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Plug-in Hybrid Yard Tractor: Demonstration Plan

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REPORT SUMMARY

This document describes fleet evaluation procedures and criteria developed to evaluate electric drive and a plug-in hybrid version of a port yard tractor—also called yard hostlers, terminal tractors, or UTRs (utility tractor rigs). The demonstration plan is specifically designed to evaluate a port yard tractor retrofitted with a Plug-in Hybrid Electric Vehicle (PHEV) system.

Background

Under pressure to reduce operational emissions, some seaports and their tenants are taking significant steps to reduce emissions. Many emission reduction efforts focus on cargo handling equipment such as the terminal tractor due to this sector's share in port emissions and concerns over oxides of nitrogen (NO_x) and particulate matter (PM) emissions that result from this equipment. Emission reduction measures such as filters and alternative fuels in cargo handling equipment may help to reduce these harmful pollutants, but adopting electric technology for cargo-handling equipment such as terminal tractors may also play an important role. One recommendation is to develop a plug-in hybrid terminal tractor that can be shut off during idling, thus mitigating energy and environmental concerns. This project focuses on this option by examining the savings, performance, and reliability a converted diesel terminal tractor can meet with a PHEV system, while also maintaining the required duty cycle. The specific vehicle is a Kalmar Ottawa 50, which has been retrofitted with a PHEV system.

Objectives

To develop fleet evaluation procedures and criteria to evaluate a port yard tractor retrofitted with a PHEV system.

Approach

The project team developed a test plan for the hybrid terminal tractor that will include performance characterization, site preparation, and field demonstrations at five working ports

Results

The report details the procedures for the testing and demonstration of the hybrid terminal tractor. Data collection, already underway, includes information on:

- Diesel fuel used
- Utility electrical energy used and system impacts
- Distance driven, idle time, and other driving characteristics
- Engine hours
- Breakdowns, failures, and other remarkable incidents
- Repairs made
- Out-of-service and in-service time
- Maintenance performed
- Driver experience

Following performance characterization, field demonstrations will be conducted at five working ports: Long Beach, California; Mobile, Alabama; Savannah, Georgia; Houston, Texas; and New York City. The goals of the field demonstrations are to introduce the technology to the interested parties at the host ports, evaluate infrastructure, and to determine the fuel savings, performance, and reliability of the PHEV as compared to existing fleets.

EPRI Perspective

This effort will generate substantial new information by testing the operation of a diesel yard tractor in full electric mode, with the use of a conversion kit. Potential benefits include emissions savings, lower cost compared to equipment replacement, and the rapid implementation of electrification at seaports.

Keywords

Seaports
Emissions reduction
Electric vehicles
Plug-in hybrid electric vehicles (PHEVs)

ABSTRACT

One option for reducing emissions at seaports is to integrate plug-in hybrid technology into internal combustion applications. The project team has developed a plug-in hybrid terminal tractor that can be shut off during idling, thus mitigating energy and environmental concerns. This document describes fleet evaluation procedures and criteria developed to evaluate a Kalmar Ottawa 50 port yard tractor retrofitted with a Plug-in Hybrid Electric Vehicle (PHEV) system. Following performance characterization, already underway, field demonstrations will be conducted at five working ports: Long Beach, California; Mobile, Alabama; Savannah, Georgia; Houston, Texas; and New York City. The goals of the field demonstrations are to introduce the technology to the interested parties at the host ports, evaluate infrastructure, and to determine the fuel savings, performance, and reliability of the PHEV as compared to existing fleets.

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INTRODUCTION

Background

Diesel-powered tractors that pull containers and cargo are used extensively in ports, warehouses, and other applications where it is necessary to shuttle cargo trailers from point to point within the confines of a specific facility, terminal or yard. Often called yard tractors, yard hostlers or terminal tractors, this equipment is of a specific design with a single driver compartment and a fifth wheel that has the ability to be raised and lowered. These widely used terminal tractors are unique to the cargo industry. Our research focuses on how design changes to the terminal tractor may make it an environmentally friendly and due to reduced fuel use, an economically efficient piece of equipment.

