



MARITIME ADMINISTRATION  
U.S. DEPARTMENT OF TRANSPORTATION



# ENERGY TECHNOLOGIES

NEWSLETTER NO. 01      SPRING 2002

## INTRODUCTION

This is our first, of a series, newsletter that is designed to keep our readers informed of recent and pending events and projects. While this initial newsletter describes Maritime Administration (MARAD) related activities, future issues will include articles of national and interna-

tional importance. We invite and encourage our readership to send us articles or information for publication in the newsletter.

MARAD's Office of Shipbuilding and Marine Technology initiated the Maritime Energy Technologies program to seek through

field demonstrations and studies, economical and efficient power plants energy with zero to near-zero emissions for vessels.

For more information on the program, e-mail [richard.voelker@marad.dot.gov](mailto:richard.voelker@marad.dot.gov).

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## LEADERS GATHER FOR MARAD WORKSHOP



From left to right: Captain William G. Schubert, Maritime Administrator; Norman Y. Mineta, Secretary, Department of Transportation; Honorable Frank A. LoBiondo, Chairman, Subcommittee on Coast Guard and Maritime Transportation, U.S. House of Representatives; and David K. Garman, Assistant Secretary, Energy Efficiency and Renewable Energy, Department of Energy.

**“All of you are here because you recognize the necessity for meeting and answering the twin challenges of energy efficiency along with the reduction and ultimate elimination of**

**marine air pollution.”** With these remarks, Captain William G. Schubert, the Maritime Administrator, opened the two-day Maritime Energy and Clean Emissions Workshop, in Washington, DC, on

January 29 and 30, 2002.

The function was sponsored by the Maritime Administration (MARAD), the Department of Energy and the Environmental Protec-

tion Agency. It featured, among other speakers, the Honorable Norman Y. Mineta, Secretary of Transportation, David Garman, Assistant Secretary of Energy

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## CONVERSION OF A DIESEL FERRY TO DUAL FUEL OPERATION - A FEASIBILITY STUDY

What are the advantages/disadvantages of converting diesel engines to dual fuel operation? What factors need to be considered to evaluate such a change in a marine environment?

In late 2000, MARAD entered into a cooperative agreement with Red and White Fleet, a ferry operator in the San Francisco Bay Area, to determine the physical, regulatory and eco-

nomically feasible of converting a slow speed ferry, the *MV HARBOR QUEEN*, to dual fuel operation.

Dual fuel engines can operate on either all diesel fuel or a mixture of natural gas and diesel fuel. This study was based on operating experience on the Canadian ferries *KLATAWA* and *KULLEET* that were converted to dual fuel over 15 years ago.

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**HARBOR QUEEN**

## MARAD'S MARITIME ENERGY TECHNOLOGIES WEB SITE



*Get caught up  
in our web site*

Have you ever tried searching the Web for "air emissions"? The results can be overwhelming.

Wading through masses of unrelated data to find the answer to your specific question is a daunting task. Over the next months and years, MARAD will strive to make finding that information you need a little easier.

Our web site is new and will continue to change as developments arise. Currently, the site describes MARAD's program and projects, and presentations from our energy workshops.

Our goal is to add features to the site that will assist marine oriented investigators. The Maritime Energy Technologies web site may be

found at <http://www.marad.dot.gov/nmrec>.

Have you found other great air emissions web sites, or report or a book in this field? If so, e-mail [robert.behr@marad.dot.gov](mailto:robert.behr@marad.dot.gov). We will continually add this type of information to our site so we can share it with others.

## CHECK IT OUT...

**CHECK IT OUT...** To view sites of related interest in energy technologies, go to the following:

[www.watertransit.org](http://www.watertransit.org)  
[www.fossil.energy.gov](http://www.fossil.energy.gov)  
[www.dieselnet.com](http://www.dieselnet.com)

[www.meca.org](http://www.meca.org)

- San Francisco Bay Water Transit Authority
- a U.S. Department of Energy website
- the online information service on diesel emissions, emission control, diesel engines, fuels, and more...
- MECA stands for the Manufacturers of Emissions Controls Association

## NATURAL GAS FERRY EMISSION TESTS

A successful series of emissions tests on natural gas powered ferry engines was completed in October 2001. The data analysis and final report are nearing completion and preliminary results are now available.

