,530,000	547,648	547,425	1,052,800	1,068,422	3,130,448	3,145,847
Indirect Charges (32%)	89,338	74,290	47,040	47,264	101,046	100,400	237,424	221,954
TOTALS	1,619,338	1,604,290	594,688	594,689	1,153,846	1,168,822	3,367,872	3,367,801

The table below represents the shared cost Iowa Central Community College has contributed to this project as of September 30, 2013 as prepared for final report dated January 29, 2014.

	Unliquidated Obligations		Expended Funds		
Budget Period	Federal	Non-Federal	Federal	Non-Federal	Total
1	0	0	984,000	620,290	1,604,290
2	0	0	475,750	118,938	594,689
3	0	0	749,929	418,893	1,168,822
Totals	0	0	2,209,680	1,158,121	3,367,801

See also Federal Financial Report Form SF-425 submitted 1/29/14.

D. Closeout Reports

Final Invention and Patent Report

Refer to Final Patent Certification Form DOE F 2050.11 submitted 12/27/13.

Property Certification

Refer to U.S. Department of Energy Property Certificate submitted 12/27/13. Equipment purchased with DOE funds are identified in the final inventory detail included.

Version 1/29/14