U.S. Department of Transportation
Maritime Administration
Office of Shipbuilding and Marine Technology

Energy Technologies

Newsletter No. 02 Fall 2002

Introduction

This issue provides updates on a number of our major program activities, including the establishment of new research partnerships with the Naval Sea Systems Command (NAVSEA) and SCX Ferries, Inc. Also provided are the results of completed technology demonstrations regarding fuel cells, a nitrogen oxides (NOx) reduction technology, and biodiesel fuel.

See page 3 of the Newsletter for a featured article by Mary Culnane of the San Francisco Water Transit Authority (WTA). Steady progress toward the development of a zero-emission fuel cell ferry is described therein.

The diagram on page 5 depicts the U.S. national energy supply and consumption as published by the Energy Information Administration's Annual Energy Review 2000. It provides data on the source of energy and its production (domestic or imported). It also shows that transportation consumes almost 27 percent of the Nation's energy.

For subsequent issues, we continue to invite and encourage informative articles from our readers.

INSIDE THIS ISSUE:

MARAD and SCX Ferries Sign Research Agreement

The Maritime Administration (MARAD) entered into a Cooperative Research Agreement with SCX Ferries, Inc. The agreement, signed on September 10, 2002, will examine the performance of nitrogen oxides (NOx) and particulate matter (PM) emission control systems aboard a hydrofoil ferry serving the San Diego, CA, commuting area.

SCX is conducting a one-year hydrofoil ferry commuter demonstration from Oceanside to San Diego under an arrangement with the Port of San Diego and the California Department of Transportation (CALTRANS).

The company is also seeking to extend the demonstration to points in the Los Angeles area as a method of relieving traffic congestion from the I-5 corridor.

The *M/V WESTFOIL,* the vessel to be used in the project, is equipped with a new hydrofoil, ride control and waterjet propulsion systems. It is 85 feet in length and capable of carrying 149 passengers. The vessel will be leased from Pacific Marine, Inc., of Honolulu, HI, and Hornblower Marine, Inc., will be responsible for its daily operations. The *WESTFOIL* has four Detroit Diesel 12v92 TA engines

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FUEL CELLS—ABOARD SHIP?

What will it take to get fuel cells aboard ships? A first step in the process is to determine whether a fuel cell-based, electrical-power generating system can actually respond to highly variable shipboard electrical or propulsion loads.

Accordingly, MARAD and SurePower Corporation entered into a Cooperative Research Agreement to test and observe a fuel cell system's response to simulated marine power loads. The SurePower system incorporates two 200 kW phosphoric acid fuel cells and a flywheel energy storage unit.

Seaworthy Systems, Inc., was enlisted to develop the testing protocol. Some creativity was involved as fuel cells are not addressed by marine regulatory agencies or classification societies. Additionally, fuel cells figuratively combine the prime mover and generator into a single unit. A combination of American Bureau of Shipping (ABS) and Institute of Electrical and Electronics Engineers (IEEE) requirements for power systems installed aboard ships were ultimately utilized. These tests are summarized in the below table.

The tests demonstrated that the system met all regulations as they apply to rotating, alternating and direct current generators, with the exception of the 300% overload test. The latter negative outcome may have resulted from monitoring equipment limitations. It is intended that a re-test can be conducted in 2003.

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Fuel Cell Tests Performed

Test No.	Description	Organization
1.1	Operational Reliability, 60 min, 100% load	ABS
1.2	Operational Reliability, 30 min, 110% load	ABS
1.3	Operational Reliability, 4 hours, various loads	ABS
2.1	Voltage Stability, +/-2.5% VAC of rated voltage - 0-100% load	ABS/IEEE
2.2	Voltage Stability, 150% load, starting	ABS/IEEE
2.3	Voltage Stability, 300% load, momentary	ABS/IEEE
3.1	Frequency regulation during load change - 100%-0%-50%-100%	ABS
3.2	Frequency regulation during load change - 0%-75%-100%-25%-0%	IEEE
4.1	Parallel Operation, load sharing stability	ABS/IEEE

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SCX Ferries

each rated at 1050 BHP at 2300 RPM.