Yard Tractors at Seaports

Seaports are under pressure to reduce operational emissions. Some ports and their tenants are beginning to take great steps in reducing emissions from various aspects of their operations, from lower sulfur fuels in vehicles and equipment to electric power for ships in port. Many emission reduction efforts focus on cargo handling equipment such as the terminal tractor due to this sector's share in port emissions and concerns over oxides of nitrogen (NOx) and particulate matter (PM) emissions that result from this equipment. Emission reduction measures such as filters and alternative fuels in cargo handling equipment may help to reduce these harmful pollutants. Electric technology may play an important role in this target sector by reducing equipment emissions.

At ports, where cargo handling equipment is used throughout container terminal operations, terminal tractors can comprise as much as 65% of all container terminal cargo handling equipment. At large container ports like the Port of Long Beach, the number of terminal tractors at the container terminal alone is approximately 750 vehicles. In this environment, terminal tractors are used during the entire operational shift, which can vary from 8 to 24 hours, but typically idle 50%-80% of their shift while waiting to pick up a load and shuttle it to another area of the port. Such idling results in increased engine emissions, including PM, and NOx, and unnecessary fuel consumption which places a higher demand on imported energy needs and avoidable expense for the equipment operator.

In order to mitigate the energy and environmental concerns associated with the terminal tractor, design changes to this equipment are needed. One recommendation is to develop a plug-in hybrid terminal tractor that may address energy and environmental concerns by allowing the main drive engine to be shut off during idling, effectively mirroring the hybrid vehicles on the road today. This technology, applied to a converted diesel terminal tractor, is the focus of our research. Continuing to meet the duty cycle demands of the terminal tractor with this conversion is key to the technology's success. As such, developing relationships with all stakeholders is critical.

This effort will generate substantial new information by testing the operation of a diesel yard tractor in full electric mode, with the use of a conversion kit. The benefits include emissions savings, lower cost compared to equipment replacement, and the immediate implementation of electrification.

Vehicle Description and Specification

This specific vehicle is a Kalmar Ottawa 50, which has been retrofitted with a Plug-in Hybrid Electric Vehicle (PHEV) system.

Figure 1-1
PHEV Yard Tractor

The vehicle specifications are:

- Parallel Hybrid Post Transmission
- 120kW Permanent Magnet Motor with Digital Controller and J1939 CAN
- Li-Ion Battery, 33kWhr
- 150A, 12V dc-dc converter

- 6.6kW on-board Charger (100V-240V, 50/60 Hz)
- Safety Disconnect Unit
- Electro-Hydraulic pump and controller
- Electric Air Compressor and controller
- CAN and PC based diagnostic, service and maintenance software
- Ottawa 50 with Cummins ISB 07-200 on-road Engine
- 4 hours of EV mode operation

Demonstration Plan

This document describes fleet evaluation procedures and criteria to evaluate port yard tractors, also called yard hostlers, terminal tractors, or UTRs (utility tractor rigs), including electric drive and plug-in hybrid versions. Separately, performance characterization procedures are being developed and will be available in the final report.

Performance characterization (PC) is first conducted to document the performance of both the PHEV demonstration unit and a conventional unit. Performance characterization documents the performance and fuel economy of the PHEV unit, as compared to a conventional yard tractor. This evaluation is currently being conducted at a Long Beach test site separate from the first field demonstration at the Port of Long Beach.

Following PC, field demonstrations will be conducted at five working ports: Long Beach, California; Mobile, Alabama; Savannah, Georgia; Houston, Texas; and New York City. The goals of the field demonstrations are to introduce the technology to the interested parties at the host ports, evaluate infrastructure, and to determine the fuel savings, performance, and reliability of the PHEV as compared to existing fleets.

Before deployment, each site will be visited by a team from Southern California Edison's Electric Vehicle Technical Center (SCE) to prepare each site for the field demonstration. This site preparation will include evaluating the infrastructure, setting up data collection, and any necessary operator training relating to data collection.

