Director's Digest
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Animal Fats and Recycled Cooking Oils

Alternatives as Burner Fuels

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Introduction

During the past several months the inspiration to view animal fats and recycled cooking oils/restaurant grease as valuable energy sources have resulted from two primary sources. First the rather rapid and dramatic increase in transportation fuels beginning in early 2000 followed by a similar reaction in the burner fuel segment (natural gas, propane and fuel oils). The influence that this hardship has exerted on businesses and families alike is exemplified in a letter recently received by Illinois Senator Richard Durbin as follows: Dear Senator: "Look at this gas bill (enclosed). What are you Senators going to do about this?" Signed Loretta Durbin (his wife). Concurrently the value of fats and oils have been depressed to nearly historic lows. Fortunately there has been some resolve in both portions of the equation most recently but during this time frame it has become very evident that the respective animal fats and rendered oils have a significant contribution to make for their use as alternative fuels.

Opportunities and Challenges

US's dependence upon foreign sources of petroleum based energy continues to increase. That current reliance is now approaching 59% of our total domestic usage. This reliance has likewise spurred a US Trade deficit that now only increased 40% last year but hit an all-time high for the third consecutive year. Transportation fuel costs has influence on nearly every input that businesses and families must purchase. Similarly home heating fuels and commercial burner fuels will increase business, personal and government services fuel costs nation wide by 40% to 100% depending on geographics during this past winter. These increased operating and living costs negatively effects consumer price indices and cuts across all aspects of business transactions. A very recent survey (Gallup poll) indicated that 56%

of the people surveyed said recent increases in energy prices have caused financial hardships for their households.

Natural gas, crude oil and heating oil prices have shown some declines since mid-January. But continued stress on supplies and pricing of the natural gas and petroleum based energy is not expected to be solved in the very near future. Consequently all factions have been seeking for alternatives to trim these expenses. One of the more successful for the rendering/packing industries has been the utilization of the product they process or produce as fuel energy alternatives. Tallow, choice white grease (lard), poultry fat and recycled cooking/restaurant greases have all been used with success. The Fats and Proteins Research Foundation, Inc. has been a clearing house for providing air quality permit inputs and accumulating data on burning fuel characteristics, heating values and combustion emission data. Burner Conversions and retrofitting of most facilities have not required extensive engineering. Primary have been within the pumps and atomizing equipment. This report will summarize pertinent information to this point (March 1, 2001).

EPA Criteria for Pollutant Emissions Rates

The Federal Environmental Protection Agency (EPA) has established criteria for pollutant emission rates for a number of fuels that are contained within the AP-42 tables. The primary pollutant rates address the following:

Particulate Matter – (PM) – All PM, which includes total, condensable and filterable, is assumed to be less than 1.0 micrometer in diameter. They are expressed as PM-10, PM-2.5 or PM-1 emissions. Total PM is the sum of the filterable PM and condensable PM. Condensable PM is the particulate matter collected using EPA Method 202 (or its equivalent). Filterable PM is the particulate matter collected on, or prior to the filter of an EPA Method 5 (or equivalent) sampling train.

Volatile Organic Compounds – (VOC)
Total Organic Compounds – (TOC)
Nitrogen Oxides NO_x)
Carbon Monoxide (CO)
Carbon Dioxide (CO_2)
Lead
Sulfur (SO_2)

The following table summarizes the basic pollutant emission factors for natural gas, #2 oil and #6 oil. Complete factor values can be obtained from the AP-42 EPA Manual which contains over 500 pages of references. This is a reference that should be used as the official reference. The document contains emission factors for nearly every fuel under wide varieties of firing configurations and assumptions. Additionally the document describes approved emissions procedures, methods and references.

