TECHNICAL EVALUATION

Keys Energy Services
Stock Island Power Plant

Biodiesel Test Firing

Monroe County

DEP File No. 0870003-010-AC

Department of Environmental Protection
Division of Air Resource Management
Bureau of Air Regulation

September 29, 2008

I. APPLICATION INFORMATION

A. APPLICANT NAME AND ADDRESS

Keys Energy Services
1001 James Street
Post Office Box 6100
Key West, Florida 33041-6100

Authorized Representative:
Edward Garcia, Director of Generation

B. PROCESSING SCHEDULE

- Received construction permit application (0870003-010-AC) on April 22, 2008 to allow test firing of a biodiesel fuel in combustion turbines (CT) Nos. 1, 2, and 3 at the Stock Island Power Plant.
- Deemed the application complete on May 22, 2008.
- Received waiver of clock until August 21, 2008 on August 7, 2008.
- Received waiver of clock until September 30, 2008 on August 19, 2008.
- Posted the draft construction permit package on September 30, 2008.

C. FACILITY LOCATION

Keys Energy Services proposes to conduct test firing of the biodiesel fuel in CT 1, 2 and 3 at the Stock Island Power Plant located 6900 Front Street Extended, Stock Island, Key West, Monroe County, Florida. The location of Key West relative to the Florida peninsula is shown in Figure 1. The location of Stock Island with respect to Key West is shown in Figure 2.

Figure 1. Location of Key West.

Figure 2. Location of Stock Island.

The plant is located approximately 90 km southwest of the Class I Everglades National Park Wilderness Area.

D. FACILITY CLASSIFICATION CODE (SIC)

Industry No.	4911	Electric Services

E. REGULATORY CATEGORIES

Title III HAP: This facility is not a "Major Source" of hazardous air pollutants (HAP).

Title IV Acid Rain: The facility operates units subject to the Acid Rain provisions of the Clean Air Act (CAA).

Title V Major Source: The facility is a Title V or "Major Source" of air pollution because the potential emissions of at least one regulated pollutant exceed 100 tons per year (tpy). Regulated pollutants include pollutants such as carbon monoxide (CO), nitrogen oxides (NO_X), particulate matter (PM/PM_{10}), sulfur dioxide (SO_2) and volatile organic compounds (VOC).

PSD Major Source: The project is located in an area designated as "attainment," "maintenance" or "unclassifiable" for each pollutant subject to the National Ambient Air Quality Standard (NAAQS). The facility is not one of the 28 Prevention of Significant Deterioration (PSD) source categories, and is subject to the PSD applicability threshold of 250 tpy. Potential emissions of at least one regulated pollutant exceed 250 tpy. Therefore, the facility is classified as a PSD-major source of air pollution with respect to Rule 62-212.400, Florida Administrative Code (F.A.C.), PSD of Air Quality.

NSPS Sources: The combustion turbines specified in this project, are subject to regulation under the new Source Performance Standards (NSPS) for Stationary Gas Turbines, 40 Code of Federal Regulation (CFR), Subpart GG.

NESHAP: The National Emissions Standards for Hazardous Air Pollutants (NESHAP) Subpart YYYY for combustion turbines does not apply because the facility is not a major source of HAP.

Siting: The facility is not a steam electrical generating plant and is not subject to the power plant siting provisions of Chapter 62-17, F.A.C.

II. PROPOSED PROJECT

A. BIODIESEL DESCRIPTION

According to information provided in the application, biodiesel is a renewable, clean burning, oxygenated fuel made from vegetable oils or animal fats. Standard forms of biodiesel feed stock include soybean, rapeseed and palm oils, animal fats and grease. Biodiesel is produced by reacting alcohol (typically methanol) with these natural fats, oils, or grease in a chemical process called transesterification. The resultant product from this process, i.e., biodiesel, consists of mono alkyl esters of long-chained fatty acids. The American Society of Testing and Materials (ASTM) specification for 100-percent biodiesel (B100) is ASTM D6751-07b and is provided in Table 1.

