

Clean Cities' Guide to Alternative Fuel and Advanced Medium- and Heavy-Duty Vehicles



School Bus
Shuttle Bus
Transit Bus
Refuse Truck
Tractor
Van
Vocational Truck



U.S. Department of Energy

The mission of the Clean Cities program is to advance the nation's economic, environmental, and energy security by supporting local decisions to adopt practices that contribute to the reduction of petroleum consumption. Clean Cities carries out this mission through a network of more than 85 volunteer coalitions, which develop public/private partnerships to promote alternative fuels and vehicles, fuel blends, fuel economy, hybrid vehicles, and idle reduction. To find your local coalition, visit www.cleancities.energy.gov.





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Photos, from top: Courtesy of Peterbilt, Kenworth, New Flyer of America



Courtesy of Peterbilt

About the Guide

The medium- and heavy-duty vehicle industry is changing rapidly with fleets adopting alternative fuels and advanced technologies to reduce petroleum use and comply with the 2010 U.S. Environmental Protection Agency (EPA) and California Air Resources Board (CARB) emission standards. Clean Cities has long maintained its Heavy-Duty Vehicle Search on the Alternative Fuels and Advanced Vehicles Data Center (AFDC) Web site. This guide brings together an overview of alternative fuel power sources, including engines, microturbines, and fuel cells, and hybrid propulsion systems along with chassis compatible with the systems. The second half of the guide provides a brief overview of individual medium- and heavy-duty vehicles listed by application. We hope this guide will be helpful to public and private fleet managers who are searching for answers to reduce petroleum consumption and vehicle emissions.

Vehicle information was collected from multiple sources, including original equipment manufacturer (OEM) Web sites, conversion companies, and product literature. Diligent effort was made to contact all manufacturers offering commercially available vehicles with alternative fuel or advanced technology options. However, there may be omissions or product changes since publication. Check the AFDC's heavy-duty vehicle information at www.afdc.energy.gov/afdc/vehicles/search/heavy for the most current information. Manufacturers are also invited to add or correct any information by contacting the AFDC Webmaster at www.afdc.energy.gov/afdc/progs/webmaster.php.

Heavy-Duty Vehicle Application Overview



School Bus | Compressed natural gas (CNG) and propane are popular alternatives to gasoline and diesel fuel for school buses. Hybrid electric buses and plug-in electric hybrids are also available.



Shuttle Bus | CNG, propane, hybrid electric power, and fuel cells are potential power sources for shuttle buses and large passenger vehicles that provide transportation on standard routes.



Transit Bus | Hybrid-powered transit buses, along with CNG and liquefied natural gas (LNG), are available. Fuel cell demonstrations are also in progress.



Refuse Truck | CNG-fueled vehicles are available, and some can use biomethane produced from landfill gas. Standard routes and stop-and-go operation make refuse haulers a good application for hybrid operation. Hydraulic hybrid systems are well suited to refuse service.



Tractor | Diesel electric hybrids offer fuel-saving hybrid operation with the convenient availability of diesel. CNG and LNG operation are also available in some models.



Van | Step vans that service a set route, such as a package delivery service, may find all-electric battery operation an effective, low-polluting alternative. CNG and propane operation are also popular alternatives.



Vocational Truck | CNG, propane, all-electric, and hybrid vehicles operate in a variety of roles from beverage delivery to utility boom truck, paint striping truck, and merchandise delivery.

2010 Heavy-Duty Emissions Standards

The U.S. Environmental Protection Agency (EPA) and the California Air Resources Board (CARB) regulate emissions from engines of medium- and heavy-duty vehicles rather than by models as in light-duty vehicles. EPA classifies medium-duty vehicles as those over 8,500 lb while the CARB medium-duty classification starts at 14,000 lb.

Emissions fall into two categories:

- **Air pollution emissions** are smog-forming pollutants emitted by a vehicle. These include particulate matter (PM), non-methane hydrocarbons (NMHC), and nitrogen oxides (NO_x).
- **Greenhouse gas (GHG) emissions**, primarily carbon dioxide (CO₂), contribute to climate change. The EPA has put forth proposals to regulate GHG emissions in passenger cars and light-duty trucks.

According to the EPA, heavy-duty trucks and buses account for about one-third of NO_x emissions and one-fourth of the PM emissions from all highway traffic, even though they comprise only 2% of the total number of vehicles on the highway.

EPA established the following emission limits for 2010 medium- and heavy-duty engines:

- PM—0.01 g/bhp-hr
- NMHC—0.14 g/bhp-hr
- NO_x—0.20 g/bhp-hr

A separate EPA diesel fuel regulation limited the sulfur content in on-highway diesel fuel to 15 ppm, down from the previous 500 ppm. Ultra-low sulfur diesel fuel was introduced in 2006 as a “technology enabler” to pave the way for advanced, sulfur-intolerant exhaust emission control technologies, such as catalytic diesel particulate filters and NO_x catalysts.

PM and NMHC are well controlled by these catalytic filtering systems. NO_x have been reduced by the use of Exhaust Gas Recirculation (EGR) and Selective Catalytic Reduction (SCR).

- **EGR** is a NO_x emissions-reduction process that recirculates a portion of an engine’s exhaust gas back to the engine cylinders. This dilutes the mixture of gases and reduces the combustion temperature. Because NO_x form primarily when a mixture of nitrogen and oxygen is subjected to high temperature, the lowered combustion temperature results in reduced NO_x output.
- **SCR** involves injecting urea into a stream of exhaust gas. The urea, known as diesel exhaust fluid, is combined with engine exhaust in the presence of a catalyst to convert smog-forming NO_x into harmless nitrogen and water vapor.

Conversion emission standards for heavy-duty vehicles manufactured before 2010 remain the same as the standards applicable in the year of engine manufacture. Conversion companies must obtain a certificate of compliance for each model year engine family being converted.

Multiple-Stage Construction of Medium- and Heavy-Duty Vehicles

Vocational, heavy-duty trucks are typically manufactured in multiple stages: An incomplete vehicle or chassis cab is progressively upfitted with specialized equipment according to the specific tasks that the vehicle will perform and then certified as a complete vehicle by a final-stage manufacturer before delivery to the end user. The incomplete vehicle may be modified, or “manufactured,” by multiple intermediate-stage manufacturers before going to the final-stage manufacturer or may only require a single manufacturing operation by the final-stage manufacturer. The “manufacturing” process performed on the incomplete vehicle by intermediate- or final-stage manufacturers depends on the end-use application and the associated specialized equipment requirements, which may include installing equipment, such as refuse packing bodies, paint striping systems, snow plows, or aerial platform boom truck bodies, or modifying the chassis (e.g., moving or adding axles or modifying the length of the frame).

Due to the vast array of possible final vehicle configurations and to increase overall flexibility of the manufacturing process, alternative fuel storage systems (e.g., CNG, LNG, or propane) may be installed by intermediate- or final-stage manufacturers rather than by the incomplete chassis OEM. This may add steps to the manufacturing process but also allows greater design flexibility. This installation is typically transparent to the vehicle purchaser and is consistent with the multistage manufacturing approach utilized within the market segment. The intermediate- and final-stage manufacturers are typically coordinated by the vehicle dealer, final-stage manufacturer, or equipment manufacturer, depending on the established purchasing arrangements, which may be unique for each type of vehicle purchased or for each fleet.

