The Massachusetts Bioheat Fuel Pilot Program

Final Summary Report | June 2007

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INTRODUCTION

On August 13, 2006, the Executive Office for Administration and Finance (A&F) issued A&F Bulletin 13 ("Establishment of Minimum Requirements for Bio-Fuel Usage in State Vehicles and Buildings by Executive Agencies"). Recognizing the significant consumption of conventional heating oil by current (and future) state facilities, A&F directed the Executive Office of Energy and Environmental Affairs (EOEEA, formerly the Executive Office of Environmental Affairs) to establish a pilot program under which a minimum of two state facilities would test the use of bioheat fuel during the 2006-2007 heating season.[1]

The Bulletin also served notice that, pending the success of the pilot and the establishment of a statewide contract for fuel delivery, all state agencies would be required to use a minimum B3 bioheat fuel starting in the winter of 2007-2008. The bioheat mandate was subsequently included in Executive Order 484, dated April 18, 2007, as part of the Commonwealth's Leading by Example Program. Under the Executive Order, bioheat blends of at least three percent are required in #2 heating oil applications, where the fuel is available.

With the end of 2006-2007 heating season, EOEEA commissioned this pilot program report as a way to inform state and municipal facilities staff and management about bioheat fuel use, to document operational or logistical issues encountered during the pilot, and to provide recommendations for the use of bioheat fuel at state facilities. All information related to the pilot program was obtained through interviews with those directly responsible for managing or implementing pilot activities at state facilities.

BIOHEAT BASICS

Bioheat fuel is the name given to any blend of conventional, petroleum-based home heating oil and pure biodiesel, an alternative fuel produced through the chemical transformation of vegetable oils and animal fats. In other words, it is the space-heating equivalent of transportation biofuels, which are blends of biodiesel and conventional petroleum-based diesel fuels. Biodiesel blends are identified by their volume relative to the conventional fuel. Thus, B100 is the term used for pure biodiesel, while B3 bioheat fuel describes a blend of three percent biodiesel and 97 percent conventional heating oil.

Bioheat fuel offers several advantages over traditional fuel oil.

- **Contributes to energy security and economic development.** As domestically produced bioheat fuel further penetrates the market for heating fuels (in parallel with the growth of biodiesels as transportation fuels), it will add security to the nation's energy supply and provide new, potentially valuable outlets for the nation's agricultural products.

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[1] Climatically, the 2006-2007 heating season did not present unusual conditions that might affect an evaluation of the bioheat fuel pilot. When asked to compare the 2006-2007 season to past years, approximately half of the pilot site contacts characterized the 2006-2007 heating season as warmer than usual through December, but colder than usual in January and February, resulting in typical fuel usage for the season. The remaining contacts characterized the winter as slightly milder, resulting in slightly lower than normal fuel usage.

- **Reduces greenhouse gas emissions.** If the agricultural feedstock is grown and harvested sustainably, thereby maximizing the feedstock's carbon storage potential, combustion of bioheat fuel can result in little to no net emissions of carbon dioxide.
- **Delivers other environmental benefits.** Compared to conventional heating oils, bioheat fuel is cleaner burning. Laboratory studies and field trials conducted over the past decade in heating applications have documented reduced nitrogen oxide (NOx),[2] sulfur oxide, carbon dioxide, and particulate emissions, as well as lower smoke and odor production.

Several potential concerns associated with bioheat fuel are worth noting, though none appear to be significant obstacles to its wider adoption. In fact, with the exception of some sensitivity to the potential cost premium, none of the following concerns were experienced during the pilot.

- **Stability and cold weather performance.** If properly blended, biodiesel will go into solution with heating oil and will not separate. Cold weather conditions can affect the performance of bioheat fuel. Higher percentage blends (i.e., above B20) have a tendency to crystallize, and then gel, as the ambient temperature goes down, affecting their ability to flow properly. These cold flow issues are less significant at or below a B20 blend (they may appear at temperatures 2-5 degrees warmer than they would with conventional heating oil). Since bioheat fuel is generally no more than B20, standard precautions associated with conventional heating oil, such as blending with kerosene or the use of cold weather additives such as 'Arctic Express,' can be used to maintain proper flow characteristics.
- **Clogging of burner components.** Biodiesel acts as a cleaning agent in the fuel tank and thus can dissolve or loosen accumulated sediments, which might then become deposited in components such as filters, strainers, and nozzles. Higher blends will have a greater cleaning effect. Field tests demonstrate that blends up to B20 have the potential to result in fewer incidences of clogging once the older, accumulated deposits have been removed, since the bioheat fuel burns more cleanly and leaves less residue.
- **Compatibility with tanks and components.** According to the National Biodiesel Board, all known tanks and systems, including gaskets, seals, hoses, and O-rings, are compatible (i.e., will not be adversely affected by) bioheat fuel blends of up to 20 percent biodiesel (B20). However, given the lack of long-term experience with the fuel, oil burner manufacturers are generally not yet providing formal positions with respect to bioheat fuel and equipment warranties.

[2] Although there are some indications that NOx emissions can be a problem in vehicles using biodiesel blends over B20, we are not currently aware of any documentation describing a similar issue related to stationary sources (such as boilers).

- **Cost.** In general, bioheat fuel costs in current markets are higher than the cost of conventional heating oil, with the scale of the premium dependent on the blend. The National Biodiesel Board reports an increase of 3-5 cents per gallon for B3 and an increase of 20-30 cents per gallon for B20.

THE MASSACHUSETTS BIOHEAT FUEL PILOT PROGRAM

To implement the A&F-mandated pilot program, EOEEA reviewed the statewide contract usage of #2 heating oil, as provided by the Operational Services Division. In addition, the Massachusetts Department of Environmental Protection (Mass DEP) and the Division of Capital Asset Management (DCAM) reviewed their databases of state facilities to identify details on the oil-burning heating equipment in use. Based on this aggregated information, EOEEA issued a call for volunteers among a sample that covered a range of boiler and tank types and sizes. Four state entities volunteered to participate in the pilot: the Bay State Correctional Center (Bay State), Salem State College (Salem), Taunton State Hospital (Taunton), and the University of Massachusetts (UMass), which agreed to participate at several locations within its system. Thirteen boilers, spread across the four state entities, participated in the pilot. The specific sites were somewhat constrained by availability of bioheat fuel from vendors on the statewide #2 heating oil contract (ENE 22) which lead to most host sites being selected in state fuel delivery zones 2 and 3 (the northeast and southeast regions). Table 1 lists all of the locations that served as pilot sites.

TABLE 1 PILOT PROJECT LOCATIONS

AGENCY	LOCATION	SPECIFIC SITE(S)
Department of Correction	Bay State Correctional Center	
Board of Higher Education	Salem State College	South Campus
Department of Mental Health	Taunton State Hospital	
University of Massachusetts, Amherst[3]	Amherst Campus	Bowditch Lodge Farley Lodge Hadley Horse Farm Nelson House Tillson Farm House
	Belchertown	Cold Spring Orchard

The Division of Energy Resources (DOER) provided each of the pilot sites with a suggested operations and maintenance protocol, with a focus on system start-up (given that research has shown no need to alter operational procedures for blends less than or

[3] UMass Amherst initially included their Wareham, MA Cranberry Research Station as a pilot location. However, due to the delivery fees quoted to this particular site and concerns about availability of the bioheat fuel, this facility elected not to participate in the pilot program.

equal to five percent biodiesel and that the pilot program's objective was to test B3 fuel). Specifically, DOER recommended a comprehensive cleanout and tune-up in advance of the heating season. In addition, DOER requested that each site maintain fuel delivery and boiler service records during the heating season.

INTERVIEW METHODOLOGY

In-person and phone interviews with the participating pilot program sites (both agency and site contacts) and their fuel suppliers were conducted in late May and early June 2007.[4] An in-person interview was conducted with the agency contact at Taunton, while phone interviews were conducted with the other agency contacts (Bay State, Salem, and UMass), as well as with the sustainability coordinator at Salem. In-person interviews were conducted with the site contacts at Bay State, Salem, and Taunton and at the UMass Amherst campus. Phone interviews were conducted with the site contacts at Belchertown and Wareham. Finally, phone interviews were conducted with each of the two fuel suppliers (Alliance Energy and Burke Oil). Agency and site interviews were guided by separate questionnaires developed in advance (see Appendix A). A separate set of questions was also prepared for the interviews with fuel vendors. Each interview did not necessarily cover all questions, as the respondents' answers in some cases made specific follow-up questions unnecessary. In addition, boiler photographs were taken or provided at each of the sites that were visited (see Appendix B).

Table 2 provides a description of the 13 boilers included in the pilot program, as well as information regarding the tank location, bioheat fuel blend, and vendor at each site.

INTERVIEW FINDINGS

The purpose of conducting the agency, site, and supplier interviews was to document the results of the pilot program and to identify any specific information (including challenges or obstacles) that will be useful to convey to other state agencies planning for or considering the use of bioheat fuel. The interviews covered a range of topics, including boiler preparation, fuel delivery and storage, operations and maintenance, and post-operation performance reviews.

Interviews revealed that, to date, the concerns most commonly associated with bioheat fuel (related to preparation, storage, and operations and maintenance) were not factors during implementation of the pilot program. Boiler cleaning at the close of the heating season revealed that the bioheat fuel did not have any negative impact on the equipment and that it generally resulted in a cleaner system than would have resulted had the boiler burned traditional fuel oil. However, there were instances of fuel delivery problems, as described below.

[4] The agency contact was the person at the state agency responsible for overseeing the boiler operator, as well as general building operations. The site contact was defined as the person directly responsible for the boiler operation, i.e., overseeing fueling and maintenance operations.

TABLE 2 PILOT PROJECT BOILERS

SITE		BOILER DESCRIPTION	TANK LOCATION	BIOHEAT BLEND	VENDOR
Bay State		Two 1988 Brooks Series 100 2,193,000 Btu One Ajax Boiler 840,000 Btu	In-ground	B3	Burke
Salem		1987 Brooks 5,230,000 Btu	In-ground	B3	Burke
Taunton		1992 Brooks 20,922,000 Btu	Inside - heated	B3, B5, B10	Burke
UMass Amherst	Bowditch	HB Smith 367,000 Btu	Inside - heated	B3	Alliance
	Farley	HB Smith 367,000 Btu	Inside - heated	B3	Alliance
	Hadley Horse Farm	Buderus	Inside - heated	B3	Alliance
	Nelson House	ThermoPride	Inside - heated	B3	Alliance
	Tillson Farm Cold	ThermoPride	Inside - heated	B3	Alliance
UMass Belchertown	Cold Spring Apple Barn	American Std	Inside - unheated	B3	Alliance
	Chandler Lab	Unknown	Shed	B3	Alliance
	Cold Spring Farmhouse	Mills	Inside - heated	B3	Alliance

PREPARATION

Prior to implementation of the pilot, pilot sites needed to notify employees of the upcoming switch in fuel, and some sites also opted to thoroughly clean their boilers.