Table 1. B100 Biodiesel Fuel Specifications[1].

Property	ASTM	Limits*	Units	Property	ASTM	Limits*	Units
Flash Point	D93	130.0 min.	˚C	Acid Number	D664	0.50 max.	mg KOH/gm
Water & Sediment	D2709	0.050 max.	% vol.	Free Glycerin	D6584	0.020 max.	% mass
Kinematic Viscosity	D445	1.9 - 6.0	mm^2/sec	Total Glycerin	D6584	0.240 max.	% mass
Sulfated Ash	D874	0.020 max.	% mass	Phosphorous	D4951	0.001 max.	% mass
Total Sulfur	D5453	15 max.	ppm	Distillation Temp.	D1160	360 max.	˚C
Copper Strip	D130	No. 3 max.	--	Calcium/Magnesium	UOP 389	5 max.	ppm
Cetane	D163	47 min.	--	Oxadative Stability	D2274	3 min.	hours
Cloud Point	D2500	Customer	˚C	Sodium and Potassium Metals	UOP391-91	5 max.	ppm
Carbon Residue	D4530**	0.050 max.	% mass				

* Limiting requirements may be agreed upon between purchaser, seller and manufacturers due special operating conditions.
** Carbon residue shall be run on a B100 sample, not B20 or B80 which are the most common biodiesel blends.

Biodiesel can be blended with fossil based diesel to produce blends. For example, 20 percent biodiesel blended with 80 percent diesel is called B20. More information about biodiesel can be found at the following web site: http://www.biodiesel.org/resources/biodiesel_basics/.

According to the application, a specific biodiesel available for this project has the following critical specifications:

- Carbon residue maximum = 0.05 percent; typically <0.01 percent
- Water and sediment maximum = 0.05 percent; typically 0.005 percent
- Sulfated ash 0.02 percent maximum; typically <0.001 percent
- Sodium and Potassium <1 ppm combined
- Calcium and Magnesium <1 ppm combined
- Sulfur = 15 ppm; typically <1 ppm
- Lower Heating Value (LHV) = 115,000 to 117,000 British thermal units per gallon (BTU/gal)
- Higher Heating Value (HHV) = 122,000 to 126,000 Btu/gal
- For comparison HHV of No. 2 fuel oil is 137,000 Btu/gal (typical)

B. PROJECT DESCRIPTION

The proposed project will involve the test firing of up to 250,000 gallons of biodiesel (B100 or blends) in combustion turbines (CT) Nos. 1, 2, and 3 (Emission Unit IDs 007, 008, and 009, respectively) at the Stock Island Power Plant to determine performance and emissions information. These CT are General Electric (GE) Frame 5 models that utilize No. 2 distillate fuel oil (0.05 percent sulfur content) and use water injection to control nitrous oxide (NO_X) emissions. Specifically, CT No.1 is a 23.5 megawatt (MW) GE Model PG5341 while CT Nos. 2 and 3 are 19.77 MW GE Model MS-5001R. According to the application, since biodiesel has a significantly lower sulfur content (typically 0.0015 percent) than the No. 2 fuel oil used at the facility, SO_2 emissions should be lower. According to tests conducted by the Environmental Protection Agency (EPA) on reciprocating diesel engines firing biodiesel versus No. 2 fuel oil, particulate matter (PM), carbon monoxide (CO), and volatile organic compounds (VOC) emissions were lower, but nitrogen oxide (NO_X) emissions were greater when firing biodiesel than when firing No.2 fuel oil.[2] The Department obtained results of this study which are summarized in Figure 3 below. In addition, biodiesel was tested in a GE LM6000 CT at the Brookfield Power Carr Street Generating Plant in Syracuse New York with test results indicating lower NO_X and PM emissions compared to No. 2 fuel oil.[3]