Step-By-Step Manufacturing Process

Four major systems must be integrated into each heavy-duty vocational truck:

- Chassis
- Engine
- Fuel system
- Specialty equipment upfitting.

Chassis

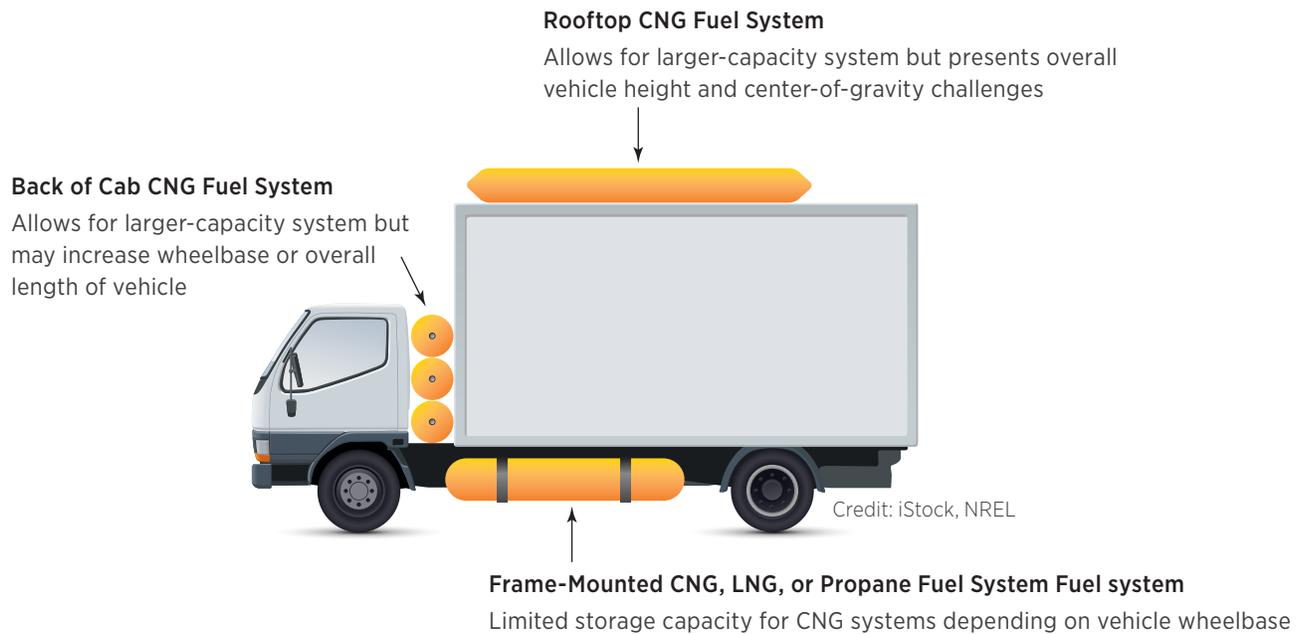
For alternative fuel applications, chassis configurations are selected based on end-use requirements in the same way that conventionally fueled chassis cabs are, except in cases where additional frame length or increased GVWR is required to accommodate a larger and/or heavier fuel storage system. Chassis are available in conventional and cab-over-axle configurations based on manufacturers' decisions about the best design that will accommodate alternative fuel engines.

Engine

Chassis are available with OEM engines or gasoline or diesel engines that may be converted to operate on alternative fuel by installing an emissions-certified conversion system. Alternative fuel engines are designed to operate on CNG, LNG, or propane. They can be dedicated to operate full time on alternative fuel, bi-fuel to run on either alternative fuel or gasoline, or dual-fuel to run on alternative fuel and use diesel for ignition assist. Advanced hybrid vehicles combine gasoline or diesel operation with battery power that reduces petroleum consumption when operating on electric power.

Fuel System

CNG, LNG, and propane are stored in tanks onboard a vehicle. These cylindrical tanks are heavier than gasoline or diesel tanks and less flexible in shape—making them more challenging to package on the vehicle. This can result in less volume or weight capacity for these alternative fuel vehicles when compared to a conventional fuel system vehicle. Thoughtful design considerations can overcome these drawbacks.



Specialty equipment manufacturers have recognized the challenges associated with packaging alternative fuel storage systems with sufficient storage capacity and have developed products that seamlessly integrate the alternative fuel system into their product or body structure. In other cases, utility body manufacturers have integrated the fuel system into the body equipment to minimize any reductions in fuel storage capacity.

Specialty Equipment Upfitting

The final step is upfitting the chassis with the equipment necessary to do the job—refuse packer, paint-stripping rig, shuttle bus, beverage delivery hauler—whatever its purpose.

Chassis Selection

A cab chassis is a body style and type of vehicle construction often found in medium-duty commercial vehicles. Instead of a preassembled flatbed, cargo container, or other equipment, the customer buys the vehicle with just chassis rails and a cab. This allows the upfitter to assemble any desired aftermarket equipment, such as fire apparatus, an ambulance, beverage truck, or other application-specific equipment.

Chassis selection for use with alternative fuels must account for the weight of required fuel tanks or battery packs. The additional weight may reduce cargo space or cargo capacity. In the case of a truck plus a trailer or trailers, the gross vehicle weight as well as the overall length of the vehicle must be within the limits specified by state regulations where the truck or tractor-trailer is to be operated.

Cab Chassis Types

Conventional Cab

The long hood design allows for the power plant to be located ahead or mostly ahead of the cowl. May be used on a two- or three-axle chassis. Best suited to long-distance highway operation.



Conventional Cab with Set-Back Axle

Similar to a conventional cab but features a set-back front axle for better maneuverability in traffic and better weight transfer to the front axle. May be used on a two- or three-axle chassis.



Tilt Cab or Cab Over Engine

Features an extremely short front bumper to back-of-cab dimension. The engine is positioned beneath the cab with a provision for tilting the cab forward on a pivot to provide access to the engine. Permits better weight transfer to the front axle and better maneuverability compared to conventional cab-forward designs. Usually used on a three-axle chassis.



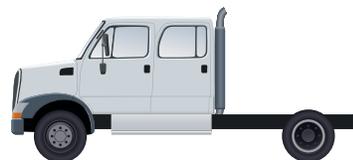
Extended Cab

Has additional storage space behind the front seat for cargo and/or passengers and is longer than a conventional cab. Usually used with a two-axle chassis.



Crew Cab

Features four doors and six-passenger seating. Used with a two-axle chassis.