During deployment, it will be the responsibility of the utility team members to collect and transmit data to SCE. SCE will be responsible for analyzing data, issuing monthly reports and submitting a final report.

This document was produced by Southern California Edison's (SCE's) Electric Vehicle Technical Center (EVTC), operated by SCE's Electric Transportation Department, a part of the Advanced Technologies group of the Transmission and Distribution Business Unit. Peer review and input was provided by the project team members. All test and evaluation is performed in strict conformance with California law, SCE standards, and the EVTC ISO 9001:2008 Quality System Manual. Any deviation is documented.

2
TEST PLAN

Vehicle baseline and report evaluation

Baseline vehicle performance is being established via performance characterization. As the vehicle continues operations in the demonstration, it is important to document any possible changes in vehicle performance with reference performance tests (RPTs). The salient values to track are: acceleration, electric drive range, charge sustaining (hybrid) fuel economy, and battery parameters (capacity and power). A set of tests will be conducted at the beginning and end of each demonstration to document these characteristics as best as possible given the facilities available on site. A final RPT will be conducted at the end of the last demonstration.

Vehicle turnkey inspection

At each demonstration site a Nameplate Data Sheet is prepared on which all applicable nameplate data, serial numbers, and ratings for all tested components, as well as all test equipment, is recorded. This data is important to keep track of the version of the software and hardware of the vehicle as tested, and to keep track of calibrated equipment usage. If any component is changed, it is important that it be recorded. A turnkey inspection is conducted with site maintenance personnel before operation at each site to confirm that the vehicle is fully operational and safe to drive.

Site preparation

Site preparation will be conducted to ensure that the vehicle will be able to be used at that site to conduct the normal business operations of the port as required of conventional yard tractors at that site. Preparation includes identification of charging site or sites, review of existing operations (including hours, loads, and duty cycles), preparation of site infrastructure for charging, briefing of utility hosts and port operators, and set-up of data collection equipment and methods.

Identification of charging sites

Based on experiences gathered at other operations, and working together with port operators and utility team members, optimum charging sites are selected. The selection is based on safety, ease of use, and data collection.

Preparation of charging site

Working with terminal operator, the site will be prepared by matching the required connector and power characteristics of the vehicle on-board charger with existing electrical infrastructure. The SCE team will provide a utility interface box which contains a utility meter for recording data. The meter can be changed to match the utility hosts' specifications, or can be maintained and read by SCE for the convenience of the demonstration. SCE may work together with utility team member to conduct site-specific power quality investigations.

Figure 2-1
Utility interface box

Review existing operations

Working with site hosts, SCE will collect data on existing site operations. Terminal operators may have existing data characterizing yard tractor operations, which will be reviewed by the team so that the results from the demonstration can be related to existing operations. If no data is available, SCE will work with the terminal operators to collect such data.

Set-up of data collection equipment

SCE will work with the terminal operator to implement or adapt methods and systems to collect the appropriate data needed to make a proper analysis. This data includes at a minimum:

- Diesel fuel used
- Utility electrical energy used
- Distance driven, idle time, and other driving characteristics
- Engine hours
- Breakdowns, failures, and other remarkable incidents
- Repairs made
- Out-of-service and in-service time
- Maintenance performed
- Driver comments

If the terminal operator does not have an asset management system, it would be prudent to add this capability for this vehicle at that site to get the needed data.

Briefing and training

SCE will help coordinate training on vehicle operation to be conducted by US Hybrid. SCE will brief terminal operators on infrastructure related issues and data collection. A single point contact at SCE will be provided for receiving the required communications.

