FY 2005 *FoodPAC* Final Report

Project Title: Combustion of Poultry Fat for Plant Heat and Steam

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EXECUTIVE SUMMARY

Presently, most chicken fat from poultry processing plants is sold to rendering facilities at very low prices. This method provides an easy way of handling disposal of the fat, but neglects the fact that animal fat can actually be a valuable byproduct of the food processing industry. The goal of this study was to examine the possibility of creating an in-house application for this by-product of the Georgia poultry processing industry while simultaneously reducing the need to purchase high-cost, outside energy by providing an alternative fuel produced on-site. The predicted result of this study was a reduction in overall costs associated with poultry production and reduced dependence on external energy sources.

The use of animal fat as an industrial boiler fuel has already been extensively documented by University of Georgia Engineering Outreach (Adams, et al., 2002). Rendered animal fats have been shown to be clean, efficient and effective fuels for such applications. This study sought to scale down this application and use poultry fat as a fuel for smaller scale boilers to provide heat or hot water within the facilities that process poultry and produce the fat itself. By eliminating the need for transportation and third party processing of the fat, a cost effective fuel was developed. Clean Burn, a leading manufacturer of recycled oil burning boilers, offered to donate a boiler for the study. These boilers are traditionally fueled with petroleum based waste oil such as crank case oil. This study showed that animal fats provided an effective fuel for the Clean Burn boiler. Emissions were also generally reduced when using biologically derived oils as compared to the emissions experienced when using oil types normally burned in Clean Burn furnaces and boilers.

Cagle's, Inc. Pine Mountain Valley, GA functioned as an industrial partner in this study. The particular operation we observed produces an estimated 22,000 lbs. of fat per day for which they desire a value-added application. Team members studied the recovery and use of their fat as a fuel for a Clean Burn boiler. In turn, Cagle’s provided fat containing byproduct for our study. The Athens, GA Pilgrim’s Pride poultry processing facility also provided byproduct which contained significant amounts of fat and offered advice, expertise and guidance during the study.

Multiple processes for extracting useable fat fuel from different by-products of poultry processing were examined. These included extracting low fat sources such as offal as well as fat rich materials such as leaf fat and saddle fat. Aerobic and anaerobic fermentations were studied for efficiency of extraction along with traditional thermal rendering techniques. It was determined that traditional thermal rendering processes provided the most simple, cost effective and efficient method of fat extraction from these sources.

A process was developed which Cagle's, Pilgrim’s Pride and similar poultry processing facilities can implement on-site to utilize their fat byproduct as a fuel. Fat was extracted and combusted in a small (350,000 btu/hr) industrial boiler. Twenty-five individual runs were executed using a variety of fuels during the study. Critical parameters such as fuel

consumption and efficiency, emissions and performance were tracked during each run. Financial feasibility of the process was determined to be dependent on both the current price of heating fuel and the value of the byproduct fat in other markets. Due to increasingly higher prices of petroleum based heating oils such as No. 2 Diesel and Kerosene, the economics of this process are even more viable at the present time than at the start of this project. Ultimately, results of this study suggest technical feasibility of such systems in the Georgia poultry processing industry. Additionally, the economic benefits of these systems will only continue to grow as the price of petroleum based energy sources continues to rise.

PROBLEM DEFINITION AND PROJECT GOALS

The intent of this study was to work with the Georgia poultry processing industry to develop a method of on-site utilization of chicken fat as an alternative heating fuel. Waste poultry fat is a plentiful commodity in Georgia. Although the fat has financial value, disposal is generally accomplished by sale to rendering facilities at undervalued prices. As a result of poultry processing, more than 44.6 million gallons of chicken fat, become available in Georgia each year. In its rendered, food grade state this material can be valued at up to $0.18/lb. ($1.33/gal). However, much of this fat ends up in waste streams and is sold to rendering facilities at $.03/lb ($.22/gal). The value of this poultry fat, based on the current market price for chicken fat sold into the food market, is $59.3 million. The equivalent in heating value to 44.6 million gallons of chicken fat is 39.9 million gallons of #2 diesel fuel. Assuming the current price of #2 diesel fuel is approximately $2.60/gallon this results in $103.8 million in offset fuel costs. Therefore, utilizing this chicken fat as a fuel could represent a price differential of up to $44.5 million for the Georgia poultry industry. Recent increases in petroleum prices have started a rise in fuel costs which shows little sign of disappearing; making this study even more relevant. Since the completion of another recent University of Georgia study (Adams, et al., 2002) which explored the use of animal fats as fuel for industrial boilers, several industries in Georgia have started purchasing rendered chicken fat as a less expensive replacement for #2 diesel fuel and natural gas.