Credit: iStock, NREL

Source: National Truck Equipment Association

Chassis Manufacturers

Manufacturer	Models	Applications	Web Site
Autocar LLC	Xpeditor ACX, Xpeditor E3, Autocar XE30	Heavy-duty refuse hauler or vocational truck	www.autocartruck.com
Blue Bird Corp.	All-American Rear Engine, Vision	School bus	www.blue-bird.com
Crane Carrier Co.	LDT2, LE2, LET2, LWT2	Medium-duty vocational truck, heavy-duty refuse hauler	www.cranecarrier.com
Ford Motor Co.	E450 Cutaway, F-450	Shuttle bus, vocational truck	www.ford.com/vehicles/commercial-vehicles
Freightliner Custom Chassis Corp.	Business Class M2 106, MB-55 Commercial Bus, MT-45, MT-55, Plug-in Walk-in Van	Hybrid vocational truck, bus, walk-in van, step van	www.freightlinerchassis.com
General Motors	Chevrolet/GMC W4500 cab forward	Vocational truck, flatbed, small sweeper	www.gmfleet.com
International	WorkStar	Heavy-duty vocational truck, refuse hauler	www.navistar.com/Trucks/Trucks/Series/WorkStar
Kenworth	T440, T470H, W900	Medium-duty vocational truck, Heavy-duty hauling, concrete mixer	www.kenworth.com/2100_vir.asp
Mack Trucks Inc.	TerraPro Cabover, TerraPro Low Entry	Heavy-duty refuse hauler or vocational truck	www.macktrucks.com/#/home
Navistar	DuraStar Hybrid	Medium-duty vocational truck	www.internationaltrucks.com/driverdisplaydemo
Peterbilt Motors	320, 330 HE, 337 HE, 365	Heavy-duty refuse hauler or cement mixer, medium-duty hybrid, medium-duty vocational truck	www.peterbilt.com/index.aspx
Smith Electric Vehicles	Newton Cab Chassis	Medium-duty vocational applications, shuttle bus	www.smithelectric.com
Workhorse Custom Chassis	W42	Shuttle bus, walk-in van	www.workhorse.com

Alternative Fuel Power Sources (Including Engines, Fuel Cells, and Microturbines)

Natural Gas Engines

Current-production natural gas engines are designed to operate solely on natural gas (dedicated), on either natural gas or gasoline (bi-fuel), or on a combination of natural gas and diesel fuel (dual-fuel). Dedicated and bi-fuel natural gas engines are spark-ignited, and dual-fuel engines utilize a minimal amount of diesel for pilot ignition in compression-ignition combustion. Natural gas is stored onboard the vehicle as either CNG or LNG. CNG is more common and has a longer history of use in vehicular applications, but LNG is gaining popularity in heavy-duty applications for which maximum fuel capacity and extended driving range are required. CNG is stored at pressures of 3,000 lb–3,600 lb per square inch in specially designed and constructed cylinders onboard the vehicle. LNG is cooled to a cryogenic temperature of approximately -260°F and stored as a liquid onboard the vehicle in double-wall, vacuum-insulated storage tanks. Vehicles that operate on LNG are typically heavy duty and require more range than CNG can provide.

Natural gas is a clean-burning alternative fuel and offers a number of advantages to users. It is clear, non-corrosive, and odorless, though an odorant is commonly added. Compared with conventional diesel vehicles, natural gas vehicles (NGVs) can produce significantly lower amounts of emissions, including NO_x, PM, and CO₂. Additionally, natural gas is generally less expensive than diesel or gasoline.



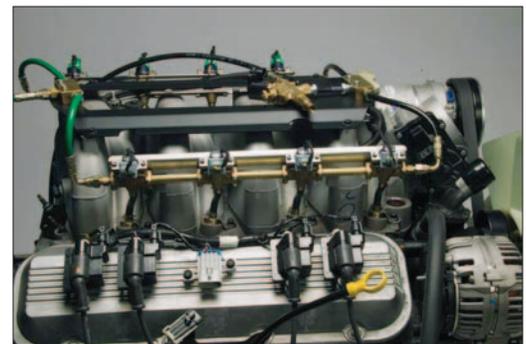
*Cummins Westport ISL G natural gas engine.
Courtesy of Cummins Westport Inc.*

Propane Engines

Propane—also known as liquefied petroleum gas, LPG, or autogas—is a byproduct of crude oil refining and natural gas processing. Propane is a gas at room temperature and is stored onboard a vehicle in a tank pressurized to around 150 lb per square inch.

Propane vehicles operate much like gasoline vehicles with spark-ignited engines. There are two types of propane fuel-injection systems available: vapor and liquid injection. In a vapor-injection system, liquid propane is controlled by a regulator or vaporizer, which converts the liquid to vapor, which is then drawn into the combustion chamber. In a liquid-injection system, fuel is delivered to the combustion chamber in liquid form.

Compared with conventional gasoline vehicles, propane vehicles can produce lower amounts of carbon monoxide and carbon dioxide.



*CleanFUEL USA Liquid Propane Injection system.
Courtesy of Clean Fuel USA.*

Battery Electrics

A battery-electric vehicle is one that operates solely on the power provided by a battery pack that is recharged by being plugged into the local power grid. Batteries may be lead acid, nickel metal hydride, or lithium ion. Electric vehicles powered by rechargeable batteries offer a number of aesthetic benefits. There is reduced noise from the lack of an internal combustion engine (ICE), no gear changes, and fewer moving parts. The vehicles themselves generate zero NO_x, PM, and CO emissions, though emissions are produced at the associated electricity-generating facility.

Fuel Cells

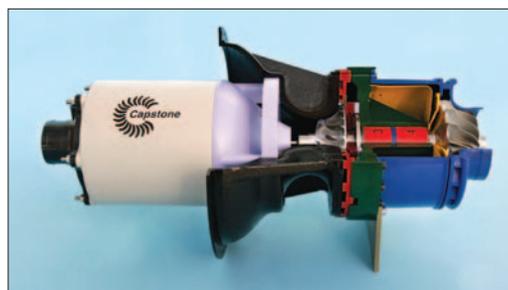
Fuel cells produce electricity through a chemical reaction—typically between hydrogen and oxygen—with water and heat as byproducts. In a fuel cell vehicle, the electricity is used to power a motor that drives the vehicle's wheels. In addition to producing zero harmful tailpipe emissions, hydrogen fuel cells are attractive for transportation applications for two main reasons. First, hydrogen can be produced from various sustainable and domestic resources. Second, fuel cells are more efficient than conventional ICEs, converting roughly 50% of the hydrogen's energy into electricity. Hydrogen storage is one of the major barriers to use of fuel cell vehicles. Hydrogen has a low energy density. To give fuel cell vehicles an adequate driving range, hydrogen must be stored on-board the vehicles as a very-high-pressure gas, a cryogenic liquid, or in another medium (e.g., methanol, ethanol, or natural gas) from which hydrogen is extracted.



Ballard FCvelocity fuel cell. Courtesy of Ballard Power Systems

Microturbines

A microturbine acts as an auxiliary power unit (APU) in series hybrid vehicles. The microturbine charges the batteries, which in turn power the electric motor that drives the wheels of the vehicle. The microturbine can be fueled with natural gas, waste methane, bio-diesel, diesel, or propane. Hybrid buses with microturbines operate in New York; Baltimore; Charlotte, North Carolina; and in several large cities in Europe.



Capstone C65 microturbine. Courtesy of Capstone Turbine Corp.

Engines Certified for Biodiesel

Biodiesel or biodiesel blends are used by heavy-duty vehicle operators to reduce petroleum consumption and pollutant emissions. Biodiesel is a domestic, renewable fuel for diesel engines, which must meet the specifications of ASTM D6751. Biodiesel is derived from vegetable oils, animal byproducts, or biomass conversion, but it is not the same as raw vegetable oil. Rather, it is produced by a chemical process that removes the glycerin from the oil.

B5 (5% biodiesel, 95% petroleum diesel) is frequently used in heavy-duty diesel vehicles. Engine manufacturers may also certify their engines for use with B20 (20% biodiesel, 80% petroleum diesel). Significant reductions of PM, CO, and hydrocarbon emissions can be achieved with B20 blends. Minor impacts in peak torque and fuel economy are related to the lower energy density of biodiesel fuels, but thermal efficiency is unchanged. The National Renewable Energy Laboratory's Biodiesel Handling and Use Guide is an excellent source of information about biodiesel transportation fuel. Find it using the AFDC publications search, www.afdc.energy.gov/afdc/progs/pubs.php.