Data collection

The PHEV yard tractor is meant to be used as a direct replacement for a conventional yard tractor. To that end, the data collection should be as invisible to the operator as possible and not affect the normal work load or workday, so it will be automated to the extent possible. SCE will work with US Hybrid, terminal operators, and utility team members to implement the methods to collect the data required, as noted in the section above, Set-up of data collection equipment. As each site is expected to differ significantly, those methods will be developed from among the following methods:

- Diesel fuel used – on-board data acquisition (OBD or US Hybrid, on site fuel records, fuel logs)
- Utility electrical energy used (ABB meter)
- Distance driven, idle time, and other driving characteristics (on site asset management system, GPS unit)
- Engine hours (OBD or maintenance records)

- Breakdowns, failures, and other remarkable incidents (driver and repair logs)
- Repairs made (repair logs)
- Out-of-service and in-service time (driver records)
- Maintenance performed (maintenance logs)
- Driver comments (driver logs, voice recorder, questionnaires)

The utility team member will be responsible for sending the data to SCE and EPRI on a regular basis, schedule is to be determined.

Reliability

During the demonstration period, all vehicle or infrastructure conditions that cause an interruption in work will be reported to the SCE contact promptly by terminal operators. A simple breakdown incident form will be provided, and is included in Appendix A. This form should be sent to the SCE contact within one working day of the breakdown.

3
TEST PROCEDURES

The specific procedures for carrying out the plan laid out in Chapter 2 will be developed based on the initial PC and demonstration in Long Beach, working with the terminal operators and US Hybrid. These procedures will be modified and adapted based on the needs and restrictions at each demonstration site. These modifications will be documented and published in the final report.

Vehicle baseline and report evaluation

Conduct acceleration, electric drive range, charge sustaining (hybrid) fuel economy, and battery parameter (capacity and power) tests at the beginning and end of each demonstration.

Vehicle turnkey inspection

Prepare a Nameplate Data Sheet, included in Appendix B. Conduct a turnkey inspection and confirm that the vehicle is fully operational and safe to drive. Form is included in Appendix C.

Site preparation

Identification of charging sites

The selection is based on safety, ease of use, and data collection.

Preparation of charging site

Prepare the site by matching the required connector and power characteristics of the vehicle on-board charger with existing electrical infrastructure. Optional: set data acquisition to investigate site-specific power quality parameters.

Review existing operations

Collect data on existing site operations by reviewing port data or placing data loggers to collect duty cycle and fuel use data.

Set-up of data collection equipment

Set up data acquisition equipment including ABB meter, asset management system, driver recorder, and logs.

Briefing and Training

Conduct training on data collection and use of infrastructure. Assist vehicle training conducted by US Hybrid. Establish a single point contact at SCE for receiving the required communications.

Data collection

Begin collecting data using the following methods:

- Diesel fuel used – on-board data acquisition (OBD or US Hybrid, on site fuel records, fuel logs)
- Utility electrical energy used (ABB meter)
- Distance driven, idle time, and other driving characteristics (on site asset management system, GPS unit)
- Engine hours (OBD or maintenance records)
- Breakdowns, failures, and other remarkable incidents (driver and repair logs)
- Repairs made (repair logs)
- Out-of-service and in-service time (driver records)
- Maintenance performed (maintenance logs)
- Driver comments (driver logs, voice recorder, questionnaires)

The utility team member will be responsible for sending the data to SCE and EPRI on a regular basis, schedule is to be determined.

Reliability

The incident form will be sent to the SCE contact within one working day of the breakdown.

4

ANALYSIS

The following topics describe the analysis of the data collected, and specifically give information on what form the analysis will be reported.

Infrastructure evaluation

Report on the site-specific power quality investigations and any pertinent system impact issues. Report on methods taken at each site to implement charging site. Report any safety or ease of use issues.

Performance

The following performance characteristics are measured, reported, and compared to conventional yard tractors.

Acceleration

The acceleration of the vehicle and any change in time throughout the project as documented in RPTs is plotted.

Electric drive range

The electric drive range of the vehicle and any change in time throughout the project as documented in RPTs is plotted.

Charge sustaining fuel economy

The charge sustaining fuel economy of the vehicle and any change in time throughout the project as documented in RPTs is plotted.

