Turn up the Heat

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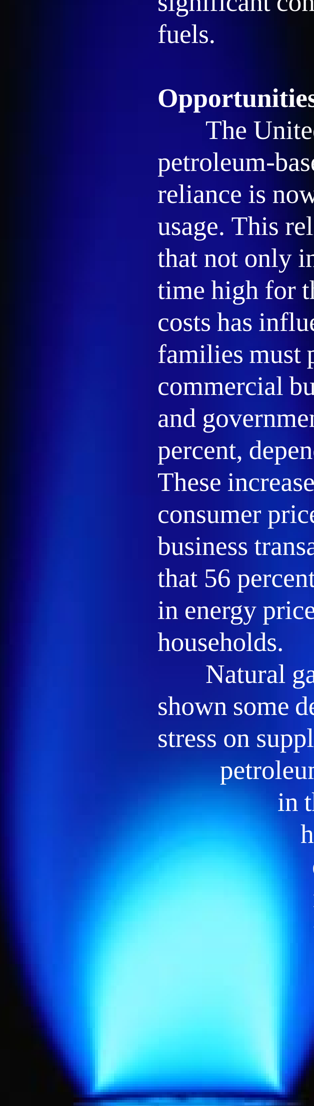
During the past several months, the inspiration to view animal fats and recycled cooking oils/restaurant grease as valuable energy sources has resulted from two primary sources. First the rather rapid and dramatic increase in transportation fuels beginning in early 2000, followed by a similar reaction 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 that read 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 has 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

The United States' dependence upon foreign sources of petroleum-based energy continues to increase. That current reliance is now approaching 59 percent of our total domestic usage. This reliance has likewise spurred a U.S. trade deficit that not only increased 40 percent 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 service's fuel costs nationwide by 40 to 100 percent, 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 Gallup poll indicated that 56 percent 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 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 (FPRF), 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 summarizes pertinent information to the point of 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 Dioxide (SO_2).

Table 1 summarizes the basic pollutant emission factors for natural gas, No. 2 oil, and No. 6 oil. Complete factor values can be obtained from the *AP-42 EPA Manual* that 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.

Tallow

Very little domestic data has been accumulated on tallow but data obtained from international sources comparing tallow to heavy fuel oil (HFO) illustrated very favorable particulate emissions of CO, hydrocarbons (HC), SO_2, 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 two percent of that from HFO. NO_x emissions were less than 70 percent and solids emissions less than nine percent for the burning of tallow when compared to HFO. Table 2 references the particulate emissions.

Rendered fats possible solution to high fuel costs

Table 1. Emission Factor Pollutant

Fuel	CO_2	Lead	N_2O (low) NOx burner)	N_2O	PM-Total Condensable	PM	PM-Filterable	SO_2	TOC	VOC
Natural Gas (lb./10^6scf)pounds per million standard cubic ft.	120,000	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./MM Btu assuming 140,000 Btu/gal.	0.0357	-	0.1429	-	0.0143	0.0143	0.0143	0.5071	-	0.0018
No. 6 Oil Fired lb./M gal.	5	-	55	-	10	10	10	78.5	-	1.28
Converted to lb./MM Btu assuming 150,000 Btu/gal.	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 U.S. Federal Environmental Protection Agency AP-42 Publication (7/98).

The gross calorific and net calorific values for tallow was 39,090 kJ/kg and 36,200 respectively and for HFO 42,232 kJ/kg and 38,830 respectively. These values represent 92 percent the gross heating value and 90.5 percent the net heating value for tallow as compared to HFO.

Choice White Grease/Lard

Work completed at Penn State University reported the data in Tables 3 and 4 on fuel analysis, combustion, and emissions data, all of which are very favorable when compared to the No. 6 fuel oil standard.

Poultry Fat

Data summarized on the use of poultry fat as a burner fuel for 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 16,230 to 16,910)	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.

Table 2. 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/hr.	27391	26410
(b) At STP	m^3/hr.	14671	14324
(c) At STP, 3%O_2, dry	m^3/hr.	-	11960
(d) At STP, 11%O_2, dry	m^3/hr.	20273	21596
Mass Flow Rate of Gases	kg hr.-1	18340	17905
Concentration of Particulates in Waste Gases			
(a) At Duct Conditions	mg/m^3	8	95
(b) At STP, 3%O_2, dry	mg/m^3	-	216
(c) At STP, 11%O_2, dry	mg/m^3	10	116
Particulate Burden	kg/hr.	0.20	2.96
Carbon Content of Dust	%	<1.0	84.4

[a] m^3/hr. Mass flow rate of gases – kg hr. – 1
[b] m^3/hr. Concentration a b c mg/m^3
[c] m^3/hr. Particulate kg/hr.
[d] m^3/hr.