Conversion Engines

Fleets that own numerous older diesel trucks may decide to have them converted to operate on alternative fuel. Conversions of heavy-duty vehicles involve replacing or rebuilding the engine and adding fuel tanks.

Alternative fuel engines and powertrains are now being packaged by their manufacturers to be a direct replacement for their diesel counterparts. A Cummins Westport CNG engine, for example, is configured to mount in a chassis just like a diesel engine, and an Allison parallel hybrid transmission can mount in the same space as a standard automatic transmission.

Companies that perform alternative fuel conversions are certified by the EPA or CARB to convert specific make and model year engines.

Engine, Power Source, Microturbine, and Fuel Cell Manufacturers

Manufacturer	Model	Fuel	Web Site
American Alternative Fuel	Bi-Fuel Propane System	Propane	www.americanaltfuel.com
Ballard Power Systems	FCvelocity HD6 Fuel Cell Module	Hydrogen	www.ballard.com
Ballard Power Systems	P5 HD Fuel Cell Module	Hydrogen	www.ballard.com
Ballard Power Systems	PEM Mark 9 SSL Fuel Cell Stack	Hydrogen	www.ballard.com
Capstone Turbine Corp.	C30 MicroTurbine	CNG, propane, biomethane	www.microturbine.com
Clean Air Power	MaxxForce 13 Dual-Fuel Engine	Natural gas	www.cleanairpower.com
Cummins Westport	ISL G 250-320 hp	CNG/LNG/ biomethane	www.cumminswestport.com
DesignLine International	ECOSaver IV	Microturbine	www.designlinecorporation.com
Doosan Infracore America Corp.	GK12-C	Natural gas	http://usa.doosaninfracore.co.kr/Product/CE_engine.aspx
Emissions Solutions	Phoenix NG 7.6L	Natural gas	www.emissionsolutionsinc.com
Enova Systems	Zero Emissions Drive System (120kW)	Electric	www.enovasystems.com
Ford Motor Co.	6.8L EFI V10 FFV engine	Ethanol	www.fleet.ford.com
General Motors	GM Vortec 8100	Propane	www.gmfleet.com
Hydrogenics	HyPM HD 8; HD 12; HD 16 Fuel Cell Power Modules	Hydrogen	www.hydrogenics.com
ISE Corp.	Fuel Cell System	Hydrogen	www.isecorp.com
Westport Innovations	GX 15L Engine	LNG	www.westport.com
UTC Power	PureMotion Model 120 Fuel Cell	Hydrogen	www.utcpower.com

Medium- and Heavy-Duty Vehicle Conversion Companies

Manufacturer	System	Fuel	Vehicle Models	Web Site
American Alternative Fuel	Bi-Fuel Propane System	Propane	Various	www.americanaltfuel.com
Azure Dynamics	Hybrid Electric	Hybrid	Walk-in vans	www.azuredynamics.com
BAF Technologies	CalComp System	Natural gas	Ford E-350 van; Ford E-450 shuttle; Ford F-450/550 truck	www.baftechnologies.com
Baytech Corporation	Conversion Systems	Natural gas	GMC 8.1L C6500/C7500/C8500 truck; GMC 6.0L in GM, Isuzu and Workhorse Custom Chassis heavy-duty vehicles	www.baytechcorp.com
Baytech Corporation	Conversion Systems	Propane	GMC 8.1L C4500/C5500 truck and shuttle; Workhorse Custom Chassis W62; 6.0L GMC C4500, Isuzu NPR HD; Workhorse Custom Chassis W42	www.baytechcorp.com
Bi-Phase Technologies	LPEFI System	Liquid propane	Medium-duty box trucks	www.bi-phase.com
CleanFuel USA	LPI System	Liquid propane	Blue Bird Propane Vision Bus; GM 8.1L C4500-C8500 Series Medium-Duty Truck; GM 6.0L G4500 Cut-Van Chassis; GM 6.0L Workhorse Custom Chassis W42; GM 6.0L G3500 Cut-Van Chassis	www.cleanfuelusa.com
Eaton	Hydraulic Hybrid System	Hydraulic	Peterbilt 320 HLA; Mack LE, MR and Granit chassis refuse trucks	www.eaton.com
Emission Solutions Inc.	Phoenix NG 7.6L	CNG, LNG, propane	Navistar	www.emissionsolutionsinc.com
Enova	Hybrid-electric: post-transmission, pre-transmission, or series	Hybrid	Ford E-250 cargo vans	www.enovasystems.com
EvoTek	Unnamed	CNG, LNG	Ford, General Motors vehicles	http://evotekllc.com
Odyne/DUECO	Plug-In Hybrid System; engine-powered recharge; regeneration; propulsion assist	Electricity	T292 Terex Hi Ranger mounted GMC 5500; ORA digger with a turret mounted winch mounted on IHC; 55' overcenter material handling device mounted on IHC 4300 4x2; underdeck hydraulically driven mounted on IHC 4300 4x2	www.odyne.com
Roush	LPI System	Propane	2009-2010 Ford 5.4L V8 F-150; F-250; F-350; E-150; E-250; E-350	www.roushperformance.com/propane.shtml

Hybrid Propulsion Systems by Design

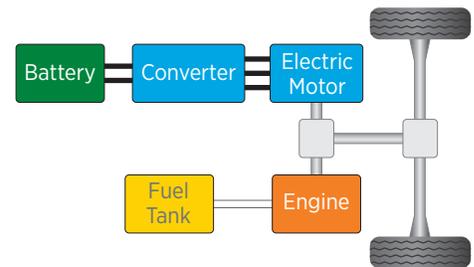
Hybrid vehicles rely on two or more sources to produce, store, and deliver power. In hybrid electric vehicles, these two sources are a conventional ICE and electricity. In hydraulic hybrids, they are the conventional engine and a hydraulic pump/motor with a hydraulic energy storage system.

Hybrid configurations use a combination of energy sources, including a power source paired with an electric motor and batteries. These configurations are very attractive for specific drive-cycle applications, including stop-and-start delivery vans and trucks, refuse collection, transit buses, utility bucket trucks, and warehouse tractors. Each of these applications involves engine stops and starts, extended idling, and frequent braking.

Parallel Hybrid System

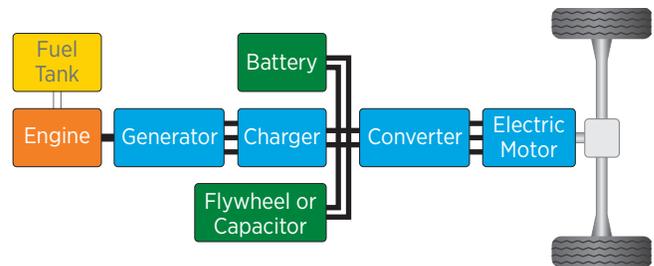
Parallel hybrid systems have both an ICE and an electric motor connected directly to the transmission. Most designs combine a large electrical generator and a motor into one unit, replacing both the conventional starter motor and the alternator. To store energy, a hybrid uses a large battery pack with a higher voltage than the normal automotive 12 volts.

Parallel hybrids can be further categorized depending on how balanced the different portions are at providing motive power. In some cases, the ICE is the dominant portion (the electric motor turns on only when a boost is needed) and vice versa. Others can run with just the electric system operating.