EMISSION FACTOR POLLUTANT

Fuel	CO_2	Lead	N_2O	N_2O (low NOx burner)	PM-Total	PM Condensable	PM-Filterable	SO_2	TOC	VOC
Natural Gas (lb/10^6scf)	120,000 pounds per million standard cubic ft.	0.0005	2.2	0.64	7.6	5.7	1.9	0.6	11	5.5
No. 2 Oil Fired lb./M gal	5	-	20.54	-	2	2	2	71		0.252
Converted to lb/MMBtU Assuming 140,000 BTU/gallon	0.0357	-	0.1429	-	0.0143	0.0143	0.0143	0.5071		0.0018
No 6 Oil Fired lb/Mgal	5	-	55	-	10	10	10	78.5		1.28
Converted to lb/MMBtU Assuming 150,000 BTU/gallon	0.0333	-	0.3667	-	0.0667	0.667	0.667	0.5233		0.0085

Please Note: The above table is extrapolated from the tables as supplied by the Iowa Department of Natural Resources – Air Quality Board and are contained within the full reference from the US Federal Environmental Protection Agency AP-42 Publication (7/98).

Tallow

Very little domestic data have been accumulated on tallow but data obtained from international sources comparing tallow to heavy fuel oil (HFO) illustrated very favorable particulate emissions of carbon monoxide (CO), hydrocarbons (HC), sulfur dioxide (SO_2), nitrous oxide (NO_x) and solids. Tallow was similar to HFO in CO and HC significantly lower in SO_2, NO_x and solid emissions. Tallow as does most emissions is negligible and representing only 2% of that from HFO. NO_x emissions were less than 70% and solids emissions less than 9% for the burning of tallow when compared to HFO. The following table references the particulate emissions.

Particulate Emissions

Fuel		Tallow	HFO
Duration	mins	60	60
Flue Temperature	°C	246	239
Mean Gas Velocity	m/s	22.3	21.4
Volume flow rate of gases			
(a) At duct conditions	m^3/h	27391	26410
(b) At STP	m^3/h	14671	14324
(c) At STP, 3%O_2,dry	m^3/h		11960
(d) At STP, 11%O_2,dry	m^3/h	20273	21596
Mass flow rate of gases	kg h-1	18340	17905
Concentration of Particulates in waste gases			
(a) At duct conditions	mg/m3	8	95
(b) At STP,3%O_2,dry	mg/m3	-	216
(c) At STP,11%O_2,dry	mg/m3	10	116
Particulate burden	kg/h	0.20	2.96
Carbon content of dust	%	<1.0	84.4

(a) m3/h Mass flow rate of gases – kg h –1
(b) m3/h Concentration a b c mg/m3
(c) m3/h Particulate kg/h
(d) m3/h

The gross calorific and net calorific values for tallow was 39090 kJ/kg and 36200 respectively and for HFO 42232 kJ/kg and 38830 respectively. These values represent 92% the gross heating value and 90.5% the net heating value for tallow as compared to HFO.

Choice White Grease/Lard

Work completed at Penn State University reported the following data on fuel analysis, combustion and emissions data all of which are very favorable when compared to the #6 fuel oil standard.

Fuel Analysis

	Semi-Finished Lard	Finished Lard	Choice White Grease	No. 6 Fuel Oil
Ultimate Analysis (%, as fired)[a]				
Carbon	77.7	77.4	77.9	85.8
Hydrogen	12.0	11.5	13.6	12.1
Nitrogen	0.4	0.6	0.2	0.6
Sulfur	0.0	0.1	0.2	1.5
Oxygen (by difference)	9.9	10.4	8.1	-
Heating Value (btu/lb.as fired)	16,941	16,990	16,977	18,454
Viscosity (cSt)[b]				
100°F	70	97	91	1,357[c]
120°F	23	25	26	520
140°F	17	17	17	232
160°F	-	-	13	128
Boiling Points (°C) [d]				
<260	0.7	0.8	0.5	8.9
280 to 450	5.1	1.9	20.9	29.3
450 to 540	1.8	1.1	11.6	12.5
540 to 700	91.6	95.3	65.6	38.3
> 700	0.3	0.3	0.9	9.8

[a] Fuel oil analysis normalized to 0% oxygen because oxygen, by difference, as –0.6%
[b] Measured using a Brookfield DVIII viscometer, a #21 spindle, and a spindle speed of 75 rpm
[c] Measured using a Brookfield DVIII viscometer, a #21 spindle, and a spindle speed of 15 rpm
[d] Measured using a Hewlett Packard 5890 plus high temperature gas chromatograph fitted with a Restek MXT-500 siliosteel column and connected to a FID.