Agency and site contacts, as well as other agency employees involved in boiler operation and maintenance, expressed optimism as well as some concerns prior to initial bioheat fuel use. Some expressed concerns that bioheat fuel deliveries might not be as timely as conventional fuel deliveries and that their site might run out of fuel; that the bioheat fuel could cause equipment damage; that the use of bioheat fuel might degrade boiler performance; that cold weather might cause the bioheat fuel to gel; that fuel lines and filters might become clogged; that "gunk" could build-up in the boilers; or that fuel tanks might get scarred. Positive expectations included the potential for higher boiler performance, which could result in fewer maintenance issues and/or less required cleaning; the potential to prolong the life of the boiler; the potential to save money because bioheat fuel burns more efficiently; and the potential to realize environmental benefits through use of a cleaner fuel.

Preparatory measures taken in advance of the use of bioheat fuel varied amongst facilities. The protocol suggested by DOER is included as Appendix C. No site reported trouble with the EOEEA systems start-up protocol. In fact, agency and site contacts recommended that all units be cleaned and prepped, as per protocol instructions, prior to the use of bioheat fuel in a boiler. In one instance, following the guidelines resulted in the diagnosis of a problem that otherwise would not have been caught, which was advantageous to the agency. The DOER protocol for minimizing dilution of the fuel also worked well, although due to the importance of fuel availability, not all sites were able to drain their tanks to the extent recommended. Agency and site contacts that were able to drain their tanks as recommended, recommended that other sites engage in similar procedures in order to "give biofuel a fair chance" and adequately assess the advantages and disadvantages of the fuel.

KEY FINDINGS: PREPARATION

- Follow normal equipment maintenance recommendations
- No additional preparation needed for bioheat fuel relative to traditional fuel oil

FUEL DELIVERY

Since bioheat fuel is a mixture of biodiesel and traditional fuel oil, blending is required. Fuel provided to pilot participants was blended prior to arrival at the host site. Splash blending is the typical method of blending employed in Massachusetts and is accomplished by adding pure biodiesel to conventional fuel already in the delivery truck tank. This typically requires two stops: one to pick up the conventional fuel, and a second to add the biodiesel. It is anticipated that in the future blending will occur at the wholesale pick-up site rather than in the truck tank itself.

Bioheat fuel availability and the reliability of fuel deliveries was an issue highlighted by several interviewees, in large part based on problems encountered at some locations. Generally speaking, contacts noted the obvious importance of knowing that deliveries will arrive as expected. To ensure a smooth transition, contacts also noted the importance of ensuring that vendors know where fuel tanks are located and that a contingency plan is in place should a delivery fail to occur as scheduled or requested. Vendors echoed these suggestions, noting the time needed to make the extra fueling stop and the need for customers to provide sufficient notice of their delivery requirements.

During the pilot, however, there were two instances of delivery problems that are worth noting. One site with a relatively small tank was unable to get a delivery of bioheat fuel on at least one Friday and never on weekends, necessitating a delivery of conventional heating oil to last through a very cold weekend. The site contact expressed optimism,

however, that increased demand for bioheat fuel would make weekend deliveries routine. At the same time, the site contact described a general concern expressed by the vendor that bioheat fuel deliveries on the coldest days of the year could result in the fuel "chunking up" on the way to the site. Although this was expressed as a concern, it is important to note that it never occurred, even on cold days in February. Furthermore, the general experience with bioheat fuels suggests that, at least for blends less than or equal to B20, cold weather should not necessitate delivery practices that are substantially different from those employed with conventional heating oil.

The second reported delivery problem occurred at Wareham. As discussed above, Wareham elected not to use bioheat fuel because of the increased cost and the uncertainty regarding delivery reliability.

Given the Executive Order mandate to increase bioheat fuel use among state agencies, the future availability of supply on a larger scale was explored directly with the two pilot program vendors. Two very different responses were received. One vendor indicated that meeting demand would not be a problem even if all state agencies switched to bioheat fuel. The second vendor held the opposite view, expressing concerns about the possibility that availability and quality might decline and prices might increase as demand goes up.

KEY FINDINGS: FUEL DELIVERY

- Delivery problems arose due to customer location and the relatively small delivery volumes
- No "gelling" occurred during cold weather

STORAGE

No issues with bioheat fuel storage were reported. The locations of the sites' storage tanks are noted in Table 2. Two tanks were in-ground and outside, two tanks were above-ground inside unheated buildings, and seven were above-ground inside heated buildings.

KEY FINDINGS: STORAGE

- No reported issues associated with bioheat fuel storage

OPERATIONS AND MAINTENANCE

No operational issues associated with use of the bioheat fuel were identified at any of the pilot sites. In fact, contacts reported no significant difference between bioheat fuel and conventional fuel oil in terms of day-to-day controls and operation. Two sites reported that their stack appeared to be cleaner, and one site reported that bioheat fuel use resulted in less boiler exhaust odor.

Despite the small cost premium that currently exists for bioheat fuel, site contacts recognized that its use can result in a long-term heating cost reduction. Bioheat fuel burns more cleanly than conventional fuel oil, which results in less soot build-up in the boiler. Since soot acts as an insulator, less soot means more efficient heat transfer in the boiler and a lower rate of fuel consumption. Site contacts did note, however, the importance of taking the marginal increase in the unit cost of fuel into account when budgeting heating expenditures.