Series Hybrid System

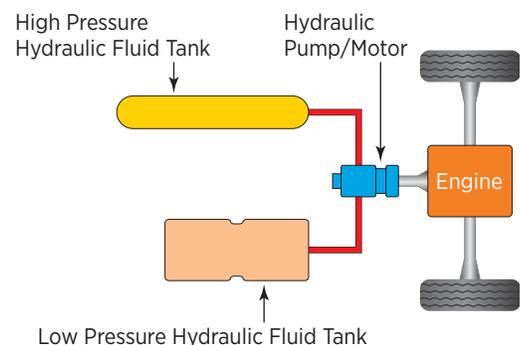
In series or serial hybrids, the ICE drives an electric generator instead of directly driving the wheels. The generator can either charge the batteries or power an electric motor that moves the vehicle. When large amounts of power are required, the motor draws electricity from both the batteries and the generator. Series hybrids can also be fitted with an ultracapacitor or a flywheel to store regenerative braking energy, which can improve efficiency by minimizing the losses in the battery.



Because a series hybrid lacks a mechanical link between the ICE and the wheels, the engine can run at a constant and efficient rate, even as the vehicle changes speed.

Parallel Hydraulic Hybrid System (Launch Assist)

The hydraulic launch assist (HLA) system uses a hydraulic pump and motor and hydraulic storage tanks to supplement the conventional vehicle powertrain. During braking, the vehicle's kinetic energy drives the pump/motor as a pump, transferring hydraulic fluid from the low-pressure reservoir to a high-pressure accumulator. The fluid compresses nitrogen gas in the accumulator and pressurizes the system. The regenerative braking captures about 70% of the kinetic energy produced during braking. During acceleration, fluid in the high-pressure accumulator is metered out to drive the pump/motor as a motor. The system propels the vehicle by transmitting torque to the driveshaft.

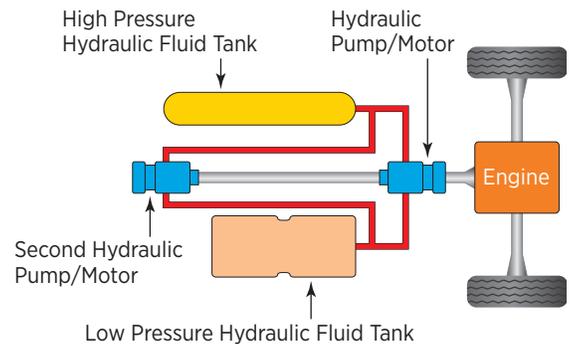


Illustrations - Credit: NREL

Series Hydraulic Hybrid System

In a series hydraulic hybrid system, the conventional transmission and driveline are replaced by the hydraulic hybrid powertrain, and energy is transferred from the engine to the drive wheels through fluid power. The vehicle uses hydraulic pump/motors and hydraulic storage tanks to recover and store energy, similar to what is done with electric motors and batteries in hybrid electric vehicles. The system is suited to vehicles that operate in stop-and-go duty cycles including heavy-duty refuse hauling.

The engine operates at its “sweet spot” of fuel consumption facilitated by the continuously variable transmission functionality of the series hydraulic hybrid system and by regenerative braking.



Hybrid Propulsion Systems by Fuel

Diesel Hybrids

Diesel electric hybrids are powered by both a diesel engine and an electric motor. The diesel engine generates electricity for the electric motor. The electric motor derives its power from an alternator or generator that is coupled with an energy storage device such as a set of batteries or super-capacitors.

Medium-duty vehicles that stop and start often are well suited for this technology that captures regenerative braking energy to power the electric motor. Hybrid vehicles produce zero emissions when running on electricity and reduce fuel use at the same time. The diesel engine's high torque combined with hybrid technology make this technology an excellent combination for medium- and heavy-duty vehicles.

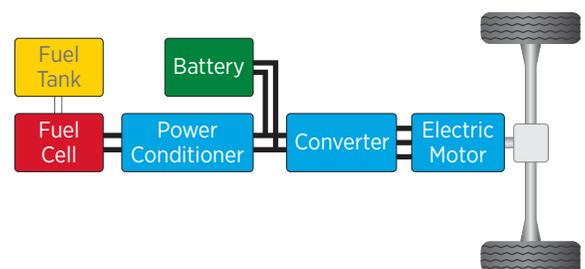
CNG Hybrids

A CNG hybrid system features a CNG-powered engine, an electric generator, inverters, two motors, and a battery pack. The electric motor derives its power from an alternator or generator that is coupled with an energy storage device, such as a set of batteries or super-capacitors.

Because natural gas is mostly methane, NGVs have much lower NMHC emissions than gasoline vehicles but higher emissions of methane. Because the fuel system is closed, there are no evaporative emissions, and refueling emissions are negligible. Cold-start emissions from NGVs are also low, because cold-start enrichment is not required; this reduces both volatile organic compound and CO emissions.

Fuel Cell Hybrids

Fuel cell hybrids operate much like other hybrid electric vehicles but with fuel cells producing electricity that charges the batteries, and a motor that converts electricity from the batteries into mechanical energy that drives the wheels. The efficiency of fuel cell hybrids can be increased through use of advanced technologies such as regenerative braking, which captures and stores energy that would otherwise be lost during braking.



Illustrations - Credit: NREL

Hybrid Propulsion System Manufacturers

Manufacturer	Model	Type	Web Site
Allison Transmission	Allison EP 40	2-Mode Split Parallel	www.allisontransmission.com
Allison Transmission	Allison EP 50	2-Mode Split Parallel	www.allisontransmission.com
Azure Dynamics	Balance Parallel Hybrid Drive	Parallel	www.azuredynamics.com
Azure Dynamics	CitiBus Series Hybrid Electric	Series	www.azuredynamics.com
BAE Systems	HybriDrive Propulsion System	Series	www.baesystems.com/ ProductsServices/bae_ prod_eis_hybriddrive.html
DesignLine International	ECOSaver IV	Series	www.designlinecorporation.com
Eaton	Eaton Hybrid Drive System	Parallel	www.eaton.com
Eaton	Eaton Hybrid HLA	Series	www.eaton.com
Eaton	Eaton Parallel Hybrid with Power Take-Off	Parallel	www.eaton.com
Enova Systems	Post Transmission Parallel Hybrid Electric Drive (90kW, 120kW, 140kW Drive Systems)	Parallel	www.enovasystems.com
ISE	Diesel Hybrid System	Series	www.isecorp.com
ISE	Gasoline Hybrid System	Series	www.isecorp.com
Parker Hannifin Corp.	RunWise	Hydraulic Hybrid	www.parker.com
Transportation Techniques (TransTeq)	EcoMark Hybrid System	Series	www.transteq.com
Voith	DIWAhybrid	Parallel	www.usa.voithturbo.com

Medium- and Heavy-Duty Vehicles by Application

School Bus



Manufacturer: Blue Bird Corp.

- Model: All American Rear Engine School Bus
- Manufacturer Web site: www.blue-bird.com
- Application: School bus
- Fuel Type Option: CNG
- Vehicle Class: Class 7 (26,001-33,000 lb)
- Maximum Seating Capacity: 66-84
- Description: Blue Bird's rear engine mount school bus is a dedicated CNG vehicle.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp



Manufacturer: Blue Bird Corp.