Combustion and Emissions

	#6 Fuel Oil	Finished Lard (Overall)	Semi-Finished Lard (Overall)
Length of Test (h)	0.65	5.90	2.53
Fuel Injection Temperature (°F)	140	130	130
Fuel Firing Rate (million Btu/h)	1.74	1.74	1.72
% O_2	2.2	2.0	2.2
% CO_2	14.4	14.7	14.6
ppm CO @ 3% O_2	111	145	147
ppm NO_x @ 3% O_2	395	137	135
ppm SO_2 @ 3% O_2	784	0	0
Zone 1 Air Temperature (°F)	353	350	366
Zone 2 Air Temperature (°F)	752	780	735
Quarl Temperature-Bottom (°F)	1,041	847	887
Quarl Temperature-Top (°F)	1,042	855	897
Economizer Inlet Temperature (°F)	519	556	518
Steam Temperature (°F)	364	379	364
Steam Generation Rate (lb/h)	1,266	1,286	1,277
Total Air (lb/h)	1,459	1,429	1,412
Zone 1 Air (% of total)	58%	58%	58%
Zone 2 Air (% of total)	33%	34%	34%
Atomizing Air (% of total)	7%	6%	6%
Cooling Air (% of total)	2%	2%	2%

Poultry Fat

Data summarized on the use of poultry fat as a burner fuel as a replacement for both natural gas and fuel oil, indicates very satisfactory performance and in general provides for a cleaner burning fuel than the comparative.

Average Fuel Characteristics of Poultry Fat

Carbon	73.6%
Hydrogen	7.68%
Nitrogen	0.06%
Oxygen	18.6%
Ash	0.1%
Sulfur	<.02%
Heating Value BTU/lb. (range 16230 to 16910)	16,790

Note: due to the low analysis of both sulfur and nitrogen content of fat, the production of nitric oxide/nitrogen dioxide and sulfur dioxide emissions is expected to be extremely favorable for the emissions data as determined by stack and chamber analyses.

Emissions Summary

Data is available for firing rates ranging from 100% thru 30% at 10% increments. Stack temperature averaged 474°F at the 100% firing rate and 352°F at the 30% rate. There appeared to be little difference in the emissions data through an apparent reduction in nitric oxide (NO_x) at the lower firing rate (stack temperature). As previous the lack of nitrogen components in fat indicates that the generation of any NO_x is the result of combustion.

	100% Firing Rate	30% Firing Rate
Carbon Monoxide	0 ppm	0 ppm
Carbon Dioxide	8.6%	6.5%
Hydrocarbons	0 ppm	0 ppm
Excess Air	16%	51%
Nitric Oxide (NO_x)	97 ppm	52 ppm
Nitrogen Dioxide	0 ppm	0 ppm
Sulfur Dioxide (SO_x)	0 ppm	0 ppm

Summary: Poultry fat can be considered to be an extremely environmentally friendly alternative burner fuel.

Yellow Grease
(Recycled Cooking/Restaurant Grease)

Stack tests completed and reported have likewise illustrated an environmentally friendly fuel source as derived from used cooking oils and restaurant grease. Similarly the fuel and burn characteristics have been entirely satisfactory. The following is illustrative of data using 100% recycled yellow grease with no additives.

