TRUCK ELECTRIFICATION

Cutting Oil Consumption & Reducing Pollution

Photo courtesy of UPS

Union of Concerned Scientists

Citizens and Scientists for Environmental Solutions

Electricity is not just an option for passenger cars. Hybrid and all-electric technologies are moving into delivery trucks, garbage trucks, and tractor-trailers, as well as into other more out-of-sight vehicles, all of which literally help keep our economy moving. For these medium- and heavy-duty trucks, the goals of electrification are the same as with cars: reducing pollution, oil consumption (in trucks, usually diesel fuel), and fuel costs. Expanding the use of electrification technologies is a key strategy for doubling the fuel efficiency of trucks and for helping to cut our nation's projected oil consumption in half over the next 20 years.[1]

Hybrid-electric powertrains help trucks go farther on a gallon of diesel or gasoline, thereby lowering emissions and oil consumption. When the vehicles are running on electricity or hydrogen, oil consumption is eliminated entirely, and when the electricity or hydrogen is produced from renewable sources, these trucks can achieve true zero-emissions operation, thereby protecting public health and reducing global warming pollution.

Even when powered by today's electricity grid, which contains a mix of renewable, nuclear, natural gas, coal, and other sources, electric vehicle technologies can reduce global warming emissions compared with diesel- or gasoline-powered vehicles.

This report highlights the many different electric truck technologies and how they are being used in real-world applications.

Battery, fuel cell, and hybrid powertrains—already at work in today's commercial vehicles—can deliver big savings in this important sector of our economy.

Hybrid tractor-trailers, well suited for stop-and-go operation, are being used in the beverage delivery industry, reducing fuel costs and emissions.

Photo courtesy of Coca-Cola

Electric Drivetrain Technology

HYBRID-ELECTRIC VEHICLE (HEV)

HEV trucks combine a conventional internal combustion engine (burning gasoline, diesel, biofuels, or alternatives such as natural gas) with an electric motor, batteries, and braking-energy capture (called regenerative braking). The internal combustion engine may be smaller than that of a standard truck because the electric motor provides added power. And hybrid-electric delivery trucks can travel farther than their conventional diesel counterparts before refueling, while improving fuel economy and extending brake life. A review by the National Academy of Sciences found that fuel-consumption reductions of 20 to 35 percent are possible with current hybrid truck technologies, depending on the application and specific hybrid technology used.[4]

In 2010, freight-hauling trucks consumed 2.3 million barrels of oil per day—more than we currently import from the Persian Gulf—and emitted 348 million metric tons of carbon dioxide.[2,3]

Hybrid-electric powertrains are the most mature electric-drive truck technology currently on the road. New York City began testing heavy-duty hybrid-electric powertrains in its buses in 1998,[5] while commercial production of the first hybrid delivery truck began in 2007,[6] 10 years after the first mass-produced hybrid-electric passenger car.[7] Several truck manufacturers are now offering hybrid models, and thousands of hybrid systems are being used in applications ranging from public-transit and school buses to package- and beverage-delivery trucks.[8,9]

Some of the nation's largest parcel-delivery fleets, including FedEx and UPS, currently employ this technology. FedEx currently operates 330 hybrid-electric vehicles in the United States, and the company boasts one all-hybrid location in New York City.[10]

Hybrid technology can also be used in heavier trucks such as tractor-trailers. The National Renewable Energy Laboratory and Coca-Cola recently completed a test evaluation of 12 hybrid-electric regional tractor-trailers, with resultant fuel savings of up to 31 percent, depending on how the trucks were used.[12] Overall, it is estimated these systems will offer a 20 percent fuel savings over traditional diesel engines.[13] At this writing, Coca-Cola has more than 700 hybrid-electric trucks in operation in North America.[14]

Photo courtesy of CALSTART

Some companies are now using trucks powered entirely by electricity. For example, Frito-Lay was an early adopter of electric trucks as part of the company's self-imposed challenge to cut its fuel consumption in half by 2020. By the end of 2012, Frito-Lay will have more than 275 electric delivery trucks in operation.[11]

BATTERY ELECTRIC VEHICLE (BEV)

BEV trucks are propelled by an electric motor that is powered by onboard batteries. These trucks, which have no internal combustion engine, must be plugged in to recharge their batteries. The range of a present-day BEV truck varies, depending on the load it carries and the capacity of its batteries, from 50 to 100 miles per charge.[15]

Urban delivery trucks, which travel short and well-defined routes, are less constrained by the limited range of battery technology and therefore are ideal candidates for full electrification. Several manufacturers are producing BEV delivery trucks and continually

Photo courtesy of CALSTART

Photo courtesy of Balqon

Yard hostlers, used at ports and rail yards to move cargo containers, are being tested with hybrid and battery electric drivetrains.

advancing their technologies. Meanwhile, companies such as AT&T, Coca-Cola, Frito-Lay, and Staples have added electric delivery trucks to their fleets.[16]

Yard hostlers, designed for moving cargo containers within a facility such as a port or warehouse complex, also present an excellent opportunity for using BEV technology. These vehicles do not travel on regular streets and have top speeds of only about 30 mph. Because tens of thousands of yard hostlers are used daily across the United States, they represent an important opportunity for fuel, cost, and emissions reductions.