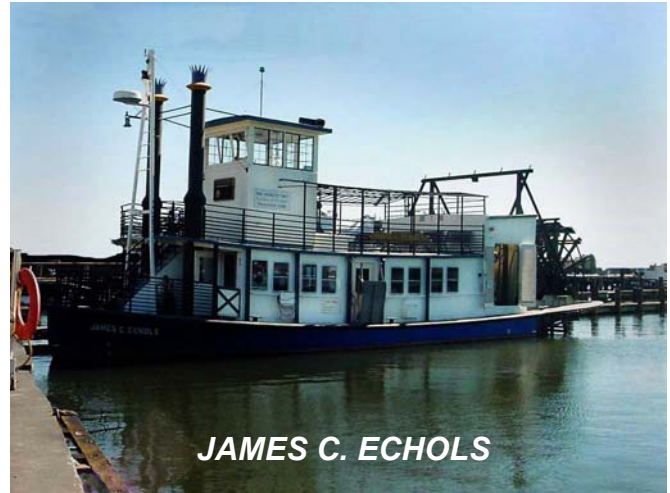
This project compared engine emissions on two nearly identical ferries, owned and operated by the Hampton Roads Transit Authority in Norfolk, VA. Two Caterpillar 3406-G natural gas, spark ignited, four-stroke cycle engines powered one ferry and two 671 Detroit Diesel, two-stroke cycle, diesel fueled engines powered the other ferry.

Emissions, including NO<sub>x</sub>, CO, CO<sub>2</sub>, HC, and particulate matter (PM), were recorded over a series of oper-

ating conditions using a full suite of emissions testing equipment provided by West Virginia University (WVU) and Department of Energy (DOE). For comparison purposes, the Environmental Protection Agency (EPA) provided a separate portable monitoring system.

Although the complete report shows significant differences in emissions at various loads, the following general trends can be identified. In general, the natural gas engines produced 10 to 100 times lower particulates, 2 to 3 times higher CO, 2.5 times higher THC and approximately the same level of NO<sub>x</sub>.

As expected, the natural gas ferry had significantly lower PM emissions, however, the emissions performance



**JAMES C. ECHOLS**

of these engines in terms of other pollutants could have been much better.

All four engines were checked for proper operation and tuning prior to the emissions test. As set up, the natural gas engines were running very rich. An attempt to adjust air-fuel ratios after initial emissions testing resulted in a dramatic drop in emissions at higher powers but also resulted in a significant loss of available power.

It is not clear that the installed air/gas mixer is capable of maintaining an air-fuel ratio that will provide low emissions and sufficient power over the operational range. It should be noted that this application was among the first variable speed marine installations of this engine. It is believed that

provision of a modified air/fuel mixing system with closed loop oxygen controls could provide significant improvements in emissions while maintaining acceptable power.

The primary lesson to be drawn from these tests is that some level of initial emissions testing is critical, particularly on new technology applications. Proper instrumentation must also be provided to permit the operator to assure that the engine is properly adjusted and is performing in accordance with design parameters.

Sponsors of the program included U.S. Coast Guard, Hampton Roads Transit, Norfolk by Boat, DOE, MARAD, EPA, Lyons Shipyard, and Naval Sea Systems Command. The economics of natural gas

*(Continued on page 6)*



**ELIZABETH RIVER II**

## FERRY BIODIESEL TESTING RESULTS—COMING SOON

In September of 2001, MARAD entered a cooperative agreement with the San Francisco Bay Water Transit Authority and the Blue and Gold Fleet. The primary objective was to facilitate a series of emission and performance tests aboard a ferry using biodiesel fuel. A secondary objective was to evaluate the nitrogen oxides (NO<sub>x</sub>) mitigation potential of a bolt-on, inlet air, continuous water injection technology. An overview of the scope of the testing is given below.