The SCX agreement with the Port of San Diego requires the installation of emission control systems aboard the vessel. The company is currently considering using a combination of water injection systems for NOx reduction and a low sulfur diesel fuel for sulfur oxides (SOx) and PM reductions.

The Department of Energy has agreed to assist in the research program by committing the services of West Virginia University's Mobile Source Testing Laboratory. This mobile lab will be utilized to perform the emission measurements early next calendar year.

Should the ferry operation prove successful, SCX may build new vessels. Liquefied natural gas (LNG) will be one of the fuels considered for the new hydrofoil design. As part of the present Cooperative Research Agreement, MARAD will sponsor a study assessing the potential supply and comparative costs of using LNG in the proposed SCX operating areas.

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FEATURED ARTICLE
SAN FRANCISCO ZERO-EMISSION FERRY

This article was contributed by: Mary Culnane, San Franisco's Bay Area Water Transit Authority (WTA) and Chris McKesson, John J. McMullen Associates (JJMA).

San Francisco's Bay Area Water Transit Authority (WTA) is actively developing a fuel cell powered ferry in order to move toward a zero-emissions future. The envisioned vessel will showcase the marine application of fuel cells for propulsion and provide an opportunity to gain essential operational experience. The vessel is intended to serve Treasure Island, approximately three miles from the San Francisco city front.

WTA awarded a contract to John J. McMullen Associates (JJMA) to develop design drawings for the vessel. JJMA's stated intent is to keep the points of innovation to a minimum, insofar as that is consistent with the fuel cell concept. This means that it will not develop a specialized hull design, but will instead attempt to develop a propulsion package that is compatible with a number of suppliers' "catalog" ferry designs.

Further, JJMA intends to use an off-the-shelf fuel cell in its design. Following acceptance of the design, WTA will procure the vessel in a conventional bid process, and the major fuel cell components will be owner furnished.

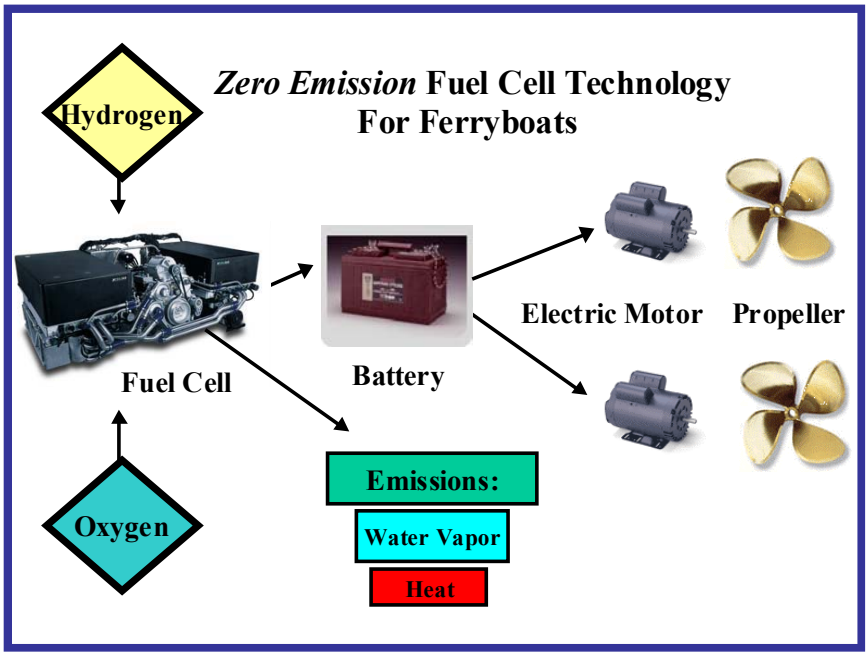
The design is focused on fuel cell "engines" being developed for use in transit buses. For example, two 200 kW bus "engines" would be sufficient to drive a 49-passenger ferry at about 12 knots, even after accounting for the weight of the system.

Another, potentially larger, issue is the matter of fuel storage. Again, following a philosophy of "minimum innovation", the current thought is to simply carry compressed hydrogen gas to fuel the cell.