No maintenance issues resulting in increased expenditures of time or money were identified at any of the sites. Contacts did not report any noticeable differences in wear and tear, any problems with hoses, gaskets, or filters, or any service calls attributable to bioheat fuel use.

Sites reported that mid-season boiler cleaning was generally less intense with the bioheat fuel, relative to conventional fuel oil. At one site, the engineer previously had cleaned the guns every couple of days when using conventional fuel oil, but barely needed to clean the guns more than once per week with the bioheat fuel. The same site reported fewer overall boiler issues when heating with the bioheat fuel, compared to previous seasons during which the site had used conventional fuels.

KEY FINDINGS: OPERATIONS AND MAINTENANCE

- No significant difference between bioheat fuel and conventional fuel oil in terms of day-to-day controls and operation
- Reduced wear and tear on equipment may provide a maintenance benefit

POST-OPERATION

The end of the year cleaning yields important information about the effect bioheat fuel may or may not have had on heating system components. Increased wear and tear would cost operators more money in parts and labor, whereas less wear and tear would save money and time, and could also prolong the life of the system. Furthermore, cleaning the boilers requires time. Since bioheat fuel is known to burn more cleanly, the boilers should require less intense cleaning, potentially saving agency resources. The following summary descriptions were provided by boiler operators at the pilot locations after they had completed their end-of-season cleaning.

Bay State Correctional Center

The cleaning at Bay State revealed that the boiler components were much cleaner than in any previous year to date. The wear and tear was found to be normal. Furthermore, the facility did not need to change the fuel nozzles, which they have in some past years, which could signify that the fuel was burning cleaner.

Salem State College

At the end of the heating season, the Salem State boiler tubes were observed to be "fairly clean, not much soot." The main fire box looked to have a red coloration on the shell and some condensation. Overall, however, the boiler contained less soot in comparison to previous summer cleanings.

Taunton State Hospital

Cleaning of the Taunton boilers, which were fueled with B3, B5 and B10 blends, revealed no adverse effects associated with bioheat fuel. In fact, the cleaning and general maintenance revealed several benefits of using bioheat fuel. Specifically, no noticeable leaks or deterioration of seals or gaskets was found, the strainers were found to have a nominal amount of material trapped in them given the quantity of fuel passed through, and the gun itself was much cleaner than when straight #2 fuel had been run through (see photos below). In addition, there was no excessive buildup on the boiler itself, and the buildup that was there was easily removed. Finally, stack efficiency tests showed greater efficiency when using bioheat fuel versus gas.

Taunton boiler "gun nozzle" after operation with B5 bioheat fuel blend, before cleaning

Taunton boiler "gun nozzle" after operation with #2 fuel oil, before cleaning

UMass Amherst Campus

Cleaning of two of the five boilers at the UMass, Amherst campus revealed no problems attributable to using the bioheat fuel. The filters in both machines were clean, neither of the nozzles were excessively dirty or needed replacement, and the chambers were both very clean.

SUMMARY OF FINDINGS

Interviews with the agency and site contacts, as well as results of the cleanings, indicate that overall the pilot went smoothly. There were two delivery problems, but the bioheat fuel worked well in the boilers. Contacts indicated that the switch to bioheat fuel was a "seamless transition," and that it's a "real win-win, for both the life of the boiler, and for the environment." As noted by one contact who had experienced no problems with the fuel, "the fact that the fuel was a non-issue is in itself worth noting."

Pilot participants were asked whether they would recommend the bioheat fuel to others, and if they would be willing to try a higher blend. All of the participants interviewed (11 of 11) indicated that they would recommend the fuel to others and would be willing to use a fuel with a higher percentage of biodiesel, though one respondent expressed a willingness to use only up to a B5 blend. Several contacts asked why the pilot only required the use of B3, noting that B3 was a very low percentage.

RECOMMENDATIONS

Agency and site contacts were able to make several key recommendations for future bioheat fuel use:

- Regularly clean boiler equipment (at least once per year);
- Follow recommended maintenance procedures, similar to those outlined in the DOER start-up protocol;
- Monitor the boiler before the switch to bioheat fuel, and record any differences noticed thereafter;
- Work closely with the vendor to ensure proper delivery; and
- Storage tanks subject to temperature fluctuations (due to an outside location, for example) may need additives to protect against gelling.

A list of agency and site contacts is provided in Appendix D. All contacts indicated that they would be happy to answer questions and generally serve as a resource for others planning or considering the use of bioheat fuel.

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APPENDIX A: BIOHEAT INTERVIEW QUESTIONNAIRES

Bioheat Interview Instrument for Agency Contacts

Thanks again for making time for this conversation. We want to get the full story, including any ups and downs, since beginning this winter all state buildings using #2 heating oil will be using bioheat by executive order. So, you are one of the pioneers, and managers at other state facilities will definitely benefit from your experience.

1. Based on your experience with the pilot, what tasks will your counterparts in other agencies need to carry out in order to get bioheat into use in their facilities?

2. [If not addressed] What triggers the notification requirement to DEP regarding fuel switching?

3. What was easier about the whole process than you expected?

4. What was more challenging than you expected?

5. What advice would you have for other managers in dealing with the challenging aspects of beginning to use bioheat?

6. From your perspective, how did the #2 bioheat perform?

7. Did [site contact] bring any problems to your attention? (If yes, what were they?)

8. Were there any differences in how the boilers were operated or maintained with the bioheat?

9. Did you get any feedback from your "customers" (positive or negative), or was the pilot more or less invisible to building occupants?