The tests were conducted aboard a 425 passenger ferry, the *MV OSKI*, from September until February 2002. The vessel was equipped with a pair of two stroke 12V-71 NA Detroit Diesel En-

gines (since the completion of the tests, the vessel has undergone a planned retrofit of new four stroke engines). Five sets of fuels and technologies were tested. For each technology fuel consumption, lube oil analysis, vessel performance and emissions were evaluated.

Biodiesel is a renewable fuel similar to diesel but formed by the chemical combination of a biological oil with an alcohol. For the San Francisco tests, the feedstock was soybean oil. 100% biodiesel fuel will reportedly reduce most pollutants, with the exception of NO<sub>x</sub>. From a life-cycle perspective, it will also

CO, NO<sub>x</sub>, SO<sub>2</sub> and to calculate CO<sub>2</sub>.

The final report is expected to be submitted in the near future and will include data on technical performance and an economical analysis for each of the five sets of tests. The report will be displayed on the Maritime Energy

Technologies web site and a synopsis of findings will be provided in the next newsletter. MARAD has also entered an agreement with the Department



### Fuels and Technologies Tested

- Baseline No.2 Diesel
- A blend of No.2 Diesel with 20% Biodiesel
- 100 % Biodiesel
- 100% Biodiesel with Continuous Water Injection
- 100% Diesel Fuel with Continuous Water Injection

significantly reduce the green house gas CO<sub>2</sub>.

Continuous Water Injection is a system designed to attach to the engine air inlet system. By injecting measured amounts of water the equipment reduces cylinder peak flame temperatures and resultant NO<sub>x</sub>.

Enerac 3000 Portable Emissions Analyzer was used to measure O<sub>2</sub>,

ment of Energy and the Department of the Navy to test biodiesel fuel in a marine engine test laboratory. Those tests should be performed in conjunction with other, NO<sub>x</sub> mitigating, engine technologies.

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## EMISSION FREE POWER BARGE

Imagine a vessel with zero air emissions while in port unloading cargo or disembarking passengers. This potential can be achieved through the use of zero emission fuel cells on a power barge moored next to a cargo or passenger vessel.

The challenge is to develop a system that is economical and generates clean power that can respond to fluctuating electrical loads aboard the vessel. The platform that provides a mobile source of electric power, capable of being towed or self-propelled, has been given the generic title, *Power Barge*.

There has been a great deal of interest expressed in developing a clean mobile source of power for ships' in-port hotel services. This is particularly true as reductions in marine vessel emissions and port activities are being considered in regional attainment strategies.

Port related emissions are being scrutinized. More than half of United States high-volume ports in 2000 were located in ozone non-attainment areas. In California, it has been determined that ocean-going ships contribute

80 and 7 tons per day of NOx and PM, respectively. Approximately one-third of ship NOx emissions result from in-port hotelling services.

MARAD is supporting the first of a two-stage development and demonstration project. The goal is to demonstrate that off-the-shelf fuel cell technology can be used to power ship hotel services with zero or near-zero emissions. Phase 1 consists of the testing of SurePower Corporation's technology designed to handle transient energy loads. Phase 2 consists of demonstrating the viability of a barge-mounted system.

Phase I addresses transient loads. Fuel cell systems are relatively new technology for the marine industry. They do not respond well to load changes encountered aboard ships. The SurePower DC Link/flywheel/rectifier components are designed to provide energy that cannot be delivered by a fuel cell during a spike in demand. The delivery system was tested in a shoreside facility using simulated ship-loads in March 2002.

