

# Managing Early Adoption of Biodiesel by Commercial Fleets



**Final Report**  
**June 2007**

**Sponsored by**

University Transportation Centers Program,  
U.S. Department of Transportation  
(MTC Project 2006-02)



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<b>16. Abstract</b>  Commercial carriers are being confronted with a variety of decisions regarding long-term petroleum dependency and near-term state and federal policies aimed at increasing the use and content of biodiesel. The purpose of this study is to help members of the Iowa Motor Truck Association identify problems regarding the use of using biodiesel blends in trucks. The participating trucking company provided two trucks that ran on similar routes, one truck using regular diesel fuel (B0) and the other one using a 2% biodiesel blend (B2). Complete mileage data and special maintenance concerns were recorded over a period of approximately one year. Iowa State University researchers analyzed and interpreted the field data in terms of fuel economy, variations in maintenance, and seasonal performance.  Data acquired from July 2006 through May 2007 were analyzed. Special attention was paid to the concern of fuel filter plugging resulting from using B2. During the period of this study, the B0 truck accumulated approximately 160,000 miles and the B2 truck accumulated about 120,000 miles. Field results indicate that both fuels provided similar miles per gallon numbers, even for different trip lengths. The average miles per gallon were 6.0 for the B0 truck and 6.1 for the B2 truck. Overall, the fuel economies of the two engines using B0 and B2 were very similar. In addition, no fuel filter plugging incidents in the B2 truck were found, even during the winter months. The final data are encouraging in terms of using B2 as an alternative fuel for trucks.			
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# MANAGING EARLY ADOPTION OF BIODIESEL BY COMMERCIAL FLEETS

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## **EXECUTIVE SUMMARY**

The purpose of this study was to help members of the Iowa Motor Truck Association (IMTA) identify problems regarding the use of using biodiesel blends in trucks. A meeting with members of the IMTA was held on May 13, 2006 to recruit participants for this project in order to compare the vehicle performance of trucks using either regular diesel fuel or biodiesel blends. The participating trucking company provided two trucks that ran similar routes, one truck using regular diesel fuel (B0) and the other using a 2% biodiesel blend (B2). Complete mileage data and special maintenance concerns were recorded over a period of approximately one year, from July 2006 through May 2007. Iowa State University researchers analyzed and interpreted the field data in terms of fuel economy, variations in maintenance, and seasonal performance.

Data acquired from July 2006 through May 2007 were analyzed. Special attention was paid to the variations in maintenance (e.g., fuel filter plugging) that resulted from using B2. During the period of this study, the B0 truck accumulated approximately 160,000 miles and the B2 truck accumulated about 120,000 miles. Field results indicate that both fuels provided similar miles per gallon numbers, even for different trip lengths. The average miles per gallon were 6.0 for the B0 truck and 6.1 for the B2 truck. Overall, the fuel economies of engines using B0 and B2 are very similar. In addition, no fuel filter plugging incidents in the B2 truck were found, even during the winter months. The final data are encouraging in terms of using B2 as an alternative fuel for trucks.



## **INTRODUCTION**

The use of biorenewable fuels can help decrease greenhouse gas emissions and reduce U.S. dependency on foreign oil. For this reason, a significant amount of research has been conducted regarding the effects of biodiesel/diesel blends on engine performance and emissions in the laboratory. Additionally, the use of biodiesel in transit fleets for public transportation has become increasingly popular. However, the use of biodiesel in long-haul trucks is still very limited. At present, commercial carriers are being confronted with a variety of decisions regarding long-term petroleum dependency and near-term state and federal policies aimed at increasing the use and content of biodiesel. Increasing market prices for petro-diesel, compounded by mandates to use low-sulfur fuels by 2007 and concerns about the cold-flow properties of biodiesel, are complicating fleet decisions regarding when and how to integrate biodiesel over the next couple of years.

As a result, the Iowa Motor Truck Association (IMTA) engaged a coalition of Iowa-based fleets to jointly study for one year the use of biodiesel in commercial service and to identify strategies for managing early adoption. The focus of this project was to support this initiative by helping fleets interpret field data in the context of fuel economy, variations in maintenance, and seasonal performance and by identifying problem solving strategies.