10. So, overall, in terms of impacts on your daily operations, it sounds like [summarize based on answers to questions 6-9]. Is that correct?

11. [If not mentioned previously] Was this fuel an improvement over your regular heating oil in any way? (If so, how?)

12. How satisfied were you with this heating oil?

13. Was there anything you worried about when you volunteered [location] to be a pilot site for this fuel? [If yes, confirm whether concern turned out to be a problem.]

14. Was there anything your staff worried about when you told them that [location] was going to be a pilot site for this fuel? [If yes, confirm whether concern turned out to be a problem.]

15. Is there anything else about using this fuel that it would be important for your counterpart in another agency to know about?

16. Would you recommend this fuel to other people?

17. If a manager at another state agency wanted to talk with you directly about using #2 bioheat, would you be willing to answer their questions?

18. Would you be willing to try a higher blend of bioheat in your boilers to see how that worked?

19. Anything else you'd like me to know or that you think would be important for other state personnel to know? (i.e., one last open response opportunity)

Thank you for going over this with me. This information will be really helpful for others who are going to be using this fuel. My goal is not to take up any more of your time, but if I find I've missed anything that EOEA or DOER or DCAM wants to know about, may I give you a call?

Bioheat Interview Instrument for Site Contacts

Thanks again for making time for this meeting [conversation]. We want to get the full story, including any ups and downs, since beginning this winter all state buildings heating with #2 fuel will be using bioheat by executive order. So, you are one of the pioneers, and buildings staff at other state facilities will definitely benefit from people like you having tested out these fuels.

1. First, I want to make sure I have accurate information on each of the boilers you used. [If there is any information they don't know off the top of their head, we will get it from DCAM later.]

Location	
Boiler Size (heat output)	
Boiler Manufacturer	
Year of Manufacture	
Bioheat Blend Used	B3___ B5___
Fuel Vendor	Burke Oils ____ Alliance Energy ___
Description of the Space(s) Being Heated	
Any special climate requirements in these spaces?	

2. How did the #2 bioheat work out? [Use this question to get a quick general impression, then work methodically through the specific issues (i.e., avoid having the conversation jump around to whatever the interviewee wants to talk about)]

3. Were there any problems with filters?

4. Were there any problems with hoses or gaskets?

5. Were there any problems with cold storage or cold flow? Any delivery problems?

6. Did you have to make any adjustments to your burners when you were using the bioheat?

7. Were there any other differences in how you operated or maintained your boilers with the bioheat?

8. Were there any problems with burner shut off?

9. At the end of the season, did you notice any difference in the condition of your burners (wear and tear) compared with other seasons?

10. So, overall, in terms of impacts on your daily operations, it sounds like [summarize based on answers to questions 2-9]. Is that correct?

11. [If there were discernable impacts] Do these impacts mean any significant changes in the amount of time spent on routine operations and maintenance?

12. Did you get any feedback from your "customers" (positive or negative), or was the pilot more or less invisible to building occupants?

13. How normal was this heating season, temperature-wise? (warmer? cooler?)

14. How did DOER's recommendations work out for minimizing dilution of the #2 bioheat when you got your first delivery? [provide text to interviewee to review if necessary, or summarize content over the phone]

15. How about DOER's recommended system start-up protocol? How doable was that? [provide text to interviewee to review if necessary or list content over the phone]

16. Did the start-up protocol properly set things up to conduct the pilot?

17. [If not mentioned previously] Was this fuel an improvement over your regular heating oil in any way? (If so, how?)

18. How satisfied were you with this heating oil?

19. Was there anything you worried about when you heard that [location] was going to be a pilot site for this fuel? [If yes, confirm whether concern turned out to be a problem.]

20. Is there anything else about using this fuel that it would important for another engineer to know about?

21. Would you recommend this fuel to other people?

22. If an engineer at another state agency wanted to talk with you directly about using #2 bioheat, would you be willing to answer their questions?

23. Would you be willing to try a higher blend of bioheat in your boilers to see how that worked?

24. Anything else you'd like me to know or that you think would be important for other state personnel to know? (i.e., one last open response opportunity)

Thank you for going over this with me. This information will be really helpful for others who are going to be using this fuel. My goal is not to take up any more of your time, but if I find I've missed anything that EOEA or DOER or DCAM wants to know about, may I give you a call?

Bioheat Interview Instrument for Fuel Supply Contacts

1. How did the pilot go, from your perspective?

2. What were the biggest challenges that the bioheat pilot presented, from your perspective?

3. What aspects of the pilot went more smoothly than you expected?

4. What feedback did you get from your customers about how the biofuel blends performed?

5. What feedback did you get from your customers about fuel delivery?

6. What advice would you have for engineers who are going to be using bioheat, to help you meet their supply needs?

7. What were the delivery times available to bioheat customers during the pilot?

8. What do you see as the potential for expanding delivery times if more state agencies are using biofuel blends? [if necessary, probe on expanded delivery hours, greater feasibility to deliver small amounts on Fridays to buffer weekend use; weekend deliveries] Be assured that we won't quote you in the report on this. We will likely make a generic statement about what might be possible given an increase in the number of state agencies using biofuel.

9. Do have any general thoughts about ability of the market to scale up sufficiently to meet the demand by state agencies?

10. Do you have any other recommendations for state agencies using biodiesel blends?

11. How about recommendations for EOEA or DOER that will help ensure that state agencies will be able to get biofuel when they need it?