Over nine million medium- and heavy-duty trucks are on the road in the United States.[17]

Fully battery-electric yard hostlers have been developed and used by the ports of Los Angeles and Long Beach, CA. The benefits of these vehicles include lower operating costs as well as zero tailpipe emissions. The Port of Los Angeles estimates fueling costs of the BEV yard hostler at $0.20 per mile, compared with its conventional diesel counterpart at $0.80 to $1.80 per mile.[18] Elimination of all emissions from the diesel engine is an important public health benefit, given that such pollution from conventional yard hostlers adversely (and disproportionately) affects nearby residents. For example, health assessments of California's ports and rail yards show that cancer risks associated with air pollution levels near these facilities are as much as twice the regional average.[19]

PLUG-IN HYBRID-ELECTRIC VEHICLE (PHEV)

PHEV trucks are similar to conventional hybrid-electric vehicles, but they have a larger battery pack. In addition to plugging in to recharge its batteries, the truck captures braking energy. The plug-in hybrid system may be designed to allow all-electric operation of the vehicle for a limited number of miles, or it may be intended primarily for providing power to accessories such as refrigeration equipment or tools at a job site. The Port of Long Beach recently tested a PHEV yard hostler with estimated fuel savings ranging from 28 to 60 percent,[20] while California's Pacific Gas & Electric (PG&E) is operating 10 plug-in hybrid-electric utility trucks with an estimated all-electric range of up to 40 miles.[21]

FUEL CELL ELECTRIC VEHICLE (FCEV)

These electric trucks are powered by fuel cells, which convert hydrogen and air into electricity while emitting only water vapor. An FCEV also has a battery to store captured braking energy and provide additional power when necessary, as in an HEV. But fuel cell electric trucks refuel with hydrogen instead of plugging into an external source of electricity.

The Port of Los Angeles is evaluating fuel cell electric trucks for "drayage" operations, which usually entail short-distance freight movement such as conveying


A fuel-cell-powered drayage truck is being used to haul containers to and from the ports of Los Angeles and Long Beach, CA.

Photo courtesy of CALSTART


A catenary system can be used to provide electric power to trucks along designated routes through the use of overhead wires.

Photo courtesy of Siemens

cargo containers from a port to a rail yard or warehouse for further distribution. Typically, drayage involves less than 100 miles of travel per trip.

The fuel cell version of these heavy-duty big rigs have electric motors for driving the wheels, a battery to store regenerative braking energy, and hydrogen-powered fuel cells that generate electricity to maintain the battery charge. The trucks have a potential range of up to 400 miles[22] between refuelings with hydrogen. Each fuel cell electric truck saves an estimated 6,000 gallons of diesel fuel a year while generating zero tailpipe emissions.

External Electric Power

As with light-rail trains or trolley cars, trucks could run on electricity that is supplied as needed instead of being stored in an onboard battery. These trucks would require dedicated lanes and be most viable on heavily traveled routes, but they would avoid range limitations and reduce battery costs. The trucks could also be fully electric or diesel-electric hybrids, which would allow them to operate away from the dedicated roadway when required.

OVERHEAD ELECTRIC SUPPLY

Demonstrations are planned for the ports of Los Angeles and Long Beach of a technology called a catenary system that would enable a hybrid-electric truck to run on external power supplied by overhead lines. A catenary system is being considered as one option for near-zero-emissions drayage operations between these ports and local rail yards; this system would alleviate the pollution from trucks now performing such operations.[23] Each of the new trucks would have a mechanism called a pantograph on its roof that reaches up and connects with the overhead catenary lines. The pantograph is automatic in that it connects when external power is available in the lines overhead and retracts when the truck leaves the catenary section of highway. While on the catenary section, the truck would draw external electrical power and produce no tailpipe emissions; when off the catenary section, it would operate like a regular hybrid-electric vehicle, providing greater flexibility and range.

IN-ROAD ELECTRIC SUPPLY

These systems would eliminate the towers and overhead lines of a catenary system by putting the power connection into the road itself. Some designs have a physical connection to a slot or track, similar to some light-rail and subway systems in use today, while other designs call for hidden power lines that are activated as the truck passes over them. Such in-road systems have the potential to power any appropriately equipped electric vehicle on the roadway—cars as well as trucks—but they are less developed than catenary systems for powering freight trucks.