### **Biodiesel Usage in Diesel Engines**

There are extensive data on emissions from mobile engines burning biodiesel, from such sources as laboratory tests of truck engines (Sharp et al., 2000; Alam et al. 2004), field tests of bus engines (Souligny et al. 2004) and tractor engines (Bouche et al. 2000), and a laboratory test of a utility engine (Zarling et al. 2004). In summary, these data show reductions in particulates, carbon monoxide, and hydrocarbons and, overall, a linear increase in nitrogen oxide (NO<sub>x</sub>) emissions with increasing proportions of biodiesel. Additionally, biodiesel has better lubricity and a higher cetane number but a lower heating value than regular No. 2 diesel fuel.

Despite some limitations, biodiesel can offer significant opportunities for reducing most of the exhaust emissions with comparable engine power output. However, the process of adopting biodiesel in truck fleets is very slow. Obstacles include the engine manufacturer's warrantee and the relatively higher tendency for biodiesel to gel during winter months.

### **Project Objective**

The objective of this study is to analyze the field data of trucks using biodiesel/diesel blends and to identify problems in order to help truck fleets during the biodiesel adoption process.

## **PROJECT TASKS**

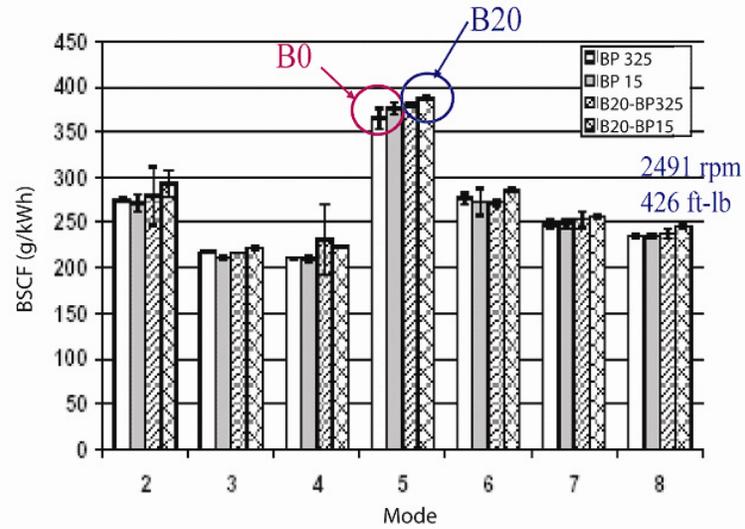
This project included three major tasks, which are outlined in this section.

### **Task 1. Meeting with Members of the Iowa Motor Truck Association**

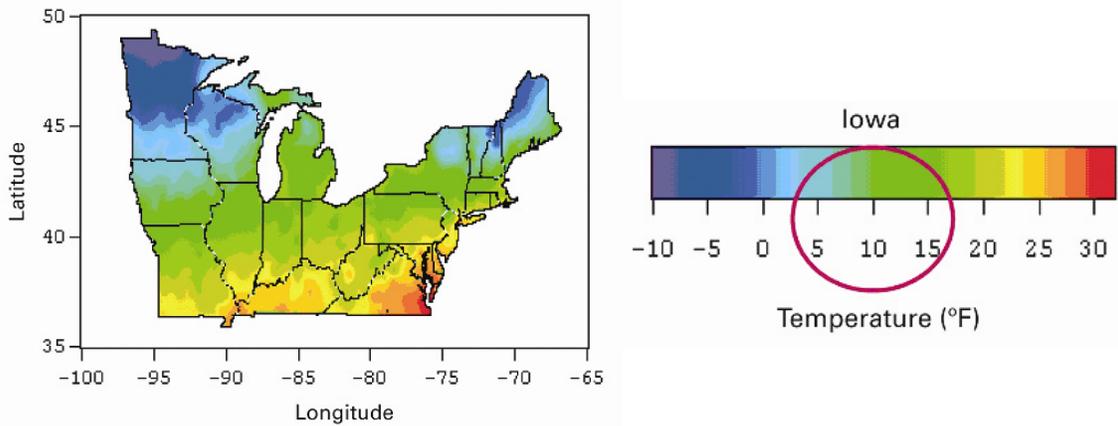
The purpose of this task was to introduce this study to IMTA members who were interested in using biodiesel blends in their fleets, to provide published research results on engine performance for engines using different biodiesel blends, and to recruit participants.