12. Did you use splash or in-tank blending for the pilot sites?

13. Anything else you'd like me to know or that you think would be important for other state personnel to know? (i.e., one last open response opportunity)

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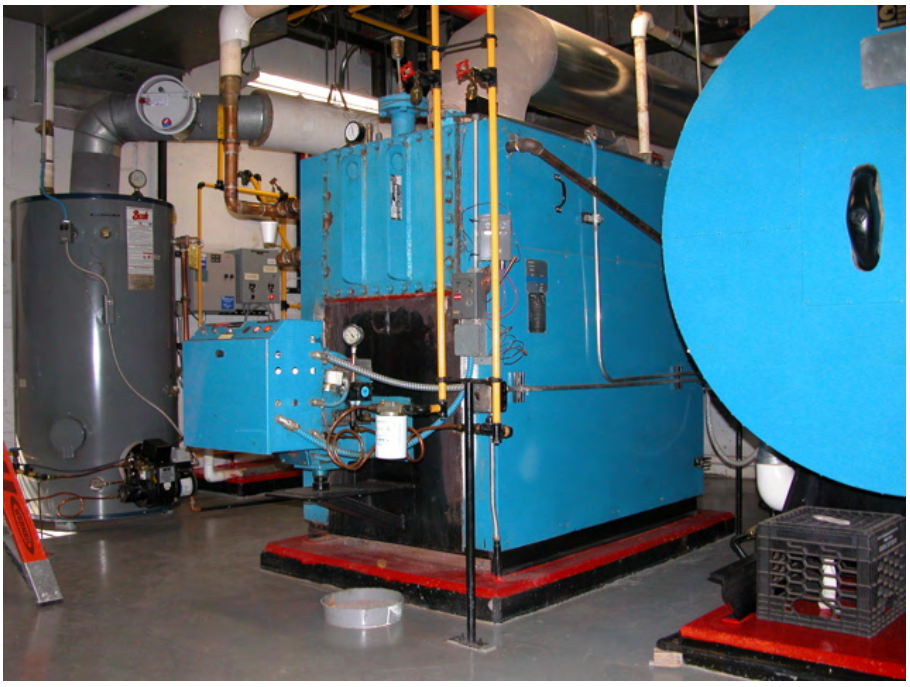
APPENDIX B: BOILER PHOTOGRAPHS

BAY STATE - APEX



BAY STATE - BROOKS

SALEM

TAUNTON

UMASS, AMHERST - BOWDITCH

UMASS, AMHERST - FARLEY

UMASS, AMHERST - HADLEY

UMASS, AMHERST - NELSON

UMASS, AMHERST - TILLSON

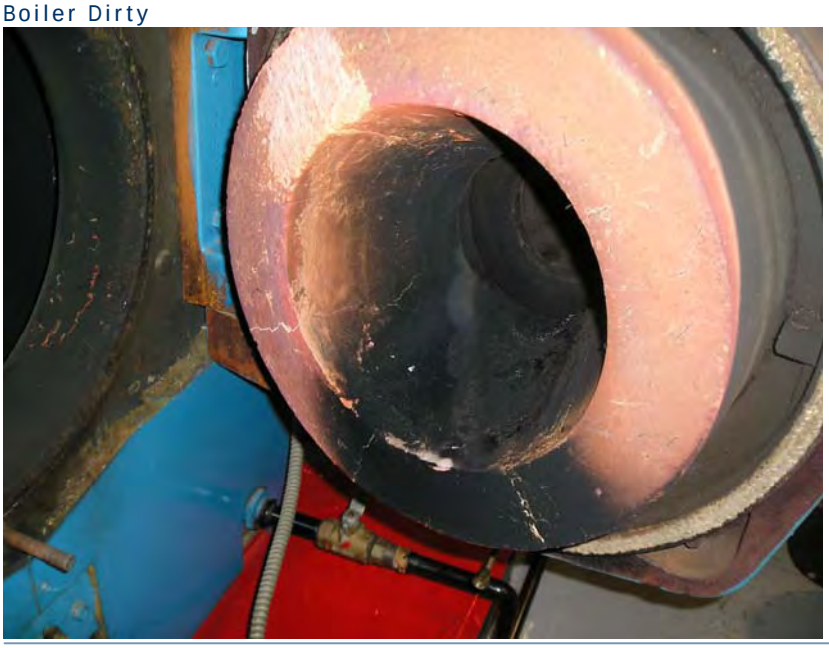
UMASS, BELCHERTOWN - COLD SPRING APPLE BARN

BAY STATE BOILERS POST-CLEANING

The following are pictures of Bay State boiler components, taken at the end of the pilot program heating season. No pictures were taken at the start of the heating season, but since Bay State used two identical boilers in the pilot it was able to simulate a "before-after" comparision by removing components from each of the two identical boilers used in the pilot and cleaning the components from one of them. Pictures of components from the boiler whose parts were cleaned simulate what the boiler components would have looked like before the use of bioheat fuel.