Emissions Summary

Data is available for firing rates ranging from 100 percent thru 30 percent at 10 percent increments. Stack temperature averaged 474 degrees Fahrenheit (F) at the 100

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percent firing rate and 352 degrees F at the 30 percent rate. There appeared to be little difference in the emissions data through an apparent reduction in 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

In summary, poultry fat can be considered to be an extremely environmentally friendly alternative burner fuel.

Yellow 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 percent 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 (Btus): 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 degrees F to 208 degrees 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) Btus of emissions compared to the respective fuels is shown in Table 5, indicating quite satisfactory results.

Table 3. 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 zero percent oxygen because oxygen, by difference, as – 0.6 percent.
[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.

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, No. 2 fuel oil, and No. 6 fuel oil at given prices and 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 percent 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 in Table 6.

Resource Supply of Product

Total animal fats/oils, including those derived from used cooking oils/restaurant grease, in the United States 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 United States primarily by the rendering industry is based on approximately nine pounds generated per population and approximately 6,300 pounds 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 United States, that of soybean production.

Table 4. Combustion and Emissions

	No. 6 Fuel Oil	Finished Lard (Overall)	Semi-Finished Lard (Overall)
Length of Test (hr.)	0.65	5.90	2.53
Fuel Injection Temperature (°F)	140	130	130
Fuel Firing Rate (million Btu/hr.)	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/hr.)	1,266	1,286	1,277
Total Air (lb/hr.)	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%

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, and 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 percent to exceeding 30 percent of products processed in given plants as the internal energy

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Table 5. Converted Factors lb./MM Btu

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

*conversion used 1,050 Btu/ft^3
** conversion used 140,000 Btu/gal.
*** conversion used 150,000 Btu/gal.
[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

Mark Your Calendar

✓ The 77th Annual **Pacific Egg and Poultry Association** (PEPA) Convention is scheduled for May 7-10, 2001, at the Doubletree Hotel, Monterey, CA. To register, call PEPA at (916) 441-0801, or fax (916) 446-1063.

✓ The **American Oil Chemists' Society** (AOCS) is holding their Annual Meeting and Expo May 13-16, 2001, at the Minneapolis Convention Center, Minneapolis, MN. A technical program will focus on various topics, including new technologies and use of animal proteins and biodiesel. Register by calling the AOCS at (217) 359-2344, on the Internet at www.aocs.org, or e-mail meetings@aocs.org.

✓ The **European Fat Processors and Renderers Association (EFPRA) Congress** will be held May 31-June 2, 2001, in Helsinki, Finland. This is the first congress of Europe's two merged associations, the European Union Renderers Association and UNEGA (the European Fat Melters Association). For information, contact the congress secretariat by phone (358) 9 58 409 347, fax (358) 9 58 409 555, or e-mail efpra@congreszon.fi.

✓ The National Renderers Association (NRA) **Central Region Convention** is being held June 7-10, 2001, at the Eagle Ridge Resort in Galena, IL. As a follow-up to last year's convention, the second phase of the **American Protein Producers Industry (APPI) Certification Program** will be held June 7 at the same location as the convention. A tabletop exhibit is scheduled for the evening of June 7 and all APPI participants are invited to attend. For information on the Central Region Convention, call Michael Carlson at (920) 494-5233. To register for APPI's certification program, contact Dara John at (660) 277-3469.

✓ The **Australian Renderers Association Symposium** will be held in conjunction with the **2nd Annual World Renderers Organization** meeting July 25-27, 2001, at the Surfers Paradise Marriott Hotel, Surfers Paradise, South East Queensland, Australia. Topics of discussion include marketing rendered products in the European Union, inactivation of pathogens in rendering systems, the feasibility of biodiesel production in Australia, and an international debate on "Over regulation is killing the rendering industry." To register, contact Graeme Banks at (61) 2 96863119, fax (61) 2 96863303, or e-mail gsbanks@ozemail.com.au. ❖

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source has been received. Similarly, reports are 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. ❖

Acknowledgements: Kevin Custer, American Proteins; David Kaluzny, II, Kaluzny Brothers, Inc.; Todd Ferrell, National By-Products; Dr. Bruce Miller, Penn State University; Steve Woodgate, Prosper De Mulder; Dr. Jim Walsh, Georgia Tech; and Gary Smith, Iowa Department of Natural Resources.

Table 6. 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
No. 2 Fuel Oil	$1.03	Per gallon	$7.36	96.17
No. 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:

No. 2 Fuel Oil	140,000 Btu per gallon	7.143 gallons per million Btu
No. 6 Fuel Oil	146,000 Btu per gallon	6.849 gallons per million Btu
All Fats	132,000 Btu per gallon	7.576 gallons per million Btu
All Fats	7.33 lbs. per gallon @ 160 degrees F	