Before the meeting, the principal investigator performed a literature search on the engine performance of engines using biodiesel blends. During the meeting, the principal investigator presented the results of this literature review to the IMTA members. Considerable materials regarding the pros and cons of using biodiesel in truck engines were provided to the fleets in order to help them decide whether to participate in this project. Presentation materials included typical fuel economy data for engines using both biodiesel blends and ordinary petro-diesel, shown in Figure 1 (Alam et al. 2004); data regarding the average minimum temperature in January for the northeast quarter of the U.S., as a cautionary reminder for biodiesel users (Figure 2); and a recent report from the National Renewable Energy Laboratory (Proc, Barnitt, and McCormick 2005) about a Denver bus project that compared the performance of ordinary petro-diesel (B0) and a 20% biodiesel blend (B20), the data from which are shown in Figure 3. IMTA members were also encouraged to consult web content and publications produced by the National Renewable Energy Laboratory (NREL 2007) and the National Biodiesel Board (NBB 2007) on the use of biodiesel.

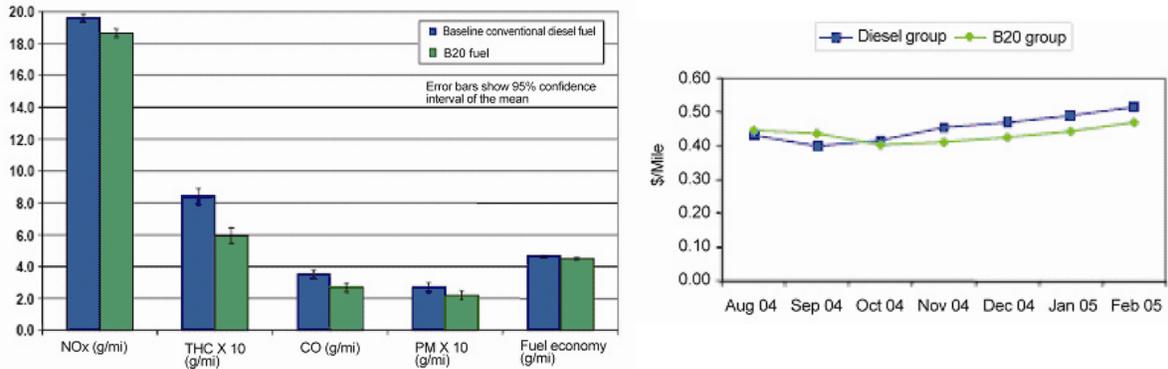
The data regarding minimum January temperatures was important to present because one of the major concerns of using biodiesel in vehicles is the tendency for fuel filters to become plugged at low temperatures. Therefore, because January is the coldest month of the year in the Midwest, the minimum, rather than the average, January temperature (as shown in Figure 2) is an important factor to consider for biodiesel users. In Iowa, the minimum January temperature ranges between 5 °F and 15°F. This range is important because of its relationship to the cloud point for fuels. The cloud point is the temperature at which small, solid crystals are first visually observed in the fuel as the fuel is cooled. The cloud point is an important factor to recognize when ensuring good performance at cold temperatures because the cloud point is related to the concern of fuel filter plugging. The cloud point is presented as a range of temperatures instead of a single temperature, since the data for the cloud point can be different if the fuel is provided from different suppliers or, in the case of biodiesel, produced from different feedstock. For reference, the data from a Department of Energy report (Tyson and McCormick 2006 ) indicate that the cloud points of B0 and 100% biodiesel (B100) range from 5°F to 41°F and from 26°F to 54°F, respectively. There is no definitive data for diesel/biodiesel blends. However, as the percentage of biodiesel in the blend increases, the cloud point increases as well. Thus, a 2% biodiesel blend (B2) will have a similar cloud point to that of B0. To help determine the type of biodiesel blends to use in local fleets, biodiesel users will need to pay attention to local minimum temperatures.



**Figure 1. Engine brake specific fuel consumption data for a specific commercial diesel engine**



**Figure 2. Average January minimum temperature data for part of the U.S.**



**Figure 3. Data on emissions and average maintenance costs for using B0 and B20 from a Denver bus study project**

### **Task 2. Collaborating with Participants and Collecting Field Study Data**

In this task, a field study was performed. For the study, the participating fleets were to designate two trucks that had similar routes and loads, with one truck running on B0 and the other on B2. The researchers at Iowa State University created a packet for each participant that contained guidelines for using biodiesel, the locations of available biodiesel fueling stations in Iowa, and blank data sheets to be filled out by the drivers or staff to record odometer readings and fuel amounts per filling. The detailed materials of the packet are provided in Appendices A and B.