It is logical that on-site rendering would reduce the cost of poultry fat based fuels for producers leading to additional fuel cost savings and the creation of a more efficient and environmentally friendly rendering process for poultry processing by-products. Other domestic meat processing facilities such as those in the beef industry already render onsite as do many non-US poultry processing facilities. Savings in transportation and overhead costs would both benefit the bottom line and reduce environmental impacts associated with transit of this material. Additionally, the proximity of the onsite facility would allow rapid rendering after collection of fatty materials from the waste stream of poultry production. This would lead to a higher quality fat for fuel use which would have reduced levels of free fatty acids and other decomposition products. Resulting fuels would have higher energy content, storability and oxidative stability.

Due to its relevance in utilization and value enhancement of a byproduct in an important Georgia food industry, this study directly addresses the ***Process and Product Improvement – Value Added Byproduct*** priority of ***FoodPAC*** as outlined in the FY2005 call for proposals. Not only does this study result in the production of a value added product in a Georgia food industry, it reduces the cost of this product by including means for its production at the same site it will be utilized.

The overall goal of this project was to develop a method by which a poultry processing facility could extract fat from their waste stream on site and utilize it in existing oil burning furnaces and/or boilers. Additional analysis of the product and its properties were also performed. The specific objectives of this study were:

1. Develop an effective method of fat recovery that poultry processing plant may accomplish from by-products on site: fuel preparation for combustion including pre-heating and filtering.

2. Develop efficient in-plant delivery of the fuel into the on-site boiler including pumping and selection of injection nozzles.

3. Examine the fuel characteristics of the prepared fat.

4. Demonstration of prepared poultry fat biofuel combustion in a Clean Burn boiler.

5. Determine legal limits on use of in-plant fat as alternative heating fuel.

6. Deliver plan for onsite utilization of poultry fat as a heating fuel at Cagle's, Inc. (Pine Mountain Valley, GA).

7. Publish results of this study and procedures for use of this biomass as an alternative fuel.

PROJECT SUMMARY AND FINDINGS

This project utilized UGA's extensive experience in the Biofuels field and facilities already existing in the UGA Biofuels Laboratory. Analytical and emissions detection equipment and expertise available at UGA were also utilized in this project. Donation of a 350 BTU/hr (Clean Burn Model #CB 350 CTB) waste oil burning boiler from Clean Burn (Leola, PA) was invaluable in conducting this study. Previous studies by the UGA Biofuels Team on large scale use of poultry fat in an industrial boiler provided a solid background for this project. Objectives (1-7) presented in the previous section were addressed as follows:

Objective 1: **Fat extraction** by several methods was examined during this project. Anaerobic and aerobic fermentations as well as direct heat rendering and autoclave methods were investigated. Additionally, several waste products were examined for fat content and viability for fuel applications. Offal (backdoor waste streams), leaf fat (fat from the upper part of the bird) and saddle fat (fat associated with the hind halves of the bird) were the three main products examined.

First, the feasibility of on-site fat extraction from Cagle's offal stream was examined. Successful separation of fuel quality fat from this stream would be a valuable upgrade to this by-product. Initial analysis of this material was achieved by a thermal rendering process. 150g of offal was heated in a beaker to 212^{o}F for one hour after which time fat melted and rose to the top of the beaker. Water in the system was vaporized and vented. The fat was poured off and filtered through a 400 mesh filter. Final material weights were calculated. It was determined that this material was composed of approximately 10.4% fat, 47.9% water and 41.7% solid residues.

Two fermenting extraction methods were also examined; aerobic fermentation using microorganisms inherent in the offal material and anaerobic fermentation using silage cultures. Aerobic fermentation was achieved by incubating offal at 82 ^{o}F for ten days without any inoculation. Anaerobic fermentation was achieved by mixing 5-6% wheat silage, 1-2% glucose and 90-93% offal in ~100g quantities. Two treatments were blended for 30 seconds in a food processor and two treatments were left unblended. These treatments were also incubated for ten days at 82 ^{o}F. At the end of the fermentation period, all treatments were autoclaved to kill any harmful microorganisms. The material was then chilled to 3 ^{o}C at which point fat solidified and was easily removed from the top of the digestion by scraping the congealed fat with a spatula. Fat yields averaged 5.8% for aerobic fermentations and 10.0 % for anaerobic fermentations. Blending had no significant effect on fat yields. As total fat in the offal used for the fermentations was taken from the top of the storage container it was determined that the material contained 21% fat, on average fermentation yields were able to recover 28% (aerobic) and 48% (anaerobic) of total fat in each treatment.