Battery performance

The battery performance and any change in time throughout the project as documented in RPTs is plotted.

Total electrical energy used

The total electrical energy used at each site and overall is reported.

Total diesel fuel used

The total diesel fuel used at each site and overall is reported.

Drive distance and drive characteristics

Drive distance and drive characteristics at each site and overall is described.

Fuel economy

Energy use per unit work at each site and overall is reported. This is then separated into electrical and diesel fuel economy.

Maintenance and reliability

Reliability is reported in terms of availability, ability to perform regular work without restriction, number of incidents, and length of repair time. Results are compared to fleet averages. Regular maintenance performed is reported and compared to both instructions provided to site host and maintenance schedules for conventional equipment.

Ease of use, Effectiveness, Comments

Driver comments are captured via daily records and questionnaires, categorized into complaints and suggestions and processed statistically to help indicate satisfaction with vehicle compared to common yard tractos in use at the site.

A
INCIDENT REPORT FORM

INCIDENT LOG

Vehicle	______________	Driver:	______________
Date	______________	Time:	______________
Location:	______________	Odometer	______________

Description of Incident or Problem:

B

VEHICLE TEST EQUIPMENT AND NAMEPLATE DATA SHEET

Project: ____________________ Test: ____________________
Date(s): ____________________ File Name(s): ____________________
Vehicle Number: ____________________ Technician: ____________________

VEHICLE

Manufacturer: ____________________ VIN: ____________________
Model: ____________ Model Year: ________ Date of Manufacture: ________
GVWR: ____________ Front AWR: ________ Rear AWR: ____________
Motor Manufacturer: ____________ Motor Type: ____________________
Version/Serial No.: ____________________________________
EPA Label Fuel Economy: ____________________________________
Controller Version/Serial No.: ____________________________________
Battery Pack Type/Version/Serial No.: ____________________________________
Other: ____________________________________
Other: ____________________________________
Tire Manufacturer: ____________________ Model: ____________________
Tire Size: ____________________ Maximum Pressure: ____________________
Maximum Tire Load: ____________________ Treadwear Rating: ____________________

CHARGER

On-board / Off-board/Type: Manufacturer: ____________________
Model: ____________________ Serial Number: ____________________
Charger Type/Version: ____________________________________
EVSE Mfr./Model: ____________________________________
EVSE Version: ____________________ Serial Number: ____________________
EVSE Software Version: ____________________________________
Charge Port Data or Other: ____________________________________

C

NEW VEHICLE TURN KEY FORM

TURNKEY INSPECTOR: ______________________ DATE: ______________________

NEW VEH. #:		VIN #:	
NEW VEH. MAKE:		MODEL:	
COLOR:		MILEAGE:	
PURCHASE ORDER #:		AUTO/SER CODE:	/
USER CONTACT:		PAX:	
USING DEPT:		REPLACED VEH. #:	
BUDGET CODE:			

FUNCTIONAL TESTING

ENGINE TESTS:		INTERIOR CHECKS:	
CHECK ENGINE OIL:		CHECK ALL LIGHTS:	
CHECK ENGINE WATER:		CHECK ALL GAUGES:	
CHECK POWER STEERING FLUID:		CHECK WIPERS/WASH:	
WINDOW WASH FLUID:		CHECK AIR COND.:	
CHECK FOR WATER LEAKS:		CHECK HEATER/DEFROST:	
CHECK FOR OIL LEAKS:		CHECK HORN:	
CHECK BELTS & HOSES:		CHECK RADIO/CASSETTE:	
CHECK ALL SEAT BELTS:			

DRIVE TEST VEHICLE: ______________________

DATE VEHICLE ARRIVED AT GARAGE: ______________________

DATE VEHICLE ACCEPTED ON-LINE: ______________________

DATE USER CALLED TO PICK UP VEH. ______________________

DATE VEHICLE GIVEN TO USER: ______________________

MILEAGE ON NEW CAR WHEN GIVEN TO USER: ______________________

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