The packet was to be sent to participating fleets so they could record all the fueling and maintenance records for the trucks observed in this study. The data sheets were filled out at every fueling and faxed back to Iowa State University every month for analysis.

### **Task 3. Data Analysis and Reporting**

The vehicle data were analyzed on a daily and monthly basis. Mileage data were computed in miles per gallon (MPG), and special attention was paid to any variations in maintenance records for the trucks using B2, in particular during the winter months. Quarterly reports were assembled and submitted to Midwest Transportation Consortium. Constant communications between the participating fleets and the Iowa State University researchers were also maintained during the project to document the overall experience of using biodiesel blends in trucks.

## **RESULTS**

### **Participating Fleet**

At the beginning stage of this project, 15 trucking companies expressed interest in participating in this research. However, all but one of the companies dropped out of the study for any of the following reasons: (1) they did not want to void the manufacturer's warranty on their truck engines by running biodiesel, (2) they had too much of a workload, or (3) they could not work out the logistics to run two similar trucks on similar routes.

Research was conducted to determine the blend of biodiesel that manufacturer warranties would cover. There seemed to be a common limit of 2%–5% blends, with no major truck manufacturer warranting over 5%. The companies that dropped out of the study for this reason also stated that they had communicated directly with their trucks' manufacturer, and the manufacturer recommended against running any biodiesel blend. As a result, only Casey's participated in this study, using B0 in one truck and B2 in another. Nonetheless, the data collected has been helpful, and Casey's has been very cooperative and has provided timely vehicle data every month for analysis.

### **Vehicle Data and Analysis**

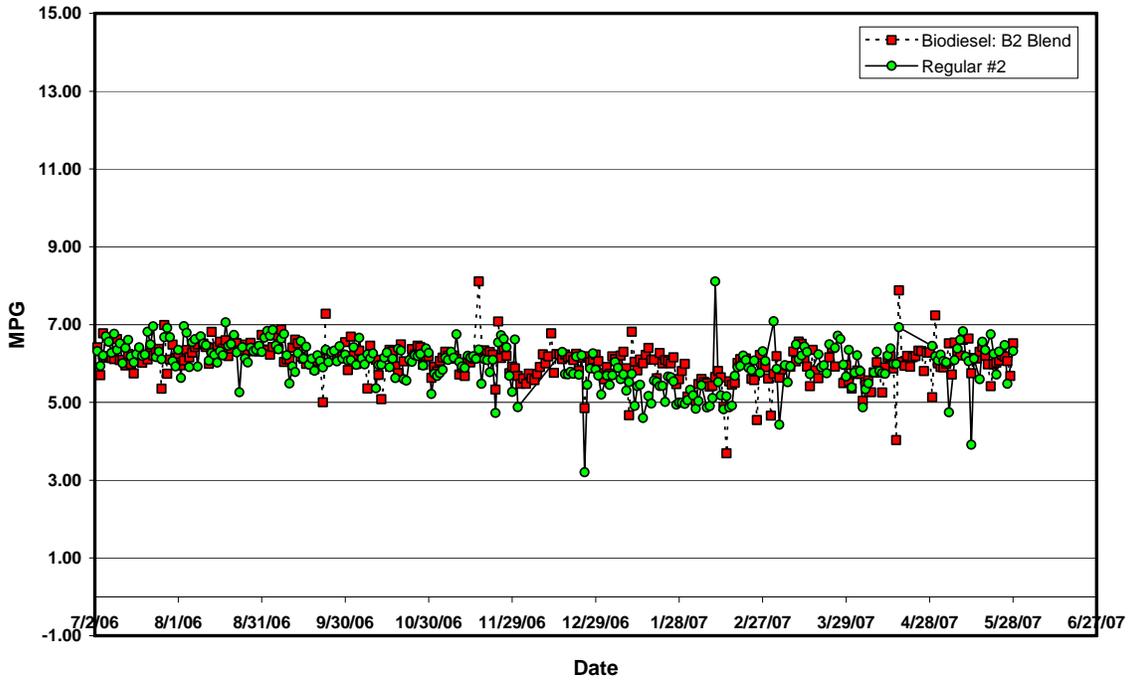
Data from Casey's was received and analyzed regularly for the months of July 2006 through May 2007. Complete mileage data for the two trucks running on either B0 or B2 were recorded for the duration of this project. In terms of the total mileages during the period of this study, the B0 truck accumulated approximately 160,000 miles and the B2 truck accumulated approximately 120,000 miles. Special attention was also paid to the fuel filter plugging issue that could have resulted from using B2 at cold weather conditions.