Fermentation proved to be a low energy input method for recovering fat from poultry plant offal. However, high volumes, long residence times and low yields prevent this method from being economically viable. Aerobic fermentation also has the disadvantage of producing a contaminated byproduct. Visual examination suggested that most of the separation had occurred after two days of incubation. Assuming two days residence time and 5% fat recovery (48% recovery of material containing 10.4% fat), anaerobic fermentation would require ~400 gallons of storage for every 1 gallon of fat collected. This fact and the challenges involved in recovering the fat from the digestion limit the feasibility of this process on-site in poultry processing plants.

Thermal processing of offal requires less total capacity than fermentation; however the low concentration of fat in offal would require the heating of massive amounts of material. Approximately 3.4 gallons of water would have to be removed for every 1 gallon of fat recovered. At 8092 btu/gallon of water vaporized, this would require 27,512 btu per gallon of fat recovered. Each gallon of fat provides approximately 124,780 btu resulting in net energy recovery of approximately 78%.

Leaf fat and saddle fat samples were obtained in 50lb quantities from Cagle's (leaf) and Pilgrim's Pride (saddle). These were pulled on the line at each facility for the expressed purpose of providing a high fat containing by-product for this study. Leaf fat is generally kept on the final product but it often falls off during processing ultimately ending up in offal. Saddle fat is also treated in a similar manner as it is desired that it remains attached to the end product. However, it too often ends up in the waste stream. This material is not 100% fat, but is much higher in fat content than offal. Thermal rendering process analysis showed leaf fat as delivered to be 75.25% fat, 8.74% water, and 14.58% other solids. As delivered, saddle fat was 43.43% fat, 29.53% water, and 27.05% solids. Only thermal rendering was examined for these highly concentrated fat source byproducts. 25-50lb. batches of these materials were heated to 212 ^{o}F in large steam kettles. Once product temperatures began to elevate above the boiling point of water, product was filtered through paper shortening filters resulting in the separation of liquefied fat from solids. This is the only method that provided large enough quantities of fuel grade fat for testing in our industrial boiler. Additionally the energy yield on this process was much higher than that of offal processing as dewatering of leaf fat has nearly a 99% energy yield and that of saddle fat is about 96%.

After the apparent success of thermal rendering, the group attempted to render fat using an autoclave. 1 pound samples of Cagle's Leaf Fat were autoclaved for one hour intervals at 230^{o}F/15psi. Fat content of solids were examined by visual inspection at the end of each heating cycle. At the end of four one hour cycles, fat was still visibly entrained in the original solid material. Pressure from the autoclave clearly kept the fat solid under autoclave conditions. While this method was clean and simple, its lack of efficiency and failure to completely extract fat from the solid material makes it an unlikely candidate for fat recovery on-site in poultry processing facilities.

Ultimately, it was determined that non-pressurized, thermal extraction of concentrated fat containing waste material such as the leaf fat and saddle fat examined in this study was determined to be the most likely candidate for fuel fat production at a poultry processing plant. Fermentation methods, while technically feasible, were deemed economically unviable due to large treatment volumes and extended residence times.

Autoclave methods were also deemed unfeasible both technically and economically as the high pressure used in these systems resulted in incomplete extraction even with extended treatment times.

Fat Recovery points were determined from examining the process stream of both Cagle's and Pilgrim's Pride facilities. Optimum recovery points were determined to be pre-waste stream. Fat that reached the waste stream required much more energy, residence time and storage volume to extract due to the large amounts of water introduced during processing. Recommendations to both facilities involved in this study suggest an analysis of all locations that introduce fat into waste streams and implementation of fat recovery processes at these points. In many cases recovery will be as simple as a line employee routing the fat into a collection vessel instead of dropping the material into waste. It was suggested that during processing up to 60% of saddle fat is lost to offal. Material that would otherwise end up in offal could be recovered by this method during the processing of hind quarters at the Pilgrim's Pride facility quite easily. Other mechanical methods such as screens to catch large fat particles and skimmers to collect floating fat could also decrease water content in processed by-product dramatically. Ultimately, any process that can inexpensively prevent introduction of water into concentrated fat containing materials and prevent these materials from entering offal will facilitate the efficient collection of this potential fuel.