As with the transit bus units, the ferry would carry a roof-mounted "tank farm" of hydrogen cylinders, amounting to some 80,000 standard cubic feet of gas. This tank farm would encompass a volume of 20 feet by 20 feet by 3 feet.

An issue not yet fully addressed is regulatory approval of a hydrogen fuel system. The U.S. Coast Guard has approved natural gas fuel for ferries in some cases, and it is hoped that the same design techniques used for natural gas would result in approval of hydrogen. In this connection, it should be noted that both gases are lighter than air and both have been carried in liquefied and compressed forms (although at present only compressed hydrogen is being considered for the ferry).

WTA's fuel cell ferry design project is scheduled for completion in early to mid 2003. At that time, WTA will hopefully be positioned to obtain funding for construction of a true zero-emission ferry and to lead the way in exploring a possible new future for ferry propulsion.



NAVY EMISSION TEST PROGRAM

MARAD has joined forces with NAVSEA-Philadelphia in a Navy Emission Test Program. Commencing January 2003, the testing of five fuels and six emission reduction technologies (see below) will be conducted by the Ship Systems Engineering Station's Marine Engine Test Laboratory. All equipment and fuels will be tested on a reconditioned, naturally aspirated, two-stroke, 12V-71, Detroit Diesel engine.

Program objectives are to assess performance and criteria pollutants generated by the various fuels and abatement technologies under controlled laboratory conditions. Subsequently, a shipboard evaluation will be conducted to assess reliability and durability of one or two combinations of optimal technologies. Particular attention will be given to NOx and PM emissions. The engine model is very common within the workboat fleets of the Navy, Army, other federal agencies, and commercial maritime industry. Results will be disseminated to all interested fleet operators.

Fuels to be Tested				
F-76 (Similar to Diesel No. 2)	JP-5 (Military Aviation)	Synthetic (Fischer Tropsch Diesel)	Diesel (Ultra Low Sulfur)	Biodiesel (Soy Based Methyl-Ester)

Equipment to be Tested					
Fuel Catalyst Additive	Air Humidification System	Cylinder Power Assemblies	Mini-Sac Injectors	Active Regenerated Particle Filter	Centrifugal Soot Collector

The test plan incorporates a total of 25 configurations utilizing International Organization for Standardization (ISO) 8178 propulsion, generator, and auxiliary engine test cycles. Performance data will be collected in addition to emission measurements of NOx, PM, hydrocarbons (HC), carbon monoxide (CO) and opacity. Particulate matter will be broadly characterized both physically in terms of size and chemically in terms of composition.

Other partners for the testing program include the Office of Naval Research, California Air Resources Board, South Coast Air Quality Management District, Environmental Protection Agency, and Department of Energy.

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FERRY ENGINE CONTINUOUS WATER INJECTION AND BIODIESEL TEST RESULTS

In June 2002, Blue and Gold Fleet and the San Francisco WTA released the results of emission testing conducted on the 400-passenger ferry *MV OSKI*. The *OSKI* is powered by twin two stroke, 12V-71, Detroit Diesel engines. The testing established NOx and PM emissions for baseline operation with low sulfur diesel fuel, for a 20% blend of biodiesel, for 100% biodiesel, and for a continuous water injection system with both low sulfur diesel and 100% biodiesel fuel.

The biodiesel fuel was a soy based methyl-ester type. Biodiesel is a renewable energy source that reduces greenhouse gases and particulate matter. However, biodiesel often increases NOx emissions. In order to reduce NOx, a continuous water injection system was installed to inject finely atomized water droplets in the engine's intake air system. Water injection reduces maximum combustion temperatures and consequently reduces NOx emissions.