A sample of recorded vehicle data is shown in Appendix C. Iowa State University researchers entered the data manually and performed the analyses.

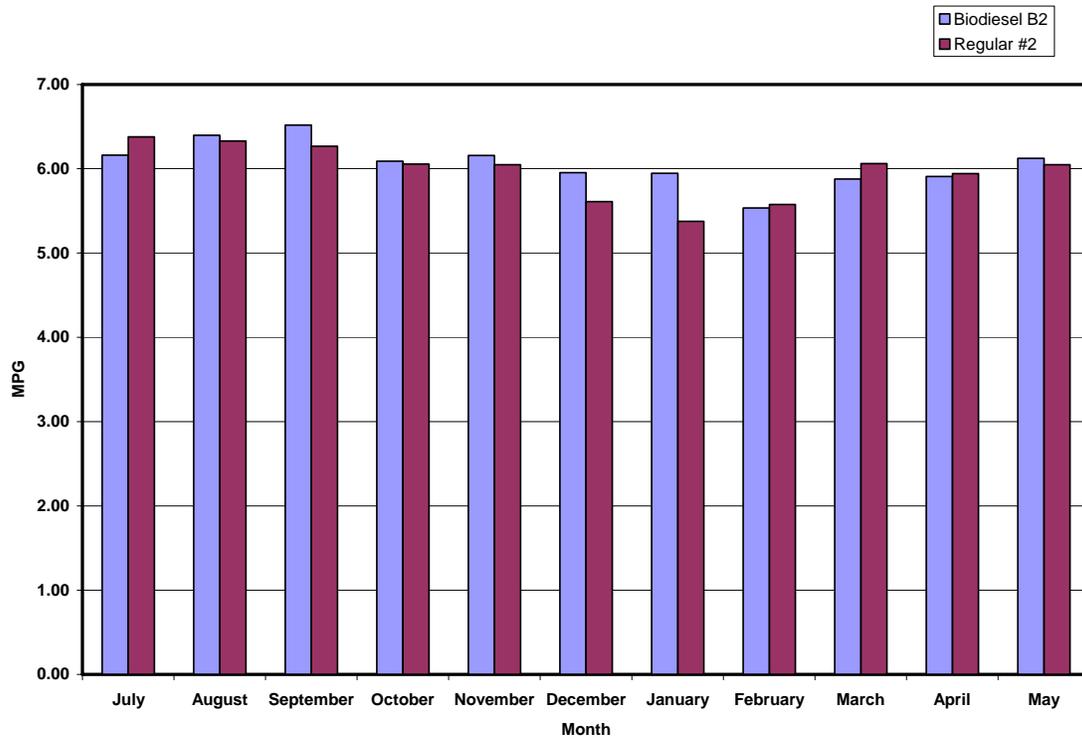
### **Field Study Results**

Figures 4 through 6 show data plots that compare the daily and monthly mileage for the Casey's trucks using either B0 or B2, as well as the average trip lengths for these two trucks. On average, the B0 truck delivered 6.0 MPG and the B2 truck delivered 6.1 MPG. The difference in the average MPG can be regarded as negligible, considering that two different trucks with different respective fuels were studied. While there were several noticeable variations in MPG on a number of occasions, these variations are thought to be due to extended idling or continuous long trips. Overall, the MPG results from using B0 and B2 were very similar.