Objective 2: Pump and nozzle selection was accomplished through the advisement of Clean Burn technicians and product developers. In house BTU analysis determined energy value per volume of biofuel was determined to be within 11% of that of petroleum diesel and other liquid fuels used in these boilers suggesting similar volumes of fuel would be required for optimal operation of the boiler when running on biofuel. Two Clean Burn stock 9-5 injectors were used in the study and were traded out periodically for cleaning. A continuous 2.5 gallon per hour pump was included with the CTB350 boiler and was used for all fuels. An optional oil regulator was left inline on the system as it allowed us to make minor adjustments to oil flow when necessary.

Objective 3: Fuel properties were measured in three laboratories:

a. University of Georgia Biofuel Testing Laboratory: Energy content, specific gravity and viscosity.
b. PSC Analytical Services Laboratory (Hatfield, PA): Ultimate Elemental Analysis (C,H,O,N,S – ASTM D5291 and ASTM D4239)
c. Eurofins Scientific Laboratory (Des Moines, IA): Triglyceride Profile, Moisture (AOCS Ca 2b-38), Insolubles (AOCS Ca 3a-46), Unsaponifiables (AOCS Ca 6A-40) and Free Fatty Acids (AOCS Ca 5a-40).

The results of these analyses are summarized in Table 1. Triglyceride profiles are shown in Table 2.

Table 1. Fuel Properties of Tested Fuels (percent composition unless otherwise noted)

Fuel	Stored Fat	80%Fat:20%D2	Saddle Fat	Leaf Fat	D2	UMO
Ash	0.1	0.193	0.12	0.076	0.01	0.807
Carbon	79.2	77.5	76.77	70.7	86.2	81.1
Hydrogen	12.5	12.4	12.40	12.2	12.8	13.5
Nitrogen	0.14	0.02	0.20	0.024	0.04	0.26
Oxygen	7.96	9.83	10.43	10.7	0.841	0.95
Sulfur	0.1	0.01	0.01	0.01	0.0488	0.372
MIU	1.22	14.83	1.38	1.19	n/a	n/a
Moisture	0.1	1.27	1.09	0.36	n/a	n/a
Insoluble	0.44	0.05	0.16	0.1	n/a	n/a
Unsaponifiable	0.68	13.51	0.13	0.73	n/a	n/a
FFA	9.4	10.5	0.45	0.4	n/a	n/a
Viscosity (cP)	15.60	9.24	15.90	14.40	1.42	18.00
Specific Gravity (g/mL)	0.887	0.88	0.88	0.885	0.852	0.87
Energy Content (BTU/lb)	17047	17547	16488	17062	19144	19155

Table 2. Triglyceride Profiles of Tested Fats (percent composition)

Fuel	Stored Fat	Saddle 1	Saddle 2	Saddle Top	Leaf
C14:0	0.57	0.5	0.51	0.5	0.64
C14:1	0.22	0.22	0.24	0.25	0.25
C16:0	23.5	23.63	24.31	23.9	25.48
C16:1	8.33	8.91	9.28	9.52	8.78
C18:0	5.37	5.14	4.97	4.61	5.52
C18:1	41.71	44.68	44	45.12	42.5
C18:2	16.86	14.37	14.22	14.17	13.8
C18:3	1.01	0.81	0.82	0.79	0.77
C18:4	0.18	0.14	0.15	0.15	0.14
C20:1	0.54	0.56	0.54	0.57	0.65
C20:2	0.18	0.15	0.14	0.14	0.13
C20:3	0.18	0.12	0.13	0.12	0.1
C20:4	0.41	0.15	0.15	0.14	0.12
Unknown	0.74	0.62	0.54	0.63	0.61

Interestingly, fat that was stored for over one year had similar energy content to the leaf fat provided by and freshly extracted in UGA laboratories. Saddle fat obtained from Pilgrim’s pride had slightly less energy than the other two examined fat sources; it also contained significantly more water as delivered, which may have had a diluting effect on the energy content of this material. Stored fat clearly had much higher free fatty acid content which is attributable to oxidative effects associated with long term storage. However, this increase in FFA did not have a large impact on energy values as the products of oxidation have similar energy content to the native triglycerides found in these oils. The 80% poultry fat/20% diesel mixture also had high free fatty acids and slightly higher energy content than pure fats as diesel fuel contains more energy than fat. Carbon and hydrogen levels were consistent throughout all fuels, but fats had much more oxygen which generally enhances combustion and reduces emissions. Petroleum based fuels (UMO, D2) had much more sulfur which is the source of sulfur oxide emissions.

