NOAA GREEN SHIP INITIATIVE

Development of Biodiesel and Bio-Products in Marine Applications

The National Oceanic and Atmospheric Administration (NOAA) operates a fleet of research vessels and small boats on the Great Lakes through its Great Lakes Environmental Research Laboratory (GLERL). As part of its larger stewardship mission in the marine environment, NOAA has explored options to convert its research vessels from petroleum-based fuels and lubricants to renewable and environmentally-friendly products that reduce fossil fuel emissions.

GLERL's Green Ship Initiative, begun in 1999, has led the nation by successfully converting the laboratory's entire diesel-powered vessel fleet to biofuels and bio-lubricants. This effort produced the first federal vessel to run completely on non-petroleum products. The marine diesel-powered vessels in the Great Lakes are now fueled by B100 (100%) soy biodiesel, a true renewable energy source. This is a significant advancement over the use of B20 petroleum blends (20% biodiesel and 80% petroleum diesel). All other

Leading the Way

Now that GLERL has met its goal of converting its vessel fleet to 100% biofuel, the lab is sharing its expertise to help others convert their vessels to petroleum-free operation. In 2002, GLERL formed the Green Ship Working Group, which has helped more than 150 small vessels from both the government and private sectors convert to biofuel.

In 2010, GLERL began to focus its technology transfer efforts on the federal government through the Federal Green Fleet Working Group. Through this group, GLERL shares its expertise and resources and collaborates on projects with other federal agencies interested in marine applications of biofuels. As a leader in the field, GLERL developed a 5-Step Conversion Process to help other agencies move towards the use of biofuels in their large vessels. In 2011, both the U.S. Army Corps of Engineers (USACE) and the Maritime Administration (MARAD) conducted marine biofuel tests. The USACE test successfully implemented GLERL's Green Ship principles on four vessels stationed around the country. MARAD conducted one of the first large-scale tests of a biofuel consisting of 50% petroleum-based diesel and 50% biodiesel made from algae, which many experts believe is a

Advantages of Biofuels

B100 biodiesel has many benefits over traditional, petroleum-based diesel fuel. It reduces air pollution, costs less than petroleum diesel, and results in cleaner engines. Experts estimate that about 1/3 of our transportation fuel needs can be met by domestically-produced biofuels.

Environmental & Social Benefits

- Decreases emissions of fossil fuels that contribute to climate change and air pollution
- Lessens risk of environmental harm in the event of a fuel spill
- Reduces dependence on imported oil
- Supports agriculture and the U.S. economy

Operational Benefits

- Improves engine performance
- Extends engine life
- Reduces need for engine maintenance due to cleaning properties of biodiesel
- Reduces operating and maintenance costs by 20-40% vs. petroleum-based fuels

Human Health Benefits

- Reduces exposure to harmful and cancer-causing chemicals
- Reduces seasickness due to less offensive odor

DID YOU KNOW?

- Ethanol and biodiesel, the primary biofuels in use today, can be blended with or substituted for gasoline and diesel for use in unmodified automobiles, trucks, and ships.
- Biodiesel in GLERL's vessels is made from soybean oil, but can be made from many agricultural products. Even used cooking oil can be reprocessed as a biofuel.
- Rapeseed and canola oils are part of the mustard or cabbage family and can be used for motor oils and hydraulic fluid.

Follow us:
Twitter @NOAA_GLERL
Facebook /noaa.glerl
YouTube /noaaglerl
Flickr /noaa_glerl

GLERL
Great Lakes Environmental Research Laboratory

www.glerl.noaa.gov/pubs/brochures/GreenShip.pdf

What's Ahead?

Although GLERL has reached its Green Ship goal of petroleum-free operation and is helping others do the same, work remains to evaluate the conversion and to explore future opportunities to expand use of renewable fuels in other aspects of GLERL's research. With more than a decade of experience, GLERL has compiled one of the largest data sets on the effects of biofuels and bio-products on marine engines. Initial results of these activities suggest that the technologies developed at GLERL are viable. Key ongoing activities include:

- Monitoring and documenting long-term effects of B100 use on engine components.
- Completing field tests and evaluating of use of bio-crankcase oils.
- Identifying and implementing measures to reduce nitrogen oxide (NOx) emissions associated with biodiesel.

Green Tips for Recreational Boaters

Any diesel-powered boat can be converted to run off biofuels, just like GLERL's vessel fleet. Converting your boat is not only good for the environment, it's better for the health and safety of you and your family. Even gasoline-powered vessels can "go green" by using bio-based oils and lubricants. There are many technologies emerging to make recreational boating more environmentally-friendly, including the use of alternative fuels such as ethanol and butanol that can improve engine performance and reduce air pollution. GLERL has assisted industry groups in evaluating alternative fuels for gasoline engines and has helped develop best industry practices.

In addition to biofuels, there are many other ways to reduce your recreational vessel's impact on the environment. These include eliminating overboard discharges of waste, following best practices for fueling your boat, and using environmentally-friendly alternatives to anti-fouling bottom coatings. These tips and more are available from the U.S. Environmental Protection Agency at www.epa.gov/otaq/boat-fs.htm and

eartheasy.com/play_eco-friendly_boating.htm.

You can also help the environment by docking your boat at a certified Clean Marina that is committed to environmental stewardship. More information on Clean Marinas is available from NOAA at coastalmanagement.noaa.gov/marinas.html.

Green Ship Project Timeline

1999 – Diesel exhaust filter test and after-treatment test on the R/V *Shenehon*. (The 67-foot vessel, built in 1953, served GLERL for several decades and was retired in 2010.)

2000 – R/V *Shenehon* converted to B100 and showed immediate reductions in visible emissions, smoke, and offensive odor with unchanged performance in main engine or generator. This was the first federal vessel in the nation to operate on 100% biodiesel.

2001 – R/V *Shenehon* and R/V *Laurentian* started on bio-based hydraulic oil.

2002 - Green Ship Working Group formed to help convert vessels in many sectors to biofuel.

2005 – R/V *Huron Explorer* converted to the first petroleum-free vessel through use of B100 and bio- motor, hydraulic, steering, and transmission oils.

2006 – April Dept. of Energy Award in recognition of GLERL leadership in Green Ship Initiative. In May, all three GLERL vessels transitioned to total petroleum-free operation.

2008-2010 - GLERL added seven more vessels operating on 100% biofuels and bio-products to its fleet.

2010 - Federal Green Fleet Working Group formed to help other federal agencies convert vessels to petroleum-free operation.

2011 – Through the Federal Green Fleet Working Group, the U.S. Army Corps of Engineers conducted a test successfully transferring GLERL's Green Ship principles to its vessel fleet.

Proven Results

Data collected by GLERL since the conversion of its vessel fleet to biofuels show significant environmental benefits and cost savings. The table shows GLERL's average B100 (100%) soy biodiesel emissions reductions as compared to #2 petroleum diesel. In some cases, these observed reductions are better than those predicted for B100 by the U.S. Environmental Protection Agency. In addition to these environmental benefits, GLERL has seen a 20-40% cost savings since converting its vessels to biofuels.

Emission Reductions: B100 vs. Petroleum

Total Unburned Hydrocarbons	-77%
Carbon Monoxide	-48%
Particulate Matter	-59%
NOx (nitrogen oxide)	-7%
Sulfates	-74%

For more information: **Dennis Donahue, Marine Superintendant**

NOAA Great Lakes Environmental Research Laboratory • 4840 S. State Rd. • Ann Arbor MI 48108 • 734 741-2235