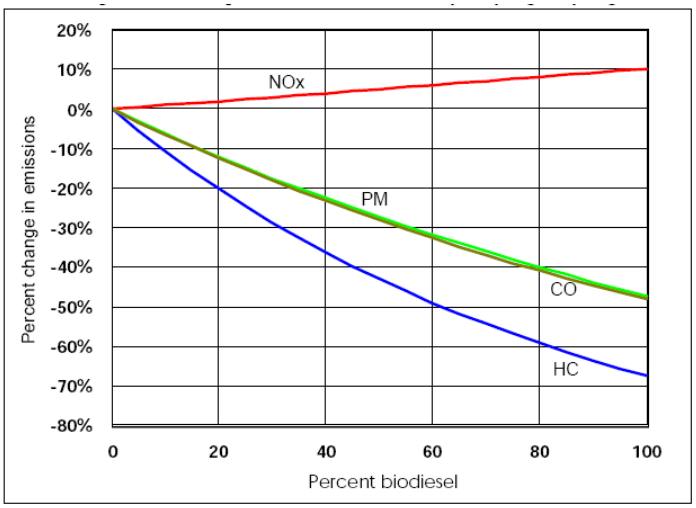

Figure 3. EPA Test Results of Biodiesel Used in Diesel Engines[2].

In summary, the applicant anticipates that firing biodiesel in CT Nos. 1, 2 and 3 will result in lower or equivalent hourly emissions of CO, PM and VOC, while significantly reducing emissions of SO_2. Emissions of NO_X should be equivalent or slightly higher when firing biodiesel compared to firing No. 2 fuel oil. This test project will allow these assumptions to be verified.

Since testing of biodiesel in a GE Frame 5 CT has not been performed, the applicant provided several tables which are combined in Table 2 below. This table provides operation and estimated emissions when using 250,000 gallons of biodiesel in CT Nos. 1, 2 or 3 assuming that short term maximum emission rates are the same as when using 0.05 percent sulfur No. 2 distillate fuel oil. Due to the difference in sulfur content between biodiesel and No. 2 fuel oil, SO_2 emission estimates presented in the table are reduced from normal operational conditions. Additionally, in the table, the emissions resulting from using the biodiesel in the CT are compared to the PSD significant emission rates (SER) thresholds. As seen from the table, according to the applicant, all emissions are less than SER thresholds.

In summary, the applicant has requested the following conditions in the air construction (AC) permit for the test firing of biodiesel at the Stock Island Power Plant:

- Allow storage of the biodiesel in either one of the two 500,000 gallon storage tanks (Emission Unit ID No. 010) that currently store No. 2 diesel fuel oil and provide fuel to CT Nos. 1, 2 and 3 during their operation;
- Allow the test firing of biodiesel-fuel at the facility;
- Fire the biodiesel in CT Nos. 1, 2, and 3 with the most likely candidate being CT No. 3;
- No limit to the number of hours that the biodiesel can be fired in the test units. However, the duration of the test firing will be limited by the duration of the air construction permit for the project;
- The ability to blend the biodiesel with No. 2 distillate fuel oil currently used in the CT; and,
- To limit the use of biodiesel during the duration of the project to 250,000 gallons in total for all CT combined.

Table 2. Estimated Emissions From CT When Firing Biodiesel.[4]

Parameter	Units	CT-1	CT-2	CT-3	Comments
Heat Input	MMBtu/hr	312.00	305.00	305.00	CT-1 @ 59 ˚F
Test Heat Input	MMBtu	30,500.00	30,500.00	30,500.00	Equivalent of 250,000 gallons
	Hours	97.76	100.00	100.00	Equivalent hours for 250,000 gallons
Emissions					
PM10 (15)**	lb/hour	18.00	16.00	16.00	Permit 0870003-008-AV
	tons/yr	0.88	0.83	0.83	Based on hours of biodiesel @ max. output
SO_2 (40)**	lb/hour	0.49	0.48	0.48	Permit 0870003-008-AV
	tons/yr	0.02	0.02	0.02	Based on hours of biodiesel @ max. output
NO_X (40)**	lb/hour	96.00	93.80	93.80	Permit 0870003-008-AV
	tons/yr	4.69	4.69	4.69	Based on hours of biodiesel @ max. output
CO (100)**	lb/hour	64.00	25.20	25.20	Permit 0870003-008-AV
	tons/yr	3.13	1.26	1.26	Based on hours of biodiesel @ max. output
VOC (40)**	lb/hour	6.00	5.55	5.55	Permit 0870003-008-AV
	tons/yr	0.29	0.28	0.28	Based on hours of biodiesel @ max. output