Boiler Clean

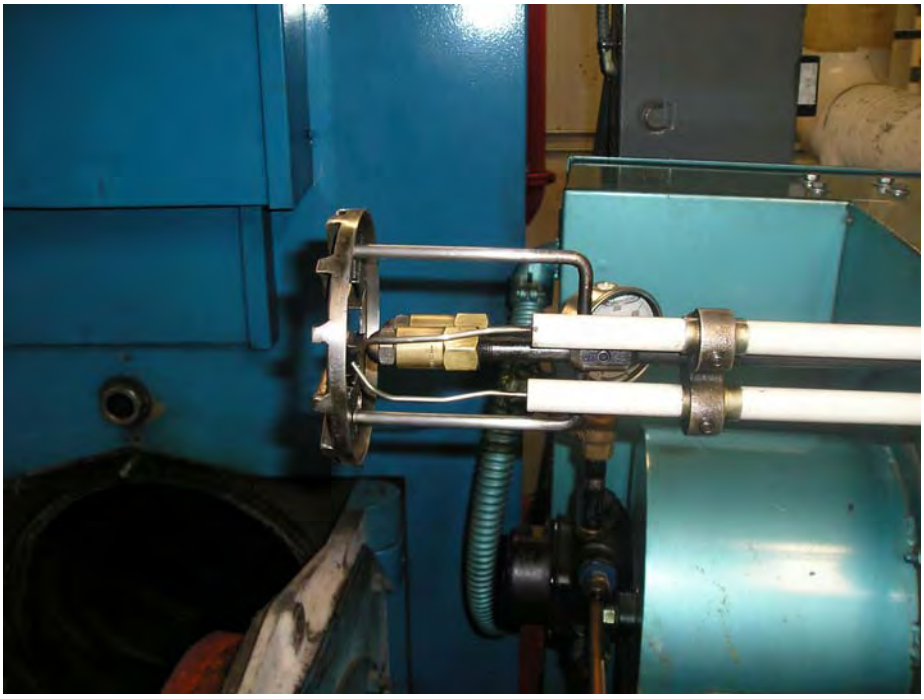
Boiler Dirty



Chamber Clean

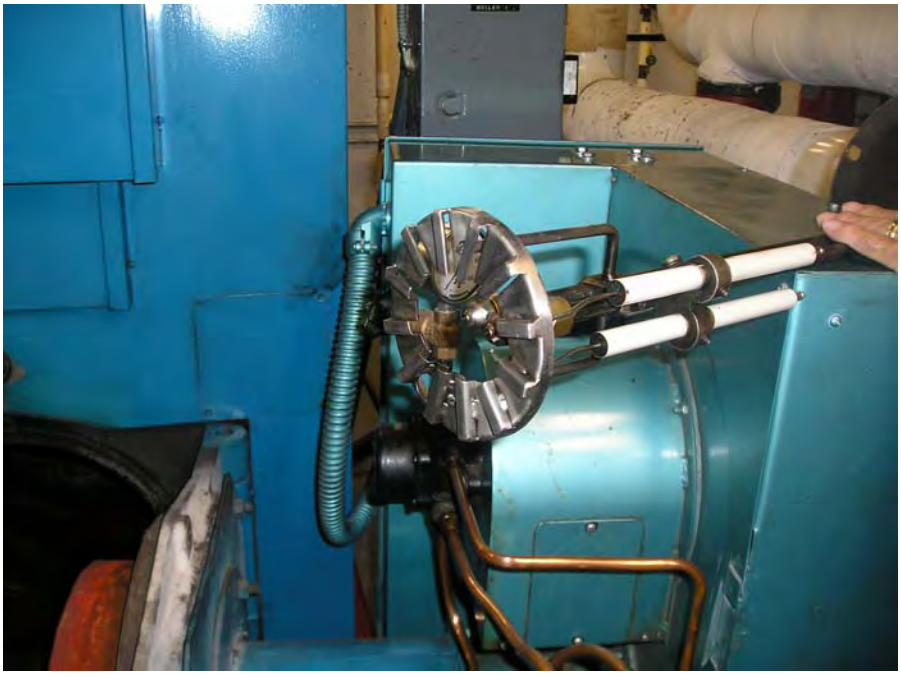
Chamber Dirty

Electrode Clean



Electrode Dirty

Nozzle Ladder Clean



Nozzle Ladder Dirty

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APPENDIX C: BIODIESEL HEATING PILOT TEST PROTOCOLS

In response to A&F Bulletin 13, "Establishment of Minimum Requirements for Bio-Fuel Usage in State Vehicles and Buildings by Executive Agencies,[1]" the Division of Energy Resources, Executive Office of Environmental Affairs, Division of Capital Asset Management and Department of Environmental Protection have developed a list of suggested protocols for facilities that participate in the Bioheat Operations & Maintenance Pilot Test during the 2006 heating season.

Low level biodiesel heating oil blends such as B3 or B5[2] (and up to B20) can be substituted for conventional No. 2 oil with no change in equipment or operating practices required. However, to establish the data and information needed for the purposes of this Pilot Test, it is requested that participants take steps to monitor system performance before and during the heating season. These steps should not present a significant burden to a responsible oilheat combustion system maintenance program and should present only a modest commitment of time and resources.

DOER expects the use of bioheat to result in positive boiler performance. Biodiesel heating oil tests have demonstrated a number of benefits including emissions reductions in nitrogen oxide, sulfur oxide, and carbon dioxide, improved odor, and cleaner combustion. Research has shown that low blend levels up to 5% biodiesel require no operational changes – simply pour and proceed as usual.

DOER requests that participants commit to the following tests and observations and report them to DOER, which will document the results of the pilot program and share them with collaborating agencies. This will provide valuable information on the costs and benefits of biofuel use and will be essential for DOER and partner agencies to establish the agency-wide bioheat program in following years.

Issues of Potential Concern:

1) **Filter Clogging** – At blend levels above B20, biodiesel has a solvent effect that may release deposits accumulated on tank walls and pipes from previous No.2 fuel storage. The release of deposits may clog filters initially and precautions should be taken. *However, there is no evidence that lower blend levels such as B3 and B5 cause filter plugging*.

2) **Gasket and Rubber Compatibility** – B100 may degrade some hoses, gaskets, seals elastomers, glues and plastics with prolonged exposure. Natural or nitrile rubber compounds, polypropylene, polyvinyl, and Tygon materials are particularly vulnerable. Teflon, Viton, and Nylon have very little reaction to

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[1] See section III "Biodiesel in State #2 heating oil applications**"**
http://www.mass.gov/eoaf/docs/administrativebulletin13.doc

[2] B3 refers to a blend of 97% No.2 oil and 3% neat biodiesel; B5 is 95% No.2 and 5% neat biodiesel.

biodiesel and are among the materials that can be used to update incompatible equipment. *Biodiesel blends of 20% or less have shown a much smaller effect on these materials. The effects are virtually non-existent in low-level blends such as B5. When handling blends of B20 or less normal monitoring of gaskets and seals for leaks is sufficient.*

3) **Cold Storage and Cold Flow** – Pure biodiesel will gel in very cold temperatures, just as the common No.2 does. Although pure biodiesel has a higher cloud point than No.2 fuel, B20 blends use the same fuel management techniques as No.2. *When using blends of B20 or lower, the cold weather performance of the blend is mostly determined by the diesel fuel portion. Blends lower than B20 (i.e. B5 or B2) have little or no affect on cold flow properties.*

4) **Burner Shutoff** – The burner's safety control is integrated with a cadmium-sulfide (cad) cell that is used to shut off fuel flow if the flame goes out. The cad cell is optimized for No.2 diesel, which has a yellowish flame. Because B100 biodiesel burns so cleanly, the cad cell may not see the flame and shut off the fuel. *This problem has been reported with tests using neat biodiesel, but is not a concern with low blend levels such as B5.*

Operations and Maintenance Protocol

Note: *To minimize the biodiesel blend dilution, we suggest that pilot participants wait until the fuel storage tank is no more than 1/3 full of No.2 oil before filling up with the biodiesel blend. Alternatively, if the quantity of fuel remaining in the tank is known, the facility can coordinate with the fuel delivery company to supply an appropriate blend of biodiesel to meet the B3-B5 target blend. For example, a 1,000 gallon storage tank half-full with No.2, could be topped off with 500 gallons of B10 (50 gallons of pure biodiesel, 450 gallons of No.2) to give a final blend of B5. We also request that participants photograph nozzle, electrodes and heat exchange surfaces before and after the pilot test.*

We recommend that the oil combustion system undergo an annual cleanout and tune-up in advance of the heating season, conducted by qualified boiler service technicians. This may include the following:

System Start-up

A. Visual inspection of oil burner (nozzle, electrodes), boiler, combustion chamber, heat exchange surfaces, fuel delivery system (pumps, pipes, valves, filters and controls), and flue/stack.

B. Photograph nozzle, electrodes and heat exchange surfaces before pilot test.

C. Cleaning of flue, heat exchange surfaces, combustion area, nozzles and filters.

D. Replace worn components as necessary.

E. Lubricate motors, pumps and bearings.

F. Test, clean and maintain safety and auxiliary controls – ensure complete interruption of burner operation (low-water fuel cut-outs), check automatic feed valves, clean float chambers, check water level.

G. Check boiler efficiency and conduct combustion tests for: Flue Temperature, Carbon Monoxide, Smoke Number, and Sulfur Dioxide. Adjust air and fuel flow based on the results of the efficiency testing and fuel pressure measurement.

Throughout the Heating Season

A. Maintain fuel delivery record

B. Maintain boiler service record

C. Retain 300mL (10 oz.) fuel sample monthly[3]

D. Check nozzles and filters as needed (have replacement filter on hand!)

End of Heating Season

A. Share fuel delivery and boiler service record with DOER

B. Photograph nozzle, electrodes and heat exchange surfaces after pilot test

C. Participate in state biodiesel outreach efforts

[3] DOER will arrange for independent laboratory analysis to verify blend levels and key ASTM standard criteria. Lexan bottles and shipping materials will be provided to facilities.

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APPENDIX D: CONTACT INFORMATION

PILOT LOCATIONS

LOCATION	AGENCY CONTACT	SITE CONTACT
Bay State Correctional Center	Andy Bakinowski (508) 541-5301 x15 Andrew.Bakinowski@state.ma.us	Wayne Whisler 508-668-1687 x128 Wayne.Whisler@state.ma.us
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Taunton State Hospital	Ken Lortie (617) 626-8049 Ken.Lortie@dmh.state.ma.us	James Condon (508) 977-3240 James.Condon@dmh.state.ma.us
UMass, Amherst	Craig Ruberti (413) 545-5119 cruberti@ehs.umass.edu	Phil Lambert (413) 545-0073 plambert@admin.umass.edu
UMass, Belchertown	Craig Ruberti (413) 545-5119 cruberti@ehs.umass.edu	Joe Sincuk 413-323-6647

STATE GOVERNMENT

OFFICE	CONTACT	
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Division of Capital Asset Management	Ed Nicosia Project Manager, Office of Facilities Management (617) 727-4030 x265 Edward.Nicosia@massmail.state.ma.us	
Division of Energy Resources	Jan Gudell Renewable Energy Project Coordinator (617) 727-4732 x40183 jan.gudell@massmail.state.ma.us	
Operational Services Division	Jim Ferri Procurement Manager - Energy (617) 720-3168 james.ferri@state.ma.us	