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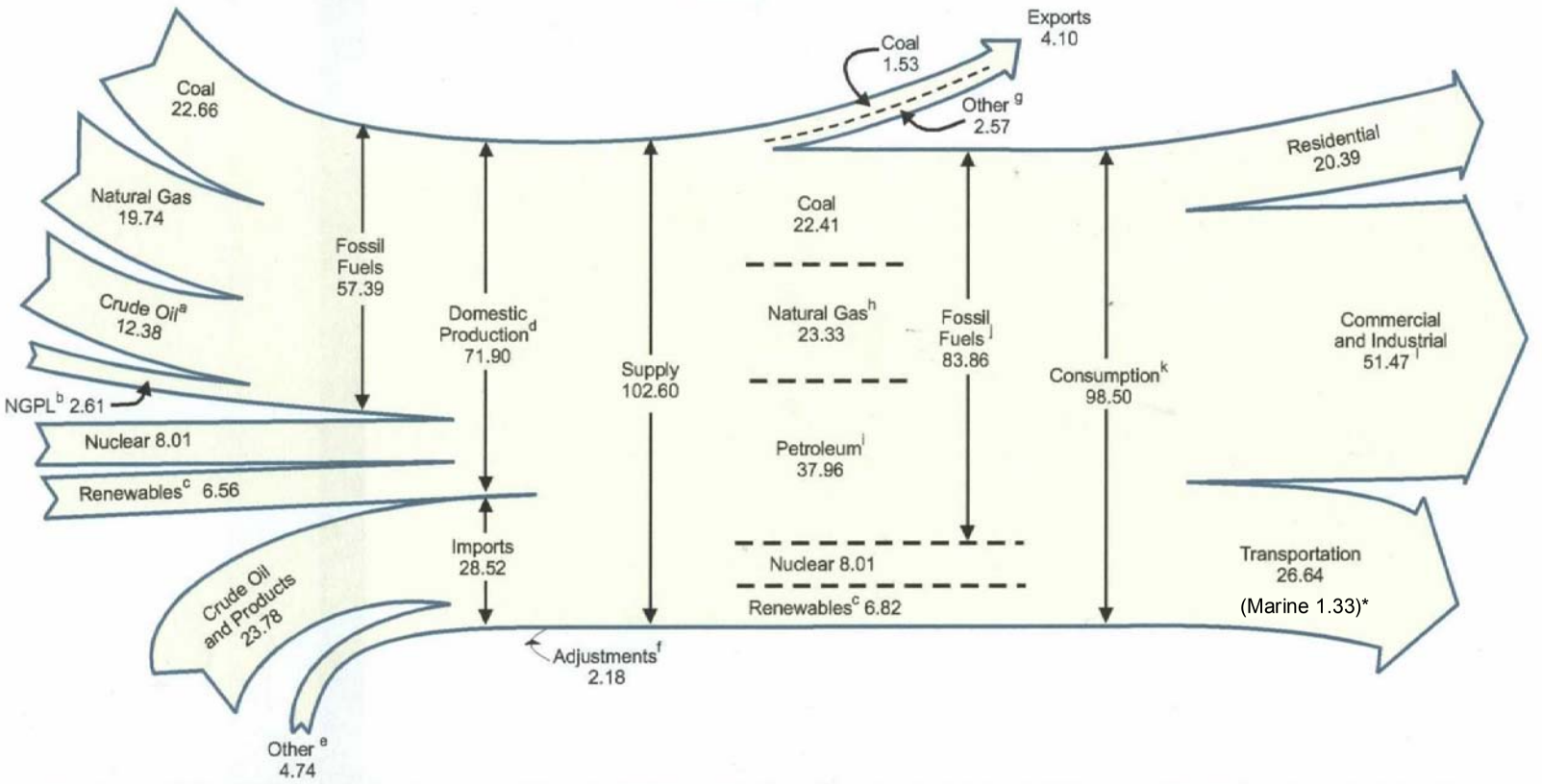
Energy Flow, 2000
(Quadrillion Btu)



[a] Includes lease condensate.
[b] Natural gas plant liquids.
[c] Conventional hydroelectric power, wood, waste, ethanol blended into motor gasoline, geothermal, solar, and wind.
[d] Includes -0.06 quadrillion Btu hydroelectric pumped storage.
[e] Natural gas, coal, coal coke, and electricity.
[f] Stock changes, losses, gains, miscellaneous blending components, and unaccounted-for supply.
[g] Crude oil, petroleum products, natural gas, electricity, and coal coke.
[h] Includes supplemental gaseous fuels.
[i] Petroleum products, including natural gas plant liquids.
[j] Includes 0.07 quadrillion Btu coal coke net imports and 0.10 electricity net imports from fossil fuels.
[k] Includes, in quadrillion Btu, 0.10 electricity net imports from fossil fuels; -0.06 hydroelectric pumped storage; and -0.14 ethanol blended into motor gasoline, which is accounted for in both fossil fuels and renewables and removed once from this total to avoid double-counting.
[l] Commercial and industrial sector totals plus adjustments to avoid double-counting the amount of petroleum, natural gas, and coal that is included under both "End-Use Sectors" and "Electric Power Sector." See Tables 5.12d, 6.5, and 7.3.