- Model: Blue Bird Vision
- Manufacturer Web site: www.blue-bird.com
- Application: School bus
- Fuel Type Option: Propane
- Vehicle Class: Class 7 (26,001-33,000 lb)
- Maximum Seating Capacity: 77
- Transmission Make: Allison 2300 Series
- Transmission Type: Auto
- Description: Blue Bird's Vision school bus is available in 48-77 passenger models and is fueled with CleanFUEL USA's LPI system.
- Compatible Power Sources:
 - › CleanFUEL USA LPI



Manufacturer: Collins Bus Corp.

- Model: NexBus Propane
- Manufacturer Phone: 800-533-1850
- Manufacturer Web site: www.collinsbus.com
- Applications: School bus
- Fuel Type Option: Propane
- Vehicle Class: Class 3 (10,001-14,000 lb)
- Maximum Seating Capacity: 14-30 with wheelchair capability
- Description: The Collins/CleanFUEL LPI Type A-1 school bus is a dedicated propane fueled bus built on the GM Cutaway chassis with a 6.0L engine and six speed automatic transmission.
- Compatible Power Sources:
 - › CleanFUEL USA LPI

Photos courtesy of manufacturers



Manufacturer: Collins Bus Corp.

- Model: NexBus Gasoline Hybrid
- Manufacturer Phone: 800-533-1850
- Manufacturer Web site: www.collinsbus.com
- Application: School Bus
- Fuel Type Option: Gasoline electric hybrid
- Vehicle Class: Class 4 (14,001-16,000 lb)
- Maximum Seating Capacity: 20
- Description: The Collins/Azure Type A-1 hybrid school bus is built on the E450 Ford chassis with a 5.4L gasoline engine.
- Compatible Hybrid Propulsion Systems:
 - › Azure Dynamics Balance Parallel Hybrid Drive



Manufacturer: IC Bus

- Model: CE Series Hybrid
- Manufacturer Web site: www.icbus.com
- Application: School bus
- Fuel Type Option: Diesel electric plug-in hybrid
- Vehicle Class: Class 6, 7 (19,501-33,000 lb)
- Maximum Seating Capacity: 81
- Transmission Make: Allison 2500 Series
- Transmission Type: Auto
- Description: The IC Bus CE Series plug-in hybrid school bus features a post-transmission, parallel hybrid system using a 25/80kW induction motor to provide sufficient power and efficiency on school bus routes.
- Compatible Hybrid Propulsion Systems:
 - › Enova Systems Post Transmission Parallel Hybrid Electric Drive



Manufacturer: Thomas Built Buses

- Model: Saf-T-Liner C2e Hybrid
- Application: School bus
- Fuel Type Option: Diesel electric hybrid
- Vehicle Class: Class 8 (over 33,000 lb)
- Transmission Make: Eaton Auto Shift Six-Speed
- Transmission Type: Manual
- Maximum Seating Capacity: 81
- Description: The Thomas Built Saf-T-Liner C2e has an Eaton charge sustaining parallel electric hybrid system with regenerative braking. Includes lithium-ion batteries.
- Compatible Hybrid Propulsion Systems:
 - › Eaton diesel electric hybrid



Manufacturer: Thomas Built Buses

- Model: Saf-T-Liner HDX CNG
- Application: School bus
- Fuel Type Option: CNG
- Vehicle Class: Class 8 (over 33,000 lb)
- Transmission Make: Allison
- Transmission Type: Manual
- Maximum Seating Capacity: 87
- Description: The Thomas Built Saf-T-Liner HDX CNG is a rear engine CNG-powered school bus.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp

Photos courtesy of manufacturers

Shuttle Bus



Manufacturer: Champion Bus Inc.

- Model: CTS - Front Engine
- Manufacturer Phone: 800-776-4943
- Manufacturer Web site: www.championbus.com
- Application: Shuttle bus
- Fuel Type Option: CNG
- Vehicle Class: Class 6 (19,501-26,000 lb)
- Maximum Seating Capacity: 32
- Transmission Make: Allison 2000
- Transmission Type: Auto
- Description: The CTS shuttle is built on a Freightliner MB55 rail chassis with a custom design bus body unique to Champion and available in 27-, 29-, 31-, 33-, and 38-ft models.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp



Manufacturer: Champion Bus Inc.

- Model: Defender
- Manufacturer Phone: 800-776-4943
- Manufacturer Web site: www.championbus.com
- Application: Shuttle bus
- Fuel Type Option: Gasoline electric hybrid
- Vehicle Class: Class 4 (14,001-16,000 lb)
- Transmission Make: Allison
- Description: The Defender is available in small to medium shuttle bus configurations with optional hybrid chassis.
- Compatible Hybrid Propulsion Systems:
 - › Azure Dynamics - Balance Parallel Hybrid Drive



Manufacturer: Ebus

- Model: EBUS22FC Plug-In Electric Fuel Cell Bus
- Manufacturer Phone: 562-904-3474
- Manufacturer Web site: www.ebus.com
- Application: Shuttle bus
- Fuel Type Option: Hydrogen fuel cell hybrid, Gasoline electric hybrid
- Vehicle Class: Class 4 (14,001-16,000 lb)
- Maximum Seating Capacity: 22
- Description: Ebus fuel cell buses are plug-in electric buses with the fuel cell and batteries configured electrically in series. The bus can operate on battery-only power for part of the day. The Ebus hybrid electric bus uses an ultra-low emission microturbine as an onboard hybrid generator.
- Compatible Power Sources:
 - › Ballard Power Systems - FCvelocity HD6 Fuel Cell Module
 - › Ballard Power Systems - PEM Mark 9 SSL Fuel Cell Stack
 - › Capstone Turbine C30 (30kW) Micro Turbine

Photos courtesy of manufacturers



Manufacturer: Glaval Bus

- Model: Universal
- Manufacturer Phone: 800-445-2825
- Manufacturer Web site: www.glavalbus.com
- Application: Shuttle bus
- Fuel Type Option: Gasoline electric hybrid
- Vehicle Class: Class 4 (14,001-16,000 lb)
- Maximum Seating Capacity: 14
- Description: Shuttle bus style vehicle powered by Azure Dynamics Balance Parallel Hybrid Drive.
- Compatible Hybrid Propulsion Systems:
 - › Azure Dynamics - Balance Parallel Hybrid Drive



Manufacturer: Goshen Coach

- Model: GCII Hybrid
- Manufacturer Phone: 574-970-6300
- Manufacturer Web site: www.goshencoach.com
- Application: Shuttle bus
- Fuel Type Option: Gasoline electric hybrid
- Vehicle Class: Class 4 (14,001-16,000 lb)
- Maximum Seating Capacity: 14
- Transmission Make: Electric Five-Speed Torqshift Automatic
- Description: The GCII Hybrid is built on a Ford F-450 chassis with a 5.4L gasoline engine and Azure parallel hybrid electric drive.
- Compatible Hybrid Propulsion Systems:
 - › Azure Dynamics - Balance Parallel Hybrid Drive



Manufacturer: IC Bus

- Model: HC Hybrid Series
- Manufacturer Web site: www.icbus.com
- Application: Shuttle bus
- Fuel Type Option: Diesel electric hybrid
- Vehicle Class: Class 5, 6, 7 (16,001-33,000 lb)
- Maximum Seating Capacity: 36
- Description: The IC Bus HC Series hybrid is a medium-size diesel hybrid electric bus dedicated to efficient shuttle and coach applications.
- Compatible Hybrid Propulsion Systems:
 - › Eaton Hybrid System



Manufacturer: StarTrans

- Model: President
- Manufacturer Phone: 574-642-4730
- Manufacturer Web site: www.startransbus.com
- Application: Shuttle bus
- Fuel Type Option: CNG, propane
- Vehicle Class: Class 6 (19,501-26,000 lb)
- Maximum Seating Capacity: 24-35
- Description: StarTrans' President model shuttle uses a Cummins 6.7 diesel engine converted to either CNG or propane fuel use.

