

Appendix G. Truck Technology Types

Dual-Mode Hybrid & Plug-In Hybrid Electric Vehicle

This vehicle is an advanced parallel hybrid with the internal combustion engine as the main source of power. The technology is moderately mature with little to no changes in operations compared to a diesel-operated truck. The actual ZE range is limited, as it only functions in ZE mode at low speeds and/or is subject to certain load limits. Unlike the Hybrid Electric Vehicles (HEVs), the Plug-In Hybrid Electric Vehicles (PHEVs) have batteries that are recharged through the electrical grid. Recharging is becoming faster and charging locations are becoming more prevalent. PHEVs can operate in ZE mode for longer distances than HEVs. These trucks achieve approximately 15 percent emissions savings compared to conventional diesel trucks.

Range-Extended Electric Vehicles with Integrated Engine

These vehicles can use either electric power or diesel fuel, but the primary source of energy is the electric motor. The engine can run either on diesel or compressed natural gas (CNG) when the batteries are depleted. The determining factor for ZE range is battery size. Therefore, this truck type can be designed for specific ZE ranges as needed, subject to corresponding changes in cost. These trucks achieve approximately 25 percent emissions savings compared to conventional diesel trucks.

Range-Extended Electric Vehicles with Integrated Fuel Cells

This technology is analogous to the Range-Extended Electric Vehicles (REEV) with integrated engines, except that it relies on a fuel cell in place of an integrated engine when the vehicle battery is depleted. The fuel cells require hydrogen refueling stations for recharging, making these trucks a practical solution only in areas where such refueling stations exist. The technology can be designed to fit within tight spaces and can be accommodated by a standard diesel truck, but it comes at a higher price point compared to other technologies. These vehicles also offer relatively long useful lifespans and small maintenance costs. This technology is already available on the market. These vehicles can operate in true zero-emissions mode making it is relatively easy to obtain regulatory certification for them.

Battery Electric Vehicles

The Battery Electric Vehicle (BEV) is an electric-only vehicle powered by its battery alone, meaning that longer ranges require larger, heavier, more costly batteries. The vehicle batteries can be recharged using dedicated recharging stations or overhead/in-pavement catenary power systems (if the vehicle is properly equipped to draw power from such a source). Recharging of the internal battery requires more time than refueling a REEV fuel cell or internal combustion engine. Alternatives to on-road charging include battery exchange. Battery exchange is currently being used in port environments, such as the Port of Long Beach's Middle Harbor Terminal, which uses battery exchange to continuously power Automated Guided Vehicles (AGV) that move cargo throughout the terminal. Full-electric trucks require larger batteries than HEVs and typically weigh more. HEVs have a longer range, but as battery

technology continues to improve some EV trucks have demonstrated travel ranges of 200 miles. One of the major disadvantages posed by EVs is cost. The batteries for full-electric trucks currently add approximately \$100,000 to the vehicle price. These vehicles can operate in true zero-emissions mode making it is relatively easy to obtain regulatory certification for them.

On-site Solar Generation at Truck Parking Facilities

On-site solar generation provides an opportunity for additional energy production at parking areas, with the ability to lessen demands on the grid. There are a handful of projects testing the deployment of solar panels to support Electric Vehicle Supply Equipment (EVSE) to support zero-emission trucks. The [first solar-powered truck stop](#) in the United States for heavy-duty electric trucks is expected to open late October 2022 in Bakersfield, California. The 25-megawatt, solar-powered electric-only 110-acre truck stop will feature a solar micro-grid with battery storage and grid energy from Pacific Gas & Electric, and [over time will grow](#) to support more than 40 charging bays.

Range Extenders Utilizing Roadway Power

New truck technologies require roadway infrastructure to charge the electric trucks while on route using technologies that are already widely used for transit vehicles. This technology allows for smaller, cheaper on-board batteries and therefore lower vehicle costs as well. This cost savings per vehicle is offset by significantly greater costs for infrastructure supporting systems relative to other ZE/NZE technologies. These vehicles can operate in true zero-emissions mode making it may relatively easier to obtain regulatory certification for them.

For more information and status for each truck technology type, please refer to ARB's Heavy-Duty Investment Strategy located at <https://ww2.arb.ca.gov/sites/default/files/2019-09/fy1920fundingplan-appd.pdf>.