Other Truck Electrification Technologies

Some truck electrification technologies do not directly involve moving the truck but can still reduce its fuel consumption. One approach is to use electricity to run auxiliary systems—such as air compressors, water pumps, air conditioners, cooling fans, and power steering—that in conventional trucks are typically driven by their internal combustion engines (via mechanisms such as belts).

AUXILIARY POWER UNITS

Long-haul truck trips often require several days, with drivers regularly sleeping in their truck cabs overnight. Traditionally, a driver will leave the truck engine idling in order to provide heating or cooling in the cab, as well as to power electric accessories such as televisions, computers, microwaves, and refrigerators. The U.S. Environmental Protection Agency estimates that a truck uses as much as 1,400 gallons of diesel each year just in idling.[24] To eliminate such fuel-wasting main-engine operation, while also reducing emissions, long-haul trucks are more frequently being equipped with auxiliary power units (APUs)—most commonly a small diesel-powered generator. However, many companies now also offer battery-powered APUs, which completely eliminate fuel consumption and exhaust emissions while delivering power to the cab.[25] Trucks are also being equipped with the capability to plug in to external power when parked at truck stops or warehouses, and fuel cell APUs for trucks have also been demonstrated and are moving toward commercialization.[26]

PLUG-IN HYBRID REFRIGERATION UNITS

A refrigerated unit, or "reefer," is a container or trailer used for transporting temperature-sensitive cargo. Reefer technology is critical to the movement of perishable goods, allowing fresh fruits, fresh vegetables, and frozen items to be delivered year-round throughout the country. Additionally, grocery stores often use refrigerated trailers as extra storage for perishable goods.

Reefers typically rely on diesel generators, called generator sets (or "gen-sets"), to provide power for the cooling system. These gen-sets operate while the vehicle is in transit, as well as when it is parked, in order to maintain the proper temperature in the trailer at all times. Plug-in hybrid-electric reefers also have a

Photo courtesy of CALSTART

A fuel cell auxiliary power unit (located to the left of the diesel tank and in front of the rear wheels in this photo), eliminates exhaust emissions while delivering power to the cab during rest periods.

Photo courtesy of Shorepower Technologies

A delivery truck plugs into an electrical pedestal to provide power to keep its perishable cargo cool while parked.

Photo courtesy of Terex

Odyne first began development of plug-in hybrid aerial-lift trucks, like the one pictured here, in 2007. Pennsylvania's Adams Electric Cooperative was the first to deploy the technology. The PHEV used by Adams Electric is capable of powering a full day's worth of boom operation and climate control from the vehicle's batteries. These trucks, which are estimated to reduce fuel consumption by roughly 50 percent, require eight hours to charge their batteries; this can be done overnight at off-peak (cheaper) rates.[27]

diesel gen-set, but they are capable of plugging in to external power when the vehicles are parked at truck stops, loading docks, or distribution centers. Compared with their diesel-powered counterparts, plug-in hybrid reefers can displace up to five gallons of diesel fuel when operating off an external electrical power source for six hours.[28]

ELECTRIC EXPORT POWER OR POWER TAKE-OFF (PTO)

Export power or PTO systems supply the energy to run external equipment—such as fans, lights, pumps, and other work tools—mounted on the truck. For example, utility work trucks used to repair telephone and power lines are often equipped with an aerial lift to raise an operator up to reach overhead lines. These trucks typically do not travel very many miles; they often spend much of the day parked at a work site. While there, the trucks must generate power to operate the aerial lift as well as other equipment. Traditionally, this power has been supplied by the truck's hydraulic system, which works off the vehicle's internal combustion engine. Electric PTO systems, which can replace the traditional source of power for external equipment, save fuel by reducing or eliminating engine idling at the work site; they also provide the additional benefits of quieter operation and emissions reduction.

Outlook for Truck Electrification

The electrification of trucks has only recently begun, but it is off to a strong start. Initially, electric truck technologies are being targeted to applications—urban delivery vehicles, utility work trucks, port shipping, and electric accessories such as APUs and refrigeration units—where current electrification technology fits well operationally while delivering the greatest benefits. But as electric-motor, battery, and fuel cell technology improve, even more truck electrification opportunities will be realized. Electric motors, batteries, and fuel cells are able to scale up or down as the uses and needs for each type of truck vary.

When these diverse opportunities for electrification are combined with a doubling of fuel efficiency, greater access to better biofuels, and smarter shipping alternatives—such as the elimination of empty hauls and better use of rail—truck electrification can become one of the key parts of a plan to cut projected U.S. oil use in half over 20 years.[30]

Medium- and heavy-duty trucks represent only 4 percent of the vehicles on the road, but they account for about 20 percent of the transportation fuel we consume.[29]

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