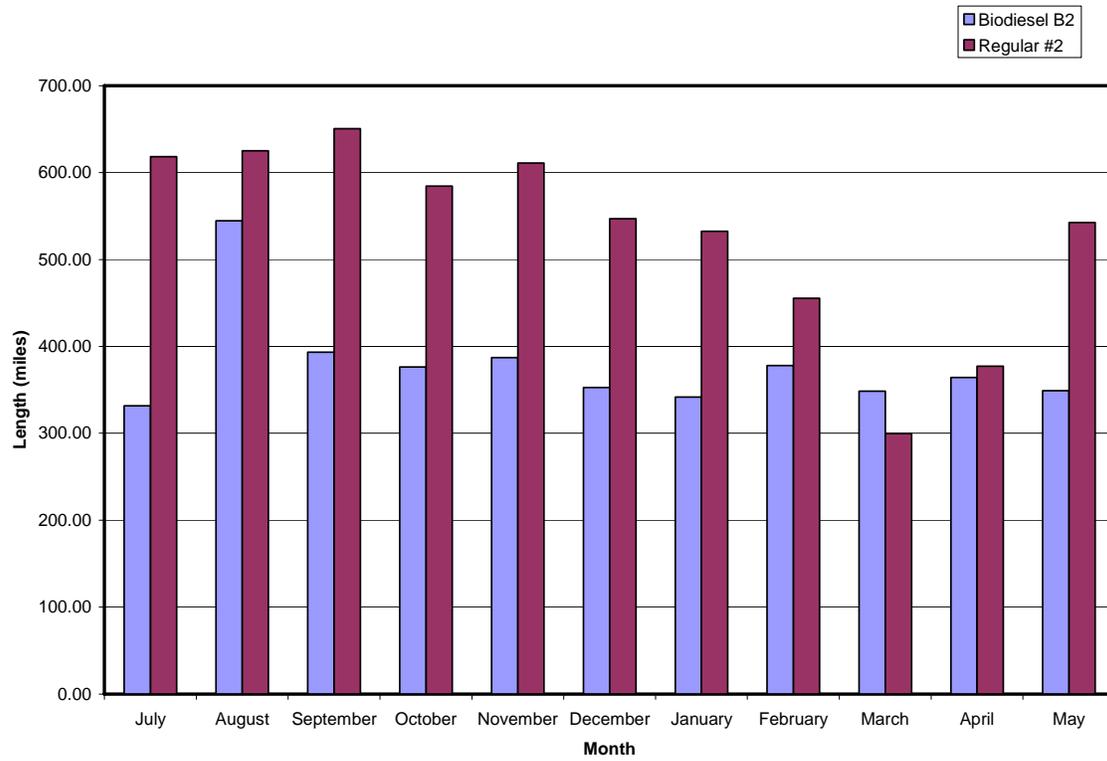
In addition to the fuel efficiency data, the participant was also asked to record mechanical problems related to the fuel system of the B2 truck, including problems with fuel filters, fuel lines, and fuel pumps. The participant's records, however, did not show any problems with the fuel system of the B2 truck, even during winter months.



**Figure 4. Daily mileage data comparisons for trucks using B0 and B2**



**Figure 5. Monthly mileage data comparisons for trucks using B0 and B2**



**Figure 6. Averaged daily trip length by month**

## **SUMMARY**

Data acquired from July 2006 through May 2007 for trucks using B0 and B2 were analyzed. Field results indicated that both fuels provided similar fuel economies over the period of this study. The B0 truck has an average of 6.0 miles per gallon and the B2 truck has an average of 6.1 miles per gallon. Although special attention was paid to the fuel filter plugging problem that may result from using B2, no such incidents were reported, even during the winter months. The final data are encouraging in terms of using B2 as an alternative fuel for trucks.

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- Zarling, D.D., K.L. Bickel, R.W. Waytulonis, and J.R. Sweeney. 2004. Improving Air Quality by Using Biodiesel in Generators. SAE Technical Paper 2004-01-3032.



## **APPENDIX A. MATERIALS IN THE PACKET TO PARTICIPANTS**

At the beginning of this study, the researchers delivered a packet that contains information about this project, biodiesel fueling stations, and daily mileage data sheets to participants. Appendix A contains the introductory materials and biodiesel fueling stations information in the packet.

## Managing Early Adoption of Biodiesel

We want to thank you for your participation in this biodiesel study. As you know the results of this project may be very beneficial to not only Iowa's economy, but the economy of the entire nation.

We have provided a list of filling stations in the state of Iowa that sell various blends of biodiesel. We would like to run only B20 blend biodiesel, but if that is not possible, any blend of fuel would help provide results. Whatever blend of biodiesel you do chose however, try to maintain that grade of fuel throughout the entire study to provide consistent results.

Filling stations in other states may be found on the website "[www.biodiesel.org](http://www.biodiesel.org)". At the top of the page is a tab that says "Buying Biodiesel," highlight the tab and click on "Biodiesel Retailers Map." Then select the area you want by clicking on it. This website provides retailers that have filled out a form that states they insure that their product confirms to ASTM and NCWM guidelines.

Provided are sheets that are for recording weekly status. The study is scheduled to go one full year upon startup. Record any tank fill ups, scheduled maintenance, or other maintenance performed. The better the records kept, the more helpful the study will be in the future.

We request that you fax or send us a photocopy of your data sheets to the number/address below at the end of every month, so that we can input them into a spreadsheet for records. Please fill out the sheets for the entire week even if the ending of the month is in the middle of the week.

**Fax Number: 515-294-3261**

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Mechanical Engr. Dept.  
2025 Black Engr. Bldg.  
Ames, IA 50011**

Thanks again, and feel free to contact us at anytime with any questions or comments. Your help is greatly appreciated.

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515-294-3244

## Biodiesel Filling Stations – Iowa Locations

As you will note by our disclaimer, we list these sites for informational and illustration purposes only. We only know about these locations if retailers report them to us.

The retailers must fill out a form, which notifies them that they should insure that their product confirms to ASTM and NCWM guidelines. However, we do not have any assurances that the retailers are complying, nor do we have the resources to police it.

### Iowa

Business Name/Location (Sort by City, Sort by Blend)	Contact	Phone	Blend	Restrictions
<b>21st Century Coop</b> Highway 92 Massena, IA 50853	<a href="#">Randy Daugherty</a>	712-779-3440	B2	
<b>Ag Vantage FS</b> 1877 10th St. Hazleton, IA 50641	<a href="#">Bob Gensen</a>	319-636-2071	B2	seasonal
<b>Berne Coop</b> Hwy 183 Ute, IA 51060	<a href="#">GARY GOSLAR</a>	712-885-2213	B2	CARDTROL MOST ALL CARDS
<b>Clarinda Coop Co.</b> 520 South Schenck Road Clarinda, IA 51632	<a href="#">Mike</a>	712-542-2146	B2	24 hrs cardtrol, mastercard, visa, discover
<b>Consumer Coop Society</b> 3500 2nd Street Iowa City, IA 52240	<a href="#">Gary Wrede</a>	319-545-2012	All	
<b>Dedham Coop Association</b> 229 Railway Dedham, IA 51440	<a href="#">Dan Seidl</a>	712-683-5515	B2	24 hour card station
<b>Des Moines Metro Biodiesel Co-op</b> 309 N. 3rd Ave E. Newton, IA 50208	<a href="#">Dan Johannsen</a>	515-371-6026	B99	Delivery in Des Moines metro area available
<b>Family Mart &amp; Deli</b> 3201 central ave.(hwy 52 n) dubuque, IA 52001	<a href="#">dennis althaus</a>	563-588-4331	B2 & B5	24 / 7
<b>Farmers 4-County Cooperative</b> 210 7th Ave. Belle Plaine, IA 52208	<a href="#">Rick Petersen</a>	319-444-2154	B10	All major credit cards 7:30 - 5:00 weekdays Sat AM
<b>Farmers Coop Association</b> 306 Hwy 69 N Forest City, IA 50436	<a href="#">Roger Barber</a>	641-585-2814	B2	24 hour Cardtrol,MC,Visa,Discover ,Am. Express
<b>Five Point Sinclair</b> 405 Rhomberg Ave. Dubuque, IA 52001	<a href="#">Kristina Hussemann</a>	563-583-5999	B5 and B12	
<b>Fredericksburg Farmers Coop</b> 110 N. Jefferson St Fredericksburg, IA 50630	<a href="#">Steve Neuendorf</a>	563-237-5324	B5	Pump 24 Retail Location - Unmanned
<b>Galva Holstein Ag, L.L.C.</b> 204 East 1st St. Holstein, IA 51025	<a href="#">Gary Brosamle</a>	712-368-4311	B5	24 hour cardtrol that is manned from 7:30 to 5:00
<b>Galva Holstein Ag, L.L.C.</b> 1583 Market Avenue Galva, IA 51020	<a href="#">Gary Brosamle</a>	712-282-4218	B5 + B20	24 hour cardtrol plus major credit cards accepted

<b>Heart of Iowa Coop</b> 22703 600th Ave. Nevada, IA 50201		515-382-5461	B20	year round
<b>Houseman Oil</b> 120 Central Ave. Estherville, IA 51334	<a href="#">Rick Houseman</a>	712-362-3857	B2	year round
<b>Krueger BP</b> 2630 SW 9th Street Des Moines, IA 50313	<a href="#">Mark</a>	515-280-6307	B5	M/C,VISA,AMEX,Wright Express,Voager--Hours: 6a-12p
<b>Krueger BP</b> 5120 NE 14th Street Des Moines, IA 50265	<a href="#">Mark</a>	515-265-0558	B5	M/C,VISA,AMEX,Wright Express,Voager--Hours: 6a-12p
<b>Krueger BP</b> 11304 NW 54th Street Grimes, IA 50222	<a href="#">Brian</a>	515-986-3017	B5	M/C,VISA,AMEX,Wright Express,Voyager--Open 24 Hrs.
<b>MFA Oil Petro-Card 24</b> Hwy 5 South Centerville, IA 52544		641-437-4188	B2	All major credit cards accepted.
<b>MFA Oil Petro-Card 24</b> Mill Street at Madison Bloomfield, IA 52537	Scott Hawkins	641-664-2014	B2	All major credit cards accepted.
<b>Mulgrew Oil Co.</b> 10314 Silverwood Dr. Dubuque, IA 52003	<a href="#">Tom Fogel</a>	563-583-7386	B5-B20	
<b>New Alliance FS</b> 2901 W. Grimes Ave. Fairfield, IA 52556		888-333-6912	B2	year round
<b>New Alliance FS</b> 1101 North Lincoln St. Knoxville, IA 50138	Doug Dejong	641-842-2116	B2	year round
<b>New Alliance FS</b> 2305 Highway 23 Oskaloosa, IA 52577		641-842-6159	B2	year round
<b>New Alliance FS</b> 425 Highway 1 and 92 North Washington, IA 52353	Jim Ross	319-653-5423	B2	year round
<b>New Century FS</b> 5616 Highway 14 North Newton, IA 50208		641-792-6933	B2	year round
<b>Northern Coop Services</b> 620 Central Ave. Northwood, IA 50459	Denise	641-324-2952	B2	public, credit card only
<b>Perfection Oil Co.</b> 2655 Lincoln Ave. Dubuque, IA 52001		563-556-0444	B2	year round
<b>Pro Cooperative</b> Hwy 3 Gilmore City, IA 50541	<a href="#">Rod Stoullil</a>	712-335-3575	B2	
<b>Sapp Bros Truck Stop</b> 2608 S 24th Street Council Bluffs, IA 51501	<a href="#">Paulette Cramer</a>	712-322-3000	B2	24 hours









8774

### Weekly Driver Records

**Project:** Managing Early Adoption of Biodiesel

**Name of Company:** Casey's Services Co.

**Truck Make:** MACK

**Truck Year:** 2006

**Displacement:**

**No. of Cylinders:** 6

**Rated Speed and Power:** 560 lb torque @ 1200 RPM  
427 HP @ 1800 RPM

**Week Dates:** 4-29-07 thru 5-5-07

**Note:** Each sheet is for a weekly log record. Weeks start on Sunday and go through Saturday. Fill out everytime the truck is fueled or maintenance is performed. Send in monthly.

**Fax Number:** 515-294-3261

**Dr. Song-Chang Kong**  
Iowa State Univ.  
Mechanical Engr. Dept.  
2025 Black Engr. Bldg.  
Ames, IA 50011

Date	Fuel Type	Odometer Reading	Gallons	Other Maintenance Performed
4-29-07	B-2	207175.3	62.12	
4-30-07	B-2	207525.0	50.62	
5-1-07	B-2	207955.4	71.75	
5-2-07	B-2	208352.6	47.25	
5-3-07	B-2	208736.6	65.12	
5-4-07	B-2	209142.8	67.75	
5-5-07	B-2	209397.6	39.12	