Notes: • Data are preliminary. • Totals may not equal sum of components due to independent rounding.

Sources: Tables 1.1, 1.2, 1.3, 1.4, and 2.1a-2.1f.

Energy Information Administration/Annual Energy Review 2000

*Marine transportation percentage as derived by MARAD from the Transportation Statistics Annual Report 2000.

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FYI

CNG — compressed natural gas
CO — carbon monoxide
CO_2 — carbon dioxide
HC— hydrocarbons
NOx — nitrogen oxides
O_2 — oxygen
PM — particulate matter
SOx — sulfur oxides
THC — total hyrdrocarbon

Energy Technologies Newsletter . . .

serves as a forum to convey timely articles of interest. You can find this and additional information on our web site at marad.dot.gov/nmrec

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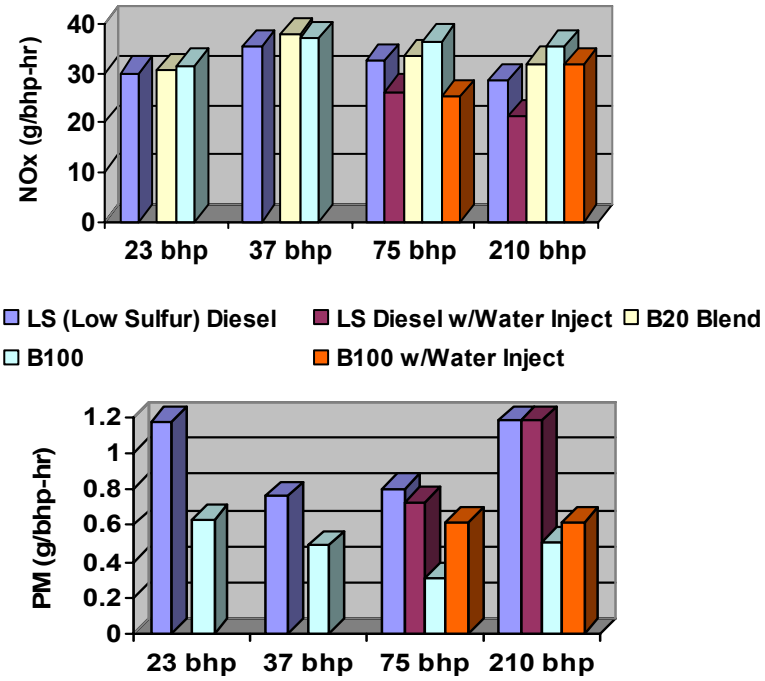
Ferry Engine Test Results

The following bar charts provide brake specific NOx and PM emissions for each condition tested. At the data points tested, B20 produced a NOx increase ranging from 2-11% and the B100 increase ranged from 5-20%. The water injection system, which was only operated at higher powers, reduced NOx by averages greater than 20%. B100 generally reduced PM emissions by over 50%.



Exhaust gas composition was measured with an Enerac Model 300 portable emission analyzer. PM was measured by weighing the accumulation of particulate on a quartz filter with no dilution tunnel. Formal fuel performance tests were not conducted, but the operator stated there was no noticeable change in consumption when the continuous water injection system was applied.

Blue and Gold, a ferry operator in San Francisco Bay, managed the project with MARAD as a co-sponsor. The water injection equipment was purchased from MA Turbo/Engine Ltd. of Vancouver, British Columbia. The biodiesel fuel was purchased from World Energy, Inc. Testing and test reports were by Walther Engineering.

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Technology Demonstrations

We welcome the opportunity to publish on our web site the status and/or results of demonstration projects in which you are engaged. If you are willing to share such information with our readers, please contact MARAD's Office of Shipbuilding and Marine Technology.

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