Photos courtesy of manufacturers



Manufacturer: StarTrans

- Model: Senator
- Manufacturer Phone: 574-642-4730
- Manufacturer Web site: www.startransbus.com
- Application: Shuttle bus
- Fuel Type Option: CNG, gasoline electric hybrid
- Vehicle Class: Class 4 (14,001-16,000 lb)
- Maximum Seating Capacity: 17
- Transmission Make: Torqshift Five-Speed
- Transmission Type: Auto
- Description: The StarTrans Senator is available in a CNG model or as an electric hybrid built on a Ford E450 chassis.
- Compatible Hybrid Propulsion Systems:
 - › Azure Dynamics - Balance Parallel Hybrid Drive



Manufacturer: Turtle Top Inc.

- Model: Odyssey
- Manufacturer Phone: 800-296-2105
- Manufacturer Web site: www.turtletop.com
- Application: Shuttle bus
- Fuel Type Option: CNG, propane, gasoline electric hybrid
- Description: Odyssey shuttle is built on either a Ford E450 chassis or a GMC G4500 chassis. Available with bi-fuel propane system, dedicated LPI, dedicated CNG system, or the P1 Azure electric hybrid system.
- Compatible Power Sources:
 - › American Alternative Fuel - Bi-fuel Propane System
 - › CleanFuel USA - Liquid Propane Injection
 - › BAF CalComp CNG System
- Compatible Hybrid Propulsion Systems:
 - › Azure Dynamics - Balance Parallel Hybrid Drive



Manufacturer: Turtle Top Inc.

- Model: Odyssey XL
- Manufacturer Phone: 800-296-2105
- Manufacturer Web site: www.turtletop.com
- Application: Shuttle bus
- Fuel Type Option: Propane
- Maximum Seating Capacity: 40
- Description: The Odyssey XL can use a bi-fuel propane system or the dedicated propane system for medium-duty cutaways built on the Chevrolet C4500/C5500 chassis, Ford F550 chassis, or Freightliner FM2 chassis.
- Compatible Power Sources:
 - › American Alternative Fuel Bi-Fuel Propane System
 - › CleanFuel USA Liquid Propane Injection

StarTrans Senator photo courtesy of Azure Dynamics
 Turtle Top photos courtesy of manufacturer



Manufacturer: Turtle Top Inc.

- Model: Odyssey XLT
- Manufacturer Phone: 800-296-2105
- Manufacturer Web site: www.turtletop.com
- Application: Shuttle bus
- Fuel Type Option: Diesel electric hybrid
- Maximum Seating Capacity: 47
- Description: The Odyssey XLT is built on the Freightliner M2-106 chassis and can be powered by the FM2 Eaton Hybrid system.
- Compatible Hybrid Propulsion Systems:
 - › Eaton Hybrid Drive System



Manufacturer: Turtle Top Inc.

- Model: Terra Transport
- Manufacturer Phone: 800-296-2105
- Manufacturer Web site: www.turtletop.com
- Application: Shuttle bus
- Fuel Type Option: Propane
- Maximum Seating Capacity: 15
- Description: The Terra Transport is a shuttle bus built on either a Chevrolet Express or GMC Savana 3500 chassis. Bi-fuel gasoline/propane engine or dedicated LPI system available.
- Compatible Power Sources:
 - › American Alternative Fuel - Bi-fuel Propane System
 - › CleanFuel USA Liquid Propane Injection System



Manufacturer: Turtle Top Inc.

- Model: Van Terra
- Manufacturer Phone: 800-296-2105
- Manufacturer Web site: www.turtletop.com
- Application: Shuttle bus
- Fuel Type Option: CNG, propane
- Maximum Seating Capacity: 15
- Description: Turtle Top shuttle van is available on a Ford E350 chassis with bi-fuel propane engine or dedicated CNG engine.
- Compatible Power Sources:
 - › American Alternative Fuel - Bi-fuel Propane System
 - › BAF Technologies - CalComp CNG System

Photos courtesy of manufacturers

Transit Bus



Manufacturer: Daimler Buses North America

- Model: Orion VII CNG LF
- Manufacturer Phone: 905-403-1111
- Manufacturer Web site: www.daimler-busna.com
- Application: Transit bus
- Fuel Type Option: CNG
- Vehicle Class: Class 8 (over 33,000 lb)
- Maximum Seating Capacity: 44
- Transmission Make: ZF HP594/Allison B400R
- Transmission Type: Auto
- Description: The Orion VII CNG is a heavy-duty, low-floor transit bus.
- Compatible Power Sources:
 - › Cummins Westport ISL G 280



Manufacturer: Daimler Buses North America

- Model: Orion VII Hybrid Low-Floor
- Manufacturer Phone: 905-403-1111
- Manufacturer Web site: www.daimler-busna.com
- Application: Transit bus
- Fuel Type Option: Diesel electric hybrid
- Vehicle Class: Class 8 (over 33,000 lb)
- Maximum Seating Capacity: 44
- Description: The Orion VII Hybrid is a series hybrid design available in 30-, 35-, and 40-ft models with roof-mounted power control and energy storage unit. The Orion VII Hybrid uses lithium-ion batteries.
- Compatible Hybrid Propulsion Systems:
 - › BAE 123 HybriDrive Propulsion System



Manufacturer: DesignLine Corporation

- Model: EcoSaver IV
- Manufacturer Phone: 704-716-1020
- Manufacturer Web site: www.designlinecorporation.com
- Application: Transit bus
- Fuel Type Option: Diesel electric hybrid or CNG electric hybrid
- Vehicle Class: Class 8 (over 33,000 lb)
- Maximum Seating Capacity: 40
- Description: All DesignLine hybrid buses are full-series hybrids that use a relatively small APU versus a full-sized diesel engine. These buses are capable of operating on battery power only and capture benefits from regenerative braking.
- Compatible Power Sources:
 - › Capstone Turbine C30 (30kW) Micro Turbine
 - › Capstone Turbine C65 (65kW) Micro Turbine
- Compatible Hybrid Propulsion Systems:
 - › DesignLine EcoSaver IV System

Photos courtesy of manufacturers



Manufacturer: DesignLine Corporation

- Model: Eco-Smart 1
- Manufacturer Phone: 704-716-1020
- Manufacturer Web site: www.designlinecorporation.com
- Application: Transit bus
- Fuel Type Option: Electricity
- Vehicle Class: Class 8 (over 33,000 lb)
- Maximum Seating Capacity: 28
- Description: DesignLine's all electric Eco-Smart 1 is powered completely by battery electricity. Batteries are recharged with an external charger. The batteries also recover energy through regenerative braking to extend range.