Phase II consists of an actual demonstration to

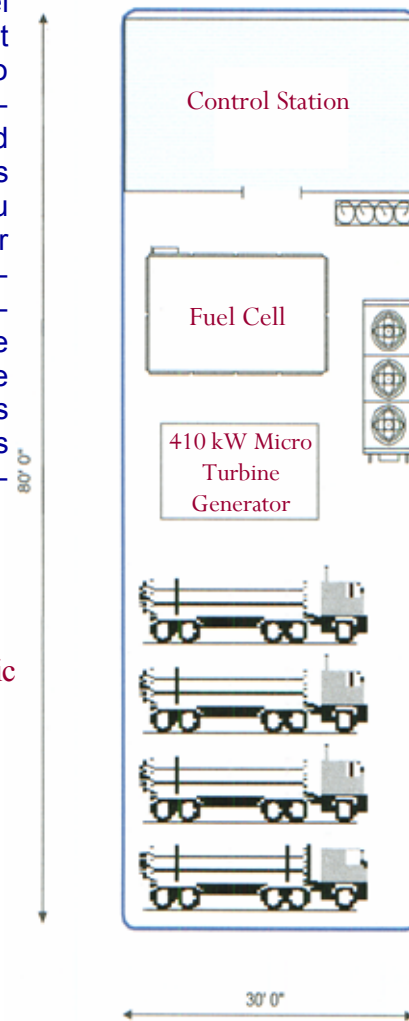
confirm the reliability of the system aboard a vessel. The prototype concept for the Phase II system is shown on Figure 1. Major system components include a 200 kW fuel cell, micro turbine generator(s), a DC Link/rectifier/flywheel assembly, a power/ship interface device, portable CNG tanks, and a non-self-propelled barge.

Natural gas would be reformed for use in the fuel cell. Due to cost limitations, micro turbine generators are proposed as extra sources of power (in lieu of fuel cells) for the demonstration. It is envisioned that the power barge components would evolve as fuel cell technology advanced.

The power barge concept may be the first logical step in the progression of fuel cells from shoreside to ship-board applications. Specifically, once fuel cells have successfully demonstrated their ability to supply variable electrical loads for hotel services, the process of developing installations aboard underway vessels can advance.

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Barge Schematic





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CHECK OUT OUR  
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[http://www.marad.dot.gov/  
nmrec](http://www.marad.dot.gov/nmrec)

**FYI**  
CNG — compressed natural gas  
CO — carbon monoxide  
CO<sub>2</sub> — carbon dioxide  
HC — hydrocarbons  
NO<sub>x</sub> — nitrogen oxides  
O<sub>2</sub> — oxygen  
PM — particulate matter  
SO<sub>2</sub> — sulfur dioxide  
THC — total hydrocarbon

## ENERGY TECHNOLOGIES NEWSLETTER . . .

is published four times a year  
and serves as a forum to con-  
vey timely articles of interest.  
You can find this and additional  
information on our web site at  
[marad.dot.gov/nmrec](http://marad.dot.gov/nmrec)

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### MARAD Workshop

Efficiency and Renewable Energy, Department of Energy, and the Honorable Frank A. LoBiondo, Chairman, Subcommittee on Coast Guard and Maritime Transportation, U.S. House of Representatives.

One hundred thirty industry and public sector leaders participated in the two-day workshop. They represented vessel operators, ports, shipyards, energy and environmental private sector interests, federal, state and mu-

nicipal agencies, foreign governments, and academic institutions.

On the first day, the group addressed environmental policy, together with national and regional air emissions issues. The second day, they focused on emission abatement methods and technology. The record of the proceedings and copies of the individual presentations are available on the MARAD web site at [www.marad.dot.gov/nmrec](http://www.marad.dot.gov/nmrec) click on "Conferences".

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(Continued from page 2) **Dual Fuel Conversion**

The report provides useful background information on evaluating the use of dual fuel or straight natural gas in marine applications. The full report and summary of the results can be found at [www.marad.dot.gov/nmrec](http://www.marad.dot.gov/nmrec).

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(Continued from page 3) **Natural Gas**

and the results obtained from emission measurement equipment will be discussed in the next issue of this newsletter. Copies of the report will be available on the MARAD web site when completed.

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### Technology Demonstrations

In the near future, a member of our Maritime Energy Technologies team will be contacting many of you to obtain information on demonstration projects conducted in your ports. Feel free to submit any information you would like to share. It is our intent to assist you by developing a place on our web site where we can learn from each other by sharing our project details and lessons learned.

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