* Biodiesel Calculations: (122,000 Btu/gal (HHV) x 250,000 gallons)/ 1,000,000 Btu/MMBtu = 30,500 MMBtu
** PSD SER thresholds in tpy

RULE APPLICABILITY

A. FEDERAL REGULATIONS

This project is subject to certain applicable federal provisions regarding air quality as established by the EPA in the Code of Federal Regulations (CFR) and summarized below.

Title 40	Description
Part 60	New Source Performance Standards (NSPS)
Part 72	Acid Rain - Permits Regulation
Part 73	Acid Rain – Sulfur Dioxide Allowance System
Part 75	Acid Rain - Continuous Emissions Monitoring
Part 76	Acid Rain - Nitrogen Oxides Emissions Reduction Program
Part 77	Acid Rain - Excess Emissions

Note: Acid rain requirements are included in the Title V air operation permit.

B. STATE REGULATIONS

The project is subject to the applicable environmental laws specified in Section 403 of the Florida Statutes (F.S.). The Florida Statutes authorize the Department of Environmental Protection to establish rules and regulations regarding air quality as part of the Florida Administrative Code (F.A.C.). This project is subject to the following rules in the F.A.C.

Chapter	Description
62-4	Permitting Requirements
62-204	State Implementation Plan (AAQS, PSD Increments, adoption of Federal Regulations)
62-210	Stationary Sources of Air Pollution – General Requirements
62-212	Preconstruction Review (including PSD Requirements)
62-213	Operation Permits for Major Sources of Air Pollution
62-214	Acid Rain Program Requirements
62-296	Emission Limiting Standards
62-297	Emissions Monitoring

C. PREVENTION OF SIGNIFICANT DETERIORATION (PSD) APPLICABILITY

The Department regulates major stationary sources in accordance with Florida's PSD program, as defined in Rule 62-210.200, F.A.C. and approved by EPA in the State Implementation Plan (SIP). A PSD review is only required in areas that are currently in attainment with the NAAQS for a given pollutant or areas designated as "unclassifiable" for the pollutant. A facility is considered "major" with respect to PSD if the facility emits or has the potential to emit:

- 250 tons per year or more of any regulated air pollutant, or
- 100 tons per year or more of any regulated air pollutant and the facility belongs to one of the 28 Major Facility Categories as defined in Section 62-210.200, F.A.C., or
- 5 tons per year of lead.

For new projects at existing PSD-major sources, each regulated pollutant is reviewed for PSD applicability based on emissions thresholds known as the Significant Emission Rates listed in 62-210.200 (Definitions, Significant Emission Rate), F.A.C. Projects that result in a significant net emissions increase are considered "major modifications." For each significant pollutant, the applicant must not only employ Best Available Control Technology (BACT) to minimize emissions but also conduct an appropriate ambient impact analyses. Although a facility may be "major" with respect to PSD for only one regulated pollutant, it may be required to install BACT

controls for several significant regulated pollutants.

As previously established, this facility is a "major source" with respect to the PSD regulations. However, this temporary field-test to fire biodiesel-fuel is not a "major modification" to the existing major source. The test firing of the biodiesel is a limited and a relatively short-term evaluation to determine: (1) emission changes of pollutants (SO_2, NO_X, CO and PM/PM_{10}) that may result from firing the biodiesel and (2) whether firing the biodiesel over the duration of the project results in any operational problems. The current emission limits are not waived during the field test, and neither emissions nor heat rates in excess of the current permit limits are allowed during the biodiesel test firing.

Because no long-term, permanent modification, or increase in potential emissions are being authorized, the Department does not consider this field-test to be a "major modification" for purposes of the PSD regulations.

III. DEPARTMENT REVIEW

A. OVERVIEW

This test project will allow the practicality of using a biodiesel fuel, with regards to emissions and operational factors, to be assessed when firing of the biodiesel fuel in a GE Frame 5 type CT.[5]

B. BIODIESEL EMISSIONS COMPARED TO NO. 2 DISTILLATE FUEL OIL

To assess the possible effects on air emissions from using this biodiesel fuel at the Stock Island Power Plant, the Department developed Table 3 which compares the typical major specifications of No. 2 distillate fuel oil to biodiesel. Based on the fuel specifications presented in Table 3, four points become apparent. First, sulfur emissions when firing biodiesel should be significantly less due to its very low sulfur content. Second, operational issues when using biodiesel could be minimized if the viscosity of the biodiesel used in the project falls toward the low end of the cited range. Third, it is unknown whether the pH of the biodiesel will cause any long-term operational problems. Finally, due to the lower energy content of biodiesel of roughly 90 percent (HHV) when compared to No. 2 fuel oil (124,000 Btu/gal of biodiesel versus 137,000 Btu/gal of No. 2 fuel oil) more biodiesel will have to be burned to generate the same amount of electrical power.

Table 3. Biodiesel Compared to No. 2 Fuel Oil.[6 7 8 9 10]

Property	No. 2	Biodiesel	Units
Flash Point	126	266 min.	˚F
Water & Sediment	0.05 max.	0.05 max.	Vol. %
Carbon Residue	0.35 max.	0.05 max.	Wt. %
Sulfated Ash	0.10 max.	0.02 max.	Wt. %
Viscosity	1.9[(a)]	1.9-6.5[(a)]	mm^2/sec
Sulfur	0.05 max.	0.0015 typ..	Wt. %
Cetane	40 min	40 min	--
90% Distillation Range Temp.	540-640	Not Distilled	˚F
Copper Corrosion	No 3 max.	No. 3b max.	--
Total Glycerin	No Given	2400	ppm
Specific Gravity	0.88[(b)]	0.88[(b)]	
LHV[(c)]	132,000	116,000	Btu/gal
HHV[(c)]	137,000	124,000	Btu/gal
pH[(d)]	--	6 to 8 typical	--
FBN[(e)]	<1000	10	ppm

(a) Viscosity given at 104 ˚F.
(b) Specific gravity given at 60 ˚F.

(c) Approximate values and can vary by source (fuel oil) and feedstock (biodiesel).
(d) The measurement of pH is not applicable to liquid fossil fuels. For biodiesel which is hygroscopic the pH range can vary significantly depending on the water content and if washing for purification was used.
(e) Typical values of fuel based nitrogen (FBN).

In addition to the biodiesel test firing in a GE LM6000 CT cited in the application (Reference 4), where NO_X and PM were reduced when using 99.9 percent biodiesel, the Department was able to find two more instances of biodiesel test firings in CT[11 12]. In the first instance, a 25 percent blend of biodiesel (B25) was burned in a 115 MW Alstom GT 11N CT at the Hopewell Cogeneration Facility in Virginia in August of 2006. Results from this test are summarized in Figures 3 and 4 below. As seen from the Figure 3, oxygen (O_2) emissions are essentially unchanged when firing the B25 blend versus No. 2 fuel oil while NO_X emissions are up by approximately 5 percent. The omega ratio, which is an indicator of steam injection, is unchanged as is the power output. Based on Figure 4, there is a significant drop in SO_2 emission when firing the B25 bend versus No. 2 fuel oil.

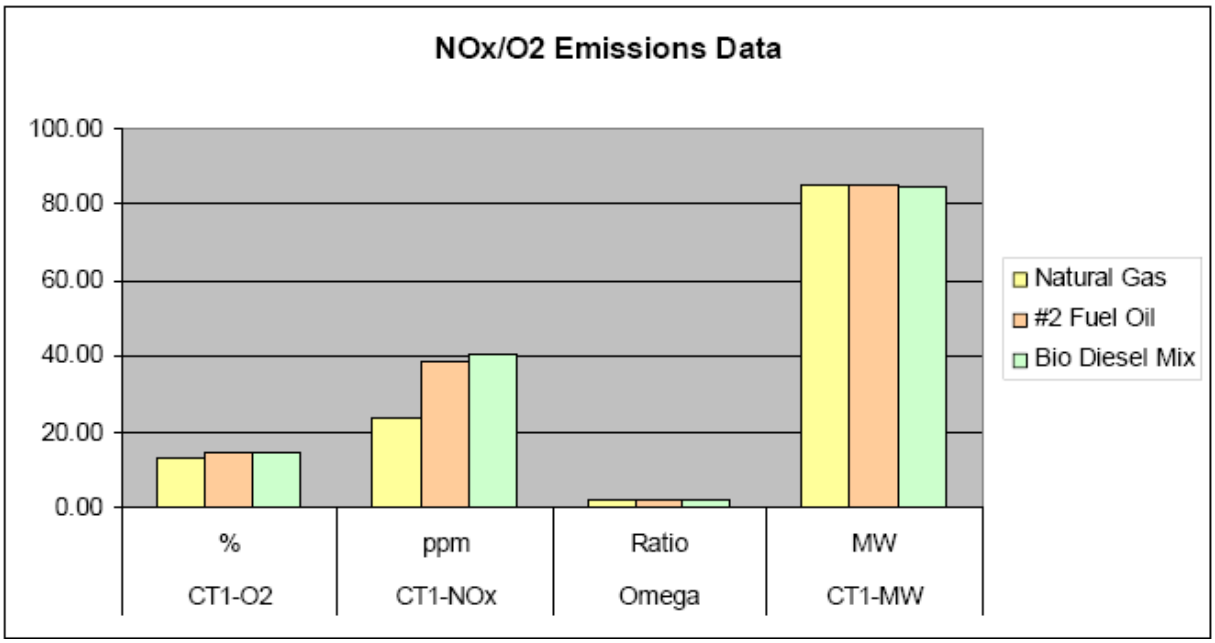

Figure 3. NO_X and O_2 Emissions.

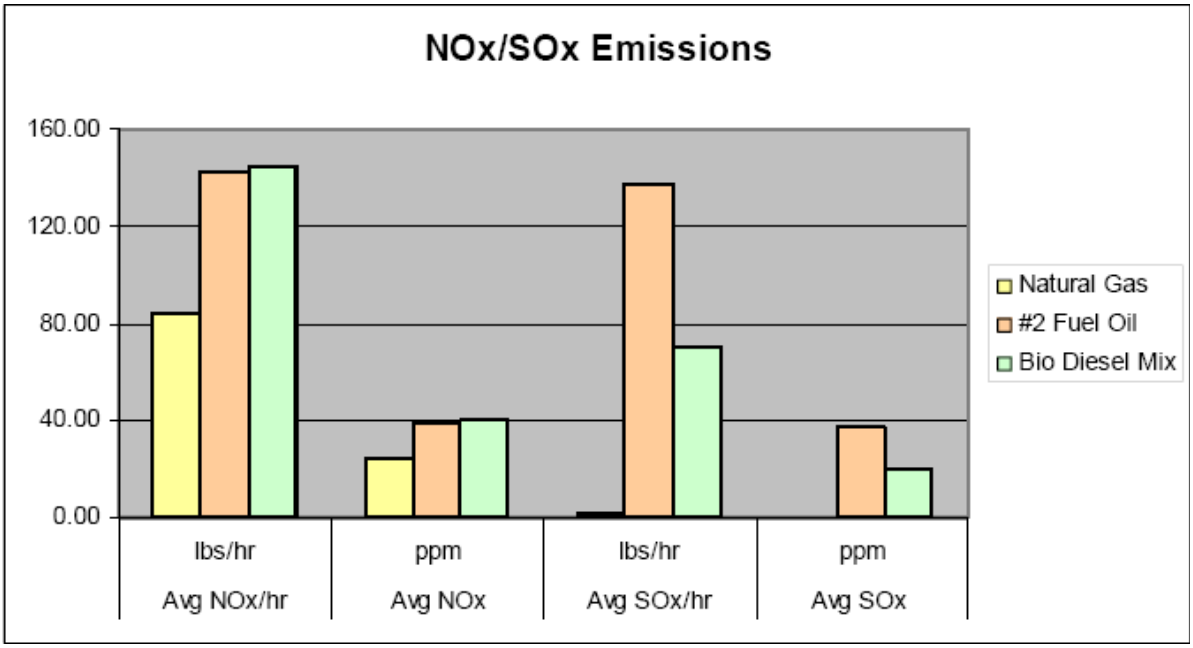

Figure 4. NO_X and SO_2 Emissions.

The second test firing of biodiesel in a CT identified by the Department, which was completed in early July of this year, was conducted by Duke Energy at its Mill Creek peaking CT plant in Blacksburg, South Carolina. As part of this test, biodiesel blends of B100, B80, B50 and B20 were burned in an 81.7 MW GE 7EA CT with dry Low NO_X technology. Early results are promising, with a reduction in all measured pollutant emissions, but the data will not be fully analyzed nor a report issued for several months. However, no significant operational problems were observed when firing any of biodiesel blends in the CT.

In summary, the limited test firing (250,000 gallons total) of biodiesel in the Stock Island Power Plant CT Nos. 1, 2 and 3 should result in emissions of CO, PM/PM_{10} and VOC that are equal or slightly less than when firing No. 2 fuel oil. NO_X emissions should be equal or slightly higher than when firing fuel oil while SO_2 emissions should be significantly less. Anticipated emissions increases/decreases resulting from the test firing of biodiesel are summarized in Table 4. Finally, any emissions increases should be well below PSD SER thresholds.

Table 4. Summary of Expected Effects of Biodiesel Fuel on Emissions.

Pollutant	Emission Effect
SO_2	much less
NO_X	slight increase or equal
CO	less/equal
VOC	less/equal
PM/PM_{10}	less/equal

In Table 5 below, the actual emissions from the CT for the last five years are presented in tons per year. As seen from the table, the emissions from none of the CT are near annual permitted limits. In all but two cases, which are highlighted, each unit's annual hours of operation are less than 400 hours. This further illustrates that the test firing of the limited amount of biodiesel proposed for this project should not pose any danger with regard to exceeding the permitted annual emission limits. However, it should be noted that as per **condition E.10** of the facility's Title V Operation Permit (0870003-008-AV) annual compliance testing of stack emissions are not required if the hours of operation for each individual unit do not exceed 400 hours. Under such circumstances,

the Environmental Protection Agency (EPA) AP-42 emissions factors are used to calculate annual emissions. Consequently, most pollutants emissions presented in Table 5 are estimates.

Table 5. Actual Annual Pollutant Emissions at the Stock Island Power Plant.

	CT-1 (EU 007)				
Year	**NO_X**	**CO**	**PM/PM_{10}**		**Annual Hours**
2007	17.1	10.7	6.0		**407**
2006	11.2	7.0	4.0		258
2005	8.1	5.1	2.9		193
2004	8.3	5.2	3.0		227
2003	9.0	5.6	3.2		233
Permit Limit	138	152	43		2888.5
	CT-2 (EU 008)				
Year	**NO_X**	**CO**	**PM**	**PM_{10}**	**Annual Hours**
2007	4.8	1.2	0.9	0.8	129
2006	1.5	0.4	0.3	0.2	43
2005	10.5	2.7	2.0	1.7	283
2004	6.1	1.6	1.2	1.0	233
2003	2.6	0.7	0.5	0.4	81
Permit Limits	172	101	55	45	4000*
	CT-3 (EU 009)				
Year	**NO_X**	**CO**	**PM**	**PM_{10}**	**Annual Hours**
2007	0.2	0.1	0.1	0.1	3
2006	2.3	0.6	0.4	0.4	68
2005	9.1	2.4	1.8	1.5	270
2004	6.7	1.7	1.3	1.1	227
2003	24.3	6.3	4.2	3.9	**735**
Permit Limits	172	101	55	45	4000*

Finally, as previously mentioned, the energy content of biodiesel (Btu/gal) based on HHV is approximately 90 percent of No. 2 fuel oil. Accordingly, for the same power output, 10 percent more biodiesel by volume would be required to be fired to equal the same power output. This additional fuel throughput in a CT could increase emissions of NO_X on a mass basis reducing the benefit of using the biodiesel. Results from this test firing should help clarify whether this energy content difference is a significant problem.

C. CONCLUSIONS

While the department does not necessarily agree with the applicant's assumptions with regard to overall pollution emissions reductions that will occur when firing the biodiesel, it does not believe that any significant increase in pollutant emissions will result from firing the limited amount of biodiesel (250,000 gallons) requested for this project. This conclusion is supported by the Departments analysis described in **Subsection III-B** above. The Department also agrees <u>that the quantity of emissions from firing the biodiesel as a supplemental fuel and any operational factors compared to operating the facility without the biodiesel fuel, can only be determined by a test firing.</u>

The use of up 250,000 gallons of biodiesel during the test firing period is authorized by the Department. A successful firing of the biodiesel will help in achieving the renewable energy goals of the state.

IV. PRELIMINARY DETERMINATION

The Department makes a preliminary determination that the proposed project will comply with all applicable State and Federal air pollution regulations as conditioned by the Draft Permit. This

conclusion is based on a technical review of the information submitted by the applicant, other reasonable assurances provided by the applicant, a review of the available literature and the conditions specified in the draft permit. David Read is responsible for reviewing the application, preparing the technical evaluation, and drafting the permit. Al Linero, P.E. is the engineer overseeing the project and will be responsible for sealing the evaluation. Additional details of this analysis may be obtained by contacting the project engineer at (850) 414-7268 or the Department's Bureau of Air Regulation at Mail Station #5505, 2600 Blair Stone Road, Tallahassee, Florida, 32399-2400.

References

[1] ASTM International Biodiesel Specification (ASTM 6751-07b).

[2] United States Environmental Protection Agency Report, "A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions", Report No. EPA420-P-02-001, October 2002.

[3] Daratech, Inc., Press Release, "Biodiesel Test Expands GE Energy's Aeroderivative Gas Turbine Fuel Capability", September 21, 2007.

[4] Air Permit Application, Golder and Associates.

[5] Electric Power Research Institute (EPRI), "Bio-Diesel for Gas Turbines", Project ID 1014867, April 2007, www.epri.com.

[6] Kinast, J. A., National Renewable Energy Laboratory, "Production of Biodiesel from Multiple Feedstocks and Properties of Biodiesel and Biodiesel/Diesel Blends", Final Report (1 of 6), March 2003.

[7] Pacific Biofuels Fact Sheet, Carson Oil Company, 2007, www.pacific-biofuels.com/staenergy.asp?id=res&subid=staenergy.

[8] Fuel and Marine Marketing, Industrial Fuel Oil Specifications, Table 1 – Detailed Requirements for Fuel Oils, www.fammpnw.com/indus_specs1.htm.

[9] Industrial Fuel Oil Specifications, ASTM D 396, www.fammpnw.com/indus_specs1.htm.

[10] Engine Manufacturers Association, Test Specification - Biodiesel Fuel, www.enginemanufacturers.org, May 2006.

[11] Suez Energy Generation NA, "Biodiesel Test on an Alstom GT 11N", August 15, 2006, www.resourcesaver.com/file/toolmanager/CustomO124C402F97595.pdf.

[12] Henderson, B., The Charlotte Observer, "Duke Energy Tries Biodiesel Blends", July 17, 2008, www.newsobserver.com/business/story/636953.html.