Broiler/Burner Description:
Manufacturer: Nebraska Boiler Company
Type Boiler: Water Tube "D" Style package steam generating boiler
Serial Number: 2D-1719
Date of Manufacture: 1976
Burner Manufacturer: Coen
Boiler Rated Horsepower:725
British Thermal Units: 17,469 Btus/Lb Method ASTM D240-87

Combustion Analyses:	**Run 1**	**Run 2**	**Run 3**
Stack Temperature	558°F	549°F	571°F
Stack gas velocity (ft/min.):	1,038	1,043	1,064
Stack flow rate (acfm):	7,337	7,371	7,520
Stack flow rate (dscfm):	3,439	3,513	3,452
CO Emissions (ppm):	34.7	44.8	27.9

VOC Emissions (ppm):	1.7	1.6	1.7
NO_x Emissions (ppm):	69.0	70.2	69.2
SO_2 Emissions (ppm):	1.4	1.3	1.4
*TSP Emissions Rate (gr/dscf):	0.0330	0.0309	0.0374
Opacity (%):	0.0		

(*Total Suspected Particulate)
Firing Rate: (range during three tests): 133 gal./hr. x 139,700 Btus/gal. = 18.6 million Btus/hr.
171 gal./hr. x 139,700 Btus/gal. = 23.9 million Btus/hr.

Fat preheated 188°F to 208°F for burning stack tests.

A further analysis of comparing the use of yellow grease on the basis of converted factors of pounds per million (MM) British Thermal units of emissions compared to the respective fuels are as follows indicating quite satisfactory results.

Converted Factors lb/MMBTU

Natural Gas Fired Small Boilers	Source	Units	PM-10	PM	VOC	NO_x	SO_x	CO
<100 MMBtu/hr	AP-42 7/98	lb/MMcf	7.6	7.6	5.5	100	0.6	84
	Converted Factors*	lb/MMBtu	0.0072	0.0072	0.0052	0.0952	0.0006	0.0800
#2 Distillate Oil								
<100 MMBtu/hr	AP-42 9/98	lb/Mgal	2	2	0.252	20	71[a]	5
	Converted Factors**	lb/MMBtu	0.0143	0.0143	0.0018	0.1429	0.5071	0.0357
No.6 Residual Oil								
<100 MMBtu/hr	AP-42 9/98	lb/Mgal	10	10	1.28	55	78.5b	5
	Converted Factors***	lb/MMBtu	0.0667	0.0667	0.0085	0.3667	0.5233	0.0333
Yellow Grease								
Yellow Grease								
<100 MMBtu/hr – fat	Stack Test Results	lb/hr	1.0033	1.0033	0.0367	1.7267	0.0500	0.5
	Converted Factors	lb/MMBtu	0.0414	0.0414	0.0015	0.0712	0.0021	0.0224

*conversion used 1,050 Btu/ft3 ** conversion used 140,000 Btu/gallon, *** conversion used 150,000 Btu/gallon
[a] emission factor is 142 x %sulfur, 142 x 0.5 – 71, [b] emission factor is 157 x % sulfur, 157 x 0.5 = 78.5

Price Comparison

The cost benefits for utilizing fats as burner fuels are of course directly related to the cost comparison of the respective fuels. Geographic pricing relationships as well as the variances between the energy efficiency of individual burners and burner fuel influences the comparative analyses. The following only serves as a model for comparing the respective fats to those of natural gas, #2 fuel oil and #6 fuel oil at given prices ant the assumption of BTU efficiency and densities of the respective products. The costs per million BTU values were compared to a base of 100 assigned to natural gas. Thus as an illustration yellow grease is projected to be 70.78% the costs per Million BTU as compared to natural gas when using the assumptions set forth.

From this basic point in time comparison, the illustration that inedible tallow, choice white grease and yellow grease are current cost effective burner fuel alternatives is very evident.

Burner Fuel Cost Analysis to Animal Fat and Greases

	Price	How Quoted	Cost Per Million BTU	Natural Gas Basis
Natural Gas	$7.65	Per Million BTU	$7.65	100.0
#2 Fuel Oil	$1.03	Per Gallon	$7.36	96.17
#6 Fuel Oil	$1.02	Per Gallon	$6.99	91.32
Edible Lard	$14.00	Per Hundred Weight	$7.77	101.63
Edible Tallow	$14.50	Per Hundred Weight	$8.05	105.26
Bleachable Fancy Tallow	$11.00	Per Hundred Weight	$6.11	79.85
Choice White Grease	$11.25	Per Hundred Weight	$6.25	81.66
Yellow Grease	$9.75	Per Hundred Weight	$5.41	70.78

Assumptions:

#2 Fuel Oil	140,000	BTU per Gallon7.143 Gallons per Million BTU
#6 Fuel Oil	146,000	BTU per Gallon6.849 Gallons per Million BTU
All Fats	132,000	BTU per Gallon7.576 Gallons per Million BTU
All Fats	7.33 lbs. Per Gallon @ 160 degrees F	

Resource Supply of Animal Fats and Recycled Cooking/Restaurant Grease

Total animal fats/oils including those derived from used cooking oils/restaurant grease in the U.S. is estimated at 11.25 billion pounds. The total is derived from the estimated billion pounds 1.5 edible tallow, 3.2 inedible tallow, 1.8 rendered grease, 2.0 poultry fat and 2.75 yellow grease. The 2.75 Billion pounds of yellow grease recycled annually in the U.S. primarily by the rendering industry is based on approximately 9 lbs. generated per population and approximately 6300# available from each food service unit. The total animal fats/recycled oils and greases represent about one-third the total of the largest oil generating industry in the U.S. that of soybean production.

Summary

Animal fats and the resources of recycled cooking oils and restaurant greases have long been recognized for their valuable energy contributions to livestock, poultry, domestic animal and a variety of other animal diets. Research supported by FPRF has historically, since 1962 provided scientific data to support these uses. Further FPRF has been involved in both research and initiatives for the utilization of these resources as alternative fuel sources. FPRF has been a charter member of the

National Soy Diesel Development Board (National Biodiesel Board) since 1992. It remains an Associative Directorship and cooperates in the research efforts to commercialize biodiesel. These initiatives have certainly brought biodiesel into prominence as a very viable alternative fuel and its gallonage sales increases annually.

Most recently FPRF has been extremely active in conveying the importance of rendered animal products as resources for biofuel/bioenergy production. As has been pointed out on numerous occasions research efforts, incentives, subsidies have favored sources derived from plant origins. These activities have often been at the exclusion of animal origin products.

This current summary for the use of animal fats/greases as burner fuel usage offers an opportunity as effective environment and economic alternatives to meet the burner fuel crisis that is upon us now. Numerous facilities are in the process of acquiring air quality permits and active in interacting with local and state environmental regulators. There have been numerous Air Quality permits issued for using animal rendered fats in a variety of facilities. Reports for utilizing from 15% to exceeding 30% of products processed in given plants as the internal energy source has been received. Similarly reports of several hundred thousand dollars savings in energy cost per plant as a result of converting from their traditional burner fuel. Their use for alternative energy sources offers marketing opportunities that may previously have not been considered.

FPRF continues to solicit data from all sources to supplement and compliment that summarized in this report. Data submission report forms have been provided to the FPRF and NRA membership in the past but should you need further guidance please contact the FPRF office. All data and information supplied will not be divulged by facility or source. The FPRF organization by policy and by its actions has demonstrated the codes of confidence. It will be respected in the summary information to be developed that is so important for the development of allied support, leveraged research opportunities, regulatory acceptance and marketing opportunities for our products in the biofuel/bioenergy arena. We thank those that have cooperated and encourage all of those that have not to consider such.

Should you wish to discuss these areas of opportunity please contact the Fats and Proteins Research Foundation at any time.

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