Manufacturer: EIDorado National

- Model: Axess
- Manufacturer Phone: 909-591-9557
- Manufacturer Web site: www.enconline.com
- Application: Transit bus
- Fuel Type Option: CNG, LNG, Diesel Electric Hybrid
- Vehicle Class: Class 8 (over 33,000 lb)
- Maximum Seating Capacity: 43
- Transmission Make: Allison B400R
- Transmission Type: Auto
- Description: The Axess is a low-floor, 35- and 40-ft transit bus with roof-mounted CNG or LNG tanks.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp



Manufacturer: EIDorado National

- Model: E-Z Rider II BRT
- Manufacturer Phone: 909-591-9557
- Manufacturer Web site: www.enconline.com
- Application: Transit bus
- Fuel Type Option: CNG, LNG, Diesel Electric Hybrid, Gasoline Electric Hybrid
- Vehicle Class: Class 8 (over 33,000 lb)
- Maximum Seating Capacity: 43
- Transmission Make: Allison B300R, B400R
- Transmission Type: Auto
- Description: The E-Z Rider II BRT is available in 30-, 32-, and 35-ft models that can operate on CNG, LNG, or as an electric diesel or gasoline hybrid.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp

Photos courtesy of manufacturers



Manufacturer: EIDorado National

- Model: XHF
- Manufacturer Phone: 909-591-9557
- Manufacturer Web site: www.enconline.com
- Application: Transit bus
- Fuel Type Option: CNG, LNG
- Vehicle Class: Class 8 (over 33,000 lb)
- Maximum Seating Capacity: 39
- Transmission Make: Allison B300R, B400R
- Transmission Type: Auto
- Description: The XHF is a 29-30 ft conventional floor body on chassis that can be configured to run on CNG or LNG.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp



Manufacturer: Foton America

- Model: FCB 30-, 35-, or 40-ft transit bus
- Manufacturer Phone: 203-740-7000
- Manufacturer Web site: www.foton-america.com
- Application: Transit bus
- Fuel Type Option: CNG, diesel electric hybrid
- Vehicle Class: Class 8 (over 33,000 lb)
- Maximum Seating Capacity: 40
- Transmission Make: Allison B300R, B400R
- Description: The Foton FCB bus is available in 30-, 35-, or 40-ft diesel-electric or CNG models.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp
- Compatible Hybrid Propulsion Systems:
 - › Eaton Diesel Electric System



Manufacturer: Gillig Corp.

- Model: Diesel Electric Hybrid Bus
- Manufacturer Phone: 510-785-1500
- Manufacturer Web site: www.gillig.com
- Application: Transit bus
- Fuel Type Option: Diesel electric hybrid
- Vehicle Class: Class 8 (over 33,000 lb)
- Maximum Seating Capacity: 40
- Transmission Make: Allison EP40
- Description: The Gillig hybrid electric bus is available in 29-, 35-, and 40-ft low-floor models, which use the Allison EP40 dual-mode compound-split parallel architecture design.
- Compatible Hybrid Propulsion Systems:
 - › Allison EP 40 System System

Photos courtesy of manufacturers



Manufacturer: Motor Coach Industries

- Model: D4500CT Hybrid Commuter Coach
- Manufacturer Phone: 866-624-2622
- Manufacturer Web site: www.mcicoach.com
- Application: Transit bus
- Fuel Type Option: CNG, diesel electric hybrid
- Vehicle Class: Class 8 (over 33,000 lb)
- Maximum Seating Capacity: 57
- Transmission Make: Allison
- Transmission Type: Auto
- Description: The Motor Coach Industries' hybrid commuter coach is a 45-ft, 57-passenger, high-floor motor coach, optimally suited for commuter express service on highway or freeway. It is available with a Cummins Westport ISL engine or Allison EP 50 Hybrid Drive system.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp
- Compatible Hybrid Propulsion Systems:
 - › Allison EP 50 System



Manufacturer: NABI-North American Bus Industries

- Model: 31LFW / 35LFW / 40LFW
- Manufacturer Phone: 909-773-0500
- Manufacturer Web site: www.nabiusa.com
- Application: Transit bus
- Fuel Type Option: CNG, LNG, diesel electric hybrid
- Vehicle Class: Class 8 (over 33,000 lb)
- Maximum Seating Capacity: 30
- Transmission Make: Allison B500 R-ZF HP604
- Transmission Type: Auto
- Description: The NABI transit bus is available as a 31-, 35-, or 40-ft low-floor model fueled by CNG, LNG, or diesel electric operation.
- Compatible Power Source:
 - › Cummins Westport ISL G 250-320 hp
- Compatible Hybrid Propulsion Systems:
 - › ISE - Diesel Hybrid System



Manufacturer: NABI-North American Bus Industries

- Model: 42BRT
- Manufacturer Phone: 909-773-0500
- Manufacturer Web site: www.nabiusa.com
- Application: Transit bus
- Fuel Type Option: CNG, LNG, diesel electric hybrid
- Vehicle Class: Class 8 (over 33,000 lb)
- Maximum Seating Capacity: 43
- Description: NABI 42-ft transit bus is available in CNG, LNG, or diesel electric hybrid.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp
- Compatible Hybrid Propulsion Systems:
 - › ISE Diesel Hybrid System

Photos courtesy of manufacturers



Manufacturer: NABI-North American Bus Industries

- Model: 60BRT
- Manufacturer Phone: 909-773-0500
- Manufacturer Web site: www.nabiusa.com
- Application: Transit bus
- Fuel Type Option: CNG, LNG, diesel electric hybrid
- Vehicle Class: Class 8 (over 33,000 lb)
- Maximum Seating Capacity: 62
- Transmission Make: Allison B500 R-ZF HP604
- Transmission Type: Auto
- Description: NABI's 60-foot, low-floor, heavy-duty articulated transit bus is available in CNG, LNG, and diesel electric hybrid models.
- Compatible Power Source:
 - › Cummins Westport ISL G 250-320 hp
- Compatible Hybrid Propulsion Systems:
 - › ISE Diesel Hybrid System



Manufacturer: NABI-North American Bus Industries

- Model: CompoBus
- Manufacturer Phone: 909-773-0500
- Manufacturer Web site: www.nabiusa.com
- Application: Transit bus
- Fuel Type Option: CNG, LNG, diesel electric hybrid
- Vehicle Class: Class 8 (over 33,000 lb)
- Maximum Seating Capacity: 47
- Description: NABI's Metro 45C is a low-floor transit bus with a glass-fiber reinforced composite body capable of operating on diesel, CNG, LNG, or as a diesel-electric hybrid.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp
- Compatible Hybrid Propulsion Systems:
 - › Allison EP 40 System



Manufacturer: New Flyer of America

- Model: Advanced Style BRT
- Manufacturer Phone: 204-224-1251
- Manufacturer Web site: www.newflyer.com
- Application: Transit bus, electric trolley
- Fuel Type Option: CNG, LNG, diesel electric hybrid, gasoline electric hybrid, hydrogen electric hybrid, electricity
- Vehicle Class: Class 8 (over 33,000 lb)
- Maximum Seating Capacity: Varies with model
- Description: New Flyer's Advanced Style BRT bus model is available in 35-, 40-, and 60-ft articulated platforms with drive systems fueled by diesel electric hybrid, gasoline electric hybrid, fuel cell hybrid technology, or CNG or LNG. New Flyer's Advanced Style BRT trolley is a rubber-tired vehicle that operates as a trackless trolley. It is available in 35- and 40-ft models and a 60-ft articulated model that use catenary wires to power the trolley with electricity from overhead electric wires.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp
- Compatible Hybrid Propulsion Systems:
 - › Allison EP 40 System

Photos courtesy of manufacturers



Manufacturer: New Flyer of America

- Model: Restyled
- Manufacturer Phone: 204-224-1251
- