

Foss Maritime Green Assist™ Hybrid Tugboat

Technology Manufacturer

Foss Maritime
Aspin Kemp & Associates
XeroPoint

Co-Participants

Port of Long Beach, Port of Los Angeles, South Coast Air Quality Management District, California Air Resources Board



Background

Foss Maritime achieved several significant milestones in the development of the World's first diesel electric hybrid tugboat. Christened the *Carolyn Dorothy*, the FOSS Green Assist™ hybrid tug was unveiled on January 23, 2009 and began working in the harbor immediately, even though some systems were still being commissioned. All system commissioning was complete on March 1, 2009, at which point the *Carolyn Dorothy* became a full working member of the Foss Maritime tug fleet. Since this time, the hybrid tug demonstrated performance comparable to a conventional Dolphin Class tugboat.

Technology Description

The Green Assist™ hybrid tug was built by Seattle-based Foss Maritime in partnership with Aspin Kemp & Associates and their affiliate XeroPoint, which developed the unique hybrid power management system. At the heart of the Foss Green Assist™ project is the Dolphin class tug currently operated by Foss at the Ports of Long Beach and Los Angeles. The conventional diesel-fueled tugs are powered by Caterpillar main engines producing a total of 5,080 bhp and a bollard pull of 60 tons. Externally, the *Carolyn Dorothy* is quite similar in appearance to its conventionally powered forebears. The only noticeable evidence of its unique power plant is a pair of smaller exhaust stacks.

The tug's diesel-battery-electric propulsion system comprises two fully azimuthing propulsion units powered by batteries, diesel generators and/or two diesel main engines. A modified engine room accommodates two battery packs, producing the equivalent of 670 horsepower, and two 335 horsepower diesel powered generators. The main engines are substantially smaller and less powerful than those in the existing Dolphin class tugs.

An essential feature is the power management system required to produce seamless transition from one power source to another, depending on the tug's duties and the power demand. In its various modes of operation, the new tug employs battery power idling and no-wake low speed maneuvering and a combination of battery and generators for transiting. When full power is required, the diesel main engines start automatically and are coupled by clutches to the drive system in addition to the electric motors. Surplus power generated at any stage is used to recharge the battery packs.

Although the main engines in the new tug are smaller than those of existing vessels, the same total horsepower and the same 60 tons bollard pull is available. The Green Assist™ Tug has four distinct modes of operation:

STOP - When the tug is docked at the pier. Main engines are off-line; power is provided by batteries for hotel loads (lighting, HVAC, etc.) and can be recharged by shore power;

IDLE - When the vessel is not secured to a pier but is stopped at sea. Main engines are off-line. Batteries provide power for hotel loads and station keeping. A generator automatically starts up and comes on line to recharge batteries;

TRANSIT - Continuous slow and fast transit 6-8 knots. One generator for the slower “harbor – speed” transit of approximately 6 knots. The second generator automatically starts when the throttle setting calls for a faster speed transit of about 8 knots. Batteries provide “ride-through” power until the second generator is online. The generators also are providing hotel loads and are recharging the batteries while simultaneously providing the propulsive power.

ASSIST - Full power ship-assist requirements. Both main engines, generator sets and batteries provide full power.

Based on the operating profile of the conventional Dolphin tugs currently operating in the Ports, it is estimated that the hybrid will spend at least 75 percent of its operating hours in the operating modes without main engines. Only batteries and generators are used during idle or low speed/low load operation, but the vessel is able to access full power on demand.

Results

Foss completed development of the project test plan in September 2009, and formed a Technical Working Group (TWG) with Foss, POLB, POLA, CARB, EPA, SCAQMD, and the Pacific Merchant Shipping Association in the fall of 2009. In late 2009, the UC Riverside College of Engineering – Center for Environmental Research and Technology (CE-CERT) began test equipment acquisition and software code upgrades to prepare for test plan implementation. Full system and emissions testing was conducted in early 2010. This project’s final report is available for download from the TAP website.

Benefits

The hybrid tugboat achieved emission reductions that exceed original targets (to reduce both NO_x and PM by approximately 44%) when compared with the Dolphin tugs currently operating in the San Pedro Bay. The *Carolyn Dorothy* reduced PM, NO_x and CO₂ emissions by 73%, 51% and 27%, respectively. Based on this evaluation, fuel consumption is reduced by approximately 20 to 30 percent.

The measured emission levels of the *Carolyn Dorothy* are cleaner than the U.S. EPA’s Tier 2 emissions standard for marine engines. Along with less pollution, the Green Assist™ tug offers improved fuel economy and requires significantly less maintenance. It is also quieter than its Dolphin sister tugs when operating on batteries that can be recharged using environmentally friendly shore power.

Project Costs

The overall cost for the design, development and commissioning of the *Carolyn Dorothy* was over \$8 million. The Port of Long Beach provided \$500,000 in TAP funding, and the Port of Los Angeles provided \$889,920 in non-TAP funding to support this project. Additional in-kind support was provided by CARB and SCAQMD. Remaining costs were covered by Foss Maritime.

Follow-On Project

The Port of Long Beach and the Port of Los Angeles teamed with Foss to implement the “Tugboat Hybridization Project”. This \$2.3 million project is funded in part by a \$1 million grant from CARB’s AB 118 Air Quality Investment Program. The tugboat *Campbell Foss* was retrofitted with hybrid technology, followed by an in-service evaluation for emissions reductions and fuel savings. The tugboat has been incorporated into Foss’ operations.

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