The consistency seen in fatty acid profiles among the three different fats studied here is significant. Poultry from different parts of the bird, differently handled birds and variable storage conditions all generally had similar fatty acid composition. This is important to note as it suggests variability of fuels will not be dependent on the source of the fat, but on extraction methods and handling procedures. Additionally, saddle fat samples from two different extraction batches (1 and 2) had consistent fatty acid profiles. Saddle fat separated into two distinct layers after about 24 hours. A liquid top layer and a semi-solid bottom layer. The top layer was sampled separately and analyzed using the same procedures as the entire fat sample. It was found that there was no significant difference in the composition and fuel properties of this liquid top layer and the rest of the fat sample suggesting similar performance characteristics can be expected from separate layers of stored fats.

American Proteins rendered fat was stored 1.5 years at room temperature for a completed storage study before the start of testing. Conveniently, this provided a high free fatty acid product which represented stored fuels for the purpose of this study.

Objective 4 – Extracted poultry fat samples were combusted in the Clean Burn CB 350 CTB boiler. The fueling system, hydronic setup and combustion setup are illustrated in Figure 1.

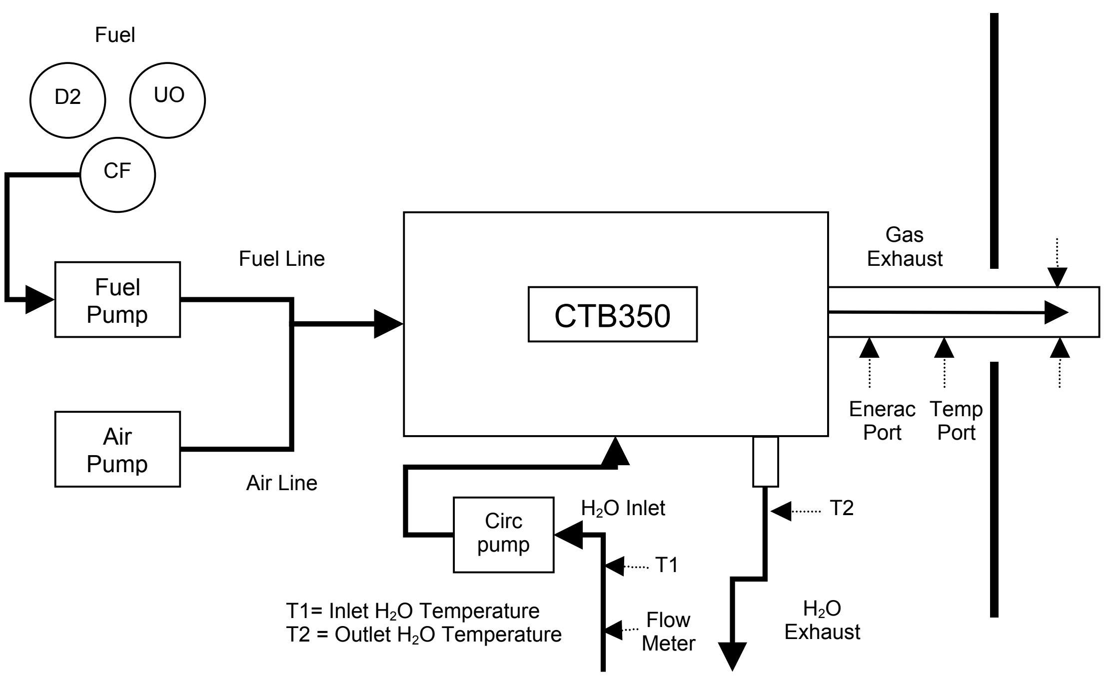

Figure 1. Bloc diagram of CB 350CTB Coil Tube Boiler, fueling system and hydronic system.

Stack emissions were measured using an ENERAC 3000E. The team recorded both average and instantaneous measurements of flue gas concentrations for oxygen, carbon monoxide, carbon dioxide, combustible gases, excess air, nitric oxide, nitrogen dioxide, NOx (NO + NO2), and sulfur dioxide. The analyzer software program enabled the recording of emissions data directly to a spreadsheet file on the hard drive of a laptop computer. Data was recorded during steady state operations for each fuel tested, at both maximum and part loads and at each FGR damper setting. The ENERAC 3000 portable emissions analyzer is a self-contained, extractive flue gas monitoring system utilizing electrochemical sensors with an internal sample pump designed for 600-900 cc/minute. A separate vacuum pump extracted flue gas from a breaching port and discharged it to the ENERAC. Teflon tubing interconnected a filter probe in the breaching through two moisture condensers to the vacuum pump and then to the analyzer. The ENERAC sensors use an electronically controlled circuit to minimize zero drift and reject cross interference from other compounds, in compliance with EPA Conditional Test Methods (CTM) –022, -030 and –034. Performance specifications of the CTM-022 method are equivalent to US EPA Method 7E requirements. Accuracy of the sensors is +/-2%, and they are capable of operating at 1.5 orders of magnitude of gas concentrations. Airflow was low in the system so precise measurements were made using a Dwyer micrometer and a pitot tube at locations shown in Figure 1.

Boiler efficiency, temperature differential, and boiler parameters were also recorded every 10 minutes during testing. Oil flow volumes and air intake were kept consistent throughout the study to assure similar boiler conditions, and therefore performance measurements, were comparable between fuels. Water flow rates were measured using an in-line flow meter produced by Universal Flow Meters specifically for this application. 100% diesel fuel runs were executed for 1 hour before each test fuel was examined to provide baseline measurements. Test results including emissions and performance data are summarized in Table 3.

Table 3. Emissions and performance of various fuels in CB350 CTB boiler. *Average refers to the average of the three poultry fat samples. Numbers in parentheses indicate number of runs per fuel type.

Fuel	100 PRF(4)	Leaf Fat(1)	Saddle Fat(4)	Average*	80/20(2)	UMO(3)	D2(11)
Stack Temp (^oF)	352	362	364	360	356	367	360
Oxygen (%)	4.00	4.03	5.17	4.67	3.98	3.35	4.30
Carbon Monoxide (lb/min)	0.0059	0.0062	0.0065	0.0063	0.0078	8.5029	0.0049
Carbon Dioxide (%)	14.98	16.56	13.94	0.00	15.00	15.56	13.83
Combustibles (lb/min)	2.47E-07	1.03E-06	1.41E-06	1.02E-06	1.31E-06	2.42E-06	1.02E-06
Excess Air (%)	22.12	22.78	31.16	27.38	21.81	17.89	24.13
Nitric Oxide (lb/min)	0.00073	0.00037	0.00043	0.00051	0.00036	0.00099	0.00030
Nitrogen Dioxide (lb/min)	0.00022	0.00019	0.00022	0.00021	0.00023	0.00006	0.00017
Oxides of Nitrogen (lb/min)	0.00095	0.00056	0.00065	0.00072	0.00059	0.00105	0.00047
Sulfur Dioxide (lb/min)	0.00007	0.00000	0.00006	0.00005	0.00008	0.00053	0.00006
Consumption (gal/hr)	2.43	2.38	2.51	2.46	2.42	2.37	2.22
Efficiency (%)	78.19	72.67	79.87	78.32	76.79	81.77	79.18
ΔT (^oF)	24.69	24.17	25.77	25.11	24.92	28.52	24.81

In all cases, poultry fat had reduced emissions as compared to used crankcase oil (UMO), the fuel the CB 350CTB was designed to burn. However, when poultry fat emissions were compared to diesel fuel emissions, diesel had slightly lower emissions although the difference was not significant. The 80% poultry fat/20% diesel fuel mixture tended to have emissions between that of the two component fuels suggesting an averaging effect of properties associated with these two fuels. These results were in contrast to those observed in a previous University of Georgia study on larger, 100,000 lb/hr boiler. In this study poultry fat had reduced emissions as compared to petroleum diesel fuel resulting in a cleaner burn.

Performance of poultry fat fuels was near that of the petroleum based fuels. As these fuels have slightly less energy value, the overall consumption of these fuels was slightly higher over the course of the study. ΔT, which is the difference in temperature between incoming water and outgoing water, was comparable between poultry fat (25.11^oF) and diesel fuel (24.81^oF). The higher BTU value of used crankcase oil resulted in a significantly higher ΔT of 28.52^oF. Efficiency was also observed to be the highest when the boiler was fueled on UMO, its intended fuel. Diesel fuel and poultry fat had almost identical efficiencies of 79% and 78% respectively.

A brief study on the effects of regulation of oil and air flow on emissions and efficiency was conducted with little significant impact on boiler performance. Changes to aspiration pressure, oil pressure and air intake led to unpredictable changes in emissions but resulted in no net change in performance or efficiency. As the focus of this study was on performance and it was determined that emissions on this scale would not be regulated, this part of the study was terminated before adequate data was collected to predict the effects of such regulation on emissions.

Objective 5 - Legal limits of in-plant use of poultry fat as a boiler fuel were explored by Bob Synk an engineering consultant contracted by the University of Georgia to aid in this study. Research revealed no legal conflicts in using this fuel in on-site boilers and heaters in the State of Georgia. The scale of such applications in poultry processing environments is small enough such that regulations over emissions and other environmental impacts would not extend to these systems.

Objective 6 - **A plan for onsite utilization was developed** and is being written for use by both Cagle's Poultry and Pilgrim's Pride Poultry. Implementation of this technology is being carefully considered by Pilgrim's Pride's Continuous Improvement Division. Cagle's is also ready to implement this system when the plan is delivered. If fuel costs continue to be elevated, it will be economically advantageous for other poultry processors throughout the state to implement similar systems.

Objective 7 - **The above plan along with this report will be published** on the University of Georgia Faculty of Engineering, Engineering Outreach website (http://www.engr.uga.edu/service/outreach/index.html). Findings from this study have already been shared directly by Engineering Outreach employees with interested parties in the state of Georgia. Engineering Outreach will continue to share the findings of this study and transfer the technology studied here within the state of Georgia via publications and presentations.

CONCLUSIONS AND EXPECTED IMPACT ON THE FOOD INDUSTRY

This project was successful in that it appears the collection and extraction of concentrated-fat containing materials from poultry processing lines is a feasible method of providing an alternative to petroleum based #2 fuel oil for industrial boilers. The methods established here require the collection of these materials inline which can be accomplished manually or with mechanical defatters. In other situations, this material can simply be redirected from waste streams. Regardless of the collection method this material must then be thermally processed and filtered to separate fat from water and solids. This is a straightforward process requiring the introduction of steam heated retort or kettle systems. As poultry processing generally requires steam heat, this should be readily available for introduction into the new processing environment. The only capital investment needed in these applications is the purchase of heating vessels used to dewater and melt the poultry fat and a filter system to remove solids after water is removed.

On-site fat extraction from offal and other waste streams proved to be resource intensive as compared to simple extraction from higher-grade fat-containing products. The low yield of fat from offal (approximately 10%) necessitates high residence volumes and high energy inputs for extraction. Dewatering of offal accounts for most of the energy needed as the product examined was about 48% water. Ultimately, the processing of offal was beyond the scope of this study. Processing fat after it has entered the wastewater stream would require the implementation of large volume, large footprint rendering equipment more suited to an actual rendering facility than on-site in a poultry processing facility. Initial capital investment and required real estate would make it a long-term return project, whereas simple on-site extraction of fat-rich materials is quite feasible.

Even with the limitation of using high-fat containing material captured before waste streams in poultry fat a significant financial impact can be realized. If only 20% of the 44.6 million gallons of poultry fat created in the state is recovered this could displace 8.9 million gallons of diesel fuel used in poultry processing. At a possible income sacrifice of $1.33/gal, its use will displace $2.60/gal in fuel costs for a net savings of $1.27/gal or $11.3 million for the state poultry industry. The capital investment for such a recovery system is relatively small as only steam jacketed kettles or retorts are needed with a simple filtration system. The required energy input of the system is only about 20% of that recovered. Taking this energy expense into account, the energy return is still near $9.0 million a year after initial capital investment is recovered. This is a conservative estimate as the price for petroleum has reached $70+ per barrel driving the price of diesel over $3.00/gal in some parts of the state. Additionally, the $.18/lb ($1.33/gal) price for poultry fat assumes the fat itself would have been kept in the box and sold for human consumption or other high-value use. Likely, much of the fat (up to 60%) would end up in offal for a price near $.03/lb ($.22/gal). If this system were to be implemented state-wide, the actual economic benefit to the state poultry industry could ultimately exceed the $11.3 million predicted above.

The economic benefit of this type of system will vary between facilities and will be dependent upon the processing taking place at any given time. Optimum efficiency of this operation will be realized when concentrated fat sources can be easily diverted from waste streams and collected for processing to fuel. As fuel prices continue to increase and the threat of possible shortages emerges the use of any and all domestic sources of fuel becomes increasingly important. Along with providing reduced fueling costs, this project increases domestic energy security by displacing foreign petroleum with domestic poultry fat. Additionally, since this material is actually produced in the state of GA, it takes advantage of Georgia's own energy resources. Finally, since this material is used in-house it eliminates transportation costs and conserves the fuel necessary to transport petroleum products to poultry processing facilities where the fuels are needed.

COST SUMMARY

Industry Capital In-Kind Contributions

Source/Description	Amount
Cagle's Inc. - Poultry Fat	$ 500
Cagle's Inc. - Labor	$ 1,000
Pilgrim's Pride – Labor	$ 1,000
Pilgrim's Pride Poultry Fat	$ 500

Clean Burn –Accessories	$ 1,000
Clean Burn – Laboratory Equipment	$ 1,000
Clean Burn - 350,000btu/hr boiler	$11,000
Free Heat Services, Inc. – Labor	$ 1,000
TOTAL	**$17,000**

FoodPac Funding Distribution
University of Georgia – Engineering Outreach 100%

Cagle's, Inc. provided initial offal and poultry fat samples and initial consultation and other personnel services. Pilgrim's Pride later assumed guidance and supply roles providing the rest of the poultry fat samples and invaluable technical assistance. Clean Burn was also essential to this study providing the major equipment needed for this study a selection of necessary accessories and laboratory equipment specialized for measuring exhaust emissions from their boiler. In addition, Free Heat Services, Inc. of Henagar, AL, a partner of Clean Burn, provided extensive on-site technical support in the operation and assembly of the Clean Burn boiler.

As the University of Georgia's Engineering Outreach was the only participating project organization, 100% of the funding went to this unit to pay personnel costs, supply costs, overhead and outsourced chemical analyses fees.

TECHNOLOGY TRANSFER ACTIVITIES

Results and technology developed in this study were presented at the Georgia Environmental Partnership Spring (GEP) 2005 meetings. These take place twice annually in seven locations across the state of Georgia and allow University of Georgia Engineering Outreach to share their progress and developing technologies with interested parties across the state. The Georgia Environmental Partnership includes P^2AD, The University of Georgia, and Georgia Tech. The locations and dates of their presentations were as follows:

Adams, T.T., 2005. RENEWABLE ENERGY IN GEORGIA. Georgia Environmental Partnership. Regional Environmental Network Meeting. Macon, GA, May 3.

Adams, T.T., 2005. RENEWABLE ENERGY IN GEORGIA. Georgia Environmental Partnership. Regional Environmental Network Meeting. Tifton, GA May 4.

Adams, T.T., 2005. RENEWABLE ENERGY IN GEORGIA. Georgia Environmental Partnership. Regional Environmental Network Meeting. Savannah, GA, May 10.

Adams, T.T., 2005. RENEWABLE ENERGY IN GEORGIA. Georgia Environmental Partnership. Regional Environmental Network Meeting. Augusta, GA, May 11.

Adams, T.T., 2005. RENEWABLE ENERGY IN GEORGIA. Georgia Environmental Partnership. Regional Environmental Network Meeting. Gainesville, GA, May 12.

Adams, T.T., 2005. RENEWABLE ENERGY IN GEORGIA. Georgia Environmental Partnership. Regional Environmental Network Meeting. Newnan, GA, May 17.

Adams, T.T., 2005. RENEWABLE ENERGY IN GEORGIA. Georgia Environmental Partnership. Regional Environmental Network Meeting. Dalton, GA, May 19.

Additional information on the project and the results and conclusions will be disseminated in the fall GEP meetings beginning on November 2nd, 2005 by Daniel P. Geller. Additionally, scholarly journal articles are being assembled to deliver the funded research to the scientific community. Finally, this report and the final report to Pilgrim's Pride and Cagle's will be posted on the University of Georgia's Engineering Outreach website: http://www.engr.uga.edu/service/outreach.

REFERENCES

Adams, T., J. Walsh, M. Brown, J. Goodrum, J. Sellers, K. Das, 2002. A Demonstration of Fat and Grease as an Industrial Boiler Fuel. University of Georgia Outreach Report. http://www.engr.uga.edu/service/outreach/Articles.htm#BioProducts.

University of Georgia Engineers work with Engineers from Clean Burn and Underwriter's Laboratories to optimize an instrumented Clean Burn used oil burning boiler to efficiently burn freshly rendered poultry fat.