

Capacity Plug-In Hybrid Electric Terminal Tractor

Technology Manufacturer

Capacity of Texas, Inc.

Co-Participants

Port of Long Beach, Port of Los Angeles

Ports America, Total Terminals, Inc., and Yusen Terminals, Inc.

Background

Terminal tractors are essential to the daily operations of a port terminal. However, they also consume large volumes of diesel fuel and generate significant levels of harmful diesel emissions within the ports they serve. The development and deployment of low-emission, high-efficiency terminal tractors are high priorities for the Ports under the Clean Air Action Plan.

In response to the need for environmentally friendly yard hostlers, Capacity of Texas, Inc. developed a Pluggable Hybrid Electric Terminal Tractor (PHETT™). The Port of Long Beach, in conjunction with Capacity, Ports America, and Total Terminals, Inc. (TTI) conducted a three-week trial of the PHETT™ from June 8 to June 25, 2009. Results from this trial are available for download from the TAP website.

A follow-on trial test to evaluate improvements made to the PHETT™ following the initial trial was conducted from December 8 to December 29, 2009 at the Port of Los Angeles' Yusen Terminals, Inc. (YTI). The final report for this trial is available for download from the TAP website as well.

Project Objective

The purpose of the demonstrations was to evaluate the performance and emissions of the PHETT™. In order to characterize the PHETT™ duty cycle and measure its load factor, the vehicle was equipped with a multi-channeled data logging system. The PHETT™ fuel economy was evaluated using the data collected by the data logger and supplemented with information provided by Capacity and site demonstration partners. In addition, surveys were developed and distributed to operators and maintenance personnel to assess the overall capability of the PHETT™.



Technology Description

The PHETT™ is a diesel-electric plug-in hybrid terminal tractor that uses a small diesel generator and a large lead-acid battery pack to provide power for vehicle operation. As a plug-in hybrid, the PHETT™ offers a modest all-electric range and higher overall efficiency, which can significantly reduce fuel consumption and emissions compared to a conventional diesel-fueled terminal tractor.

The PHETT™ operates as a series diesel-electric hybrid. In this configuration, all of the energy demands of the vehicle are supplied through the battery; regardless of whether the energy is stored in the battery by a grid-connected charger or the on-board diesel generator. Given a fully charged battery, the PHETT™ will operate entirely from battery power, providing a limited all-electric range with zero tailpipe emissions. Once the battery has been depleted to a predetermined state of charge, the diesel generator will start and attempt to sustain the current level of charge in the battery.

According to Capacity, this diesel-electric hybrid terminal tractor is a “charge sustaining series hybrid that utilizes a constant and efficient rate generator to supply power, reducing fuel consumption by as much as 60 percent and audible decibel by 30 percent.

Three electrical inverters are used to supply the vehicle subsystems with power. The inverters convert the DC voltage of the battery pack into alternating current (AC) voltage that is better suited to operate the numerous AC electrical motors in the PHETT™.

Additionally, several systems on the vehicle use a 12VDC auxiliary power supply including the safety light, radios, and cabin HVAC fan. Capacity estimates a fixed power draw of 500 watts, assumed to be constant while the vehicle is in use.

Results

The load factor for the PHETT™ was determined by measuring the diesel generator output over the entire operating time of the PHETT™. During the demonstration at TTI, the PHETT's™ load factor was evaluated as 0.58, equivalent to an average engine load of 23.3 hp. The PHETT™ was estimated to achieve a 77% reduction in NO_x emissions, and an 82% reduction in PM emissions compared, to the baseline diesel fleet (2002 levels). The emission rates of the PHETT™ were also found to be lower compared to a 2009 diesel yard tractor. Due to a lack of fueling logs, fuel economy improvements were difficult to verify; however, fuel improvements were estimated to be in the range of 28% to 60% over the baseline fleet.

During the demonstration of the “beta” unit at YTI, the PHETT's™ load factor was determined to be 0.54, equivalent to an average engine load of 21.7 hp. The beta PHETT™ was estimated to achieve a 44% reduction in NO_x emissions, and a 56% reduction in PM emissions compared to a 2009 diesel yard tractor at 43% load (CARB's approved load factor for yard tractors). However, the emission rates of the PHETT™ were similar to those of a 2009 MY diesel yard tractor at actual load (18%). Fuel consumption measurements showed a 34% improvement over the baseline fleet. Information gathered from the operators and maintenance personnel at both Ports indicated no significant problems with the PHETT™ and comparable performance to diesel yard tractors.

Following this demonstration, Capacity marketed the PHETT in various applications throughout the U.S. and internationally. However, because the PHETT utilized a Tier 4-interim generator

drive engine (genset), it did not meet the requirements for port yard tractors in California under CARB's Cargo Handling Equipment regulation, which requires engines meeting Tier 4 final off-road or 2007 on-road emissions standards. Capacity has since focused their efforts on the development of a zero-emissions terminal tractor, the zero-emission terminal tractor, powered by plug-in electric/hydrogen fuel cell technology.

Project Costs

TAP funding in the amount of \$29,500 was allocated to the Port of Long Beach PHETT™ demonstration and testing project. The Port of Los Angeles also conducted a follow-on study at Yusen Terminal, Inc. (YTI) with non-TAP funding in the amount of \$32,000. Additional in-kind contributions were provided by Capacity, Ports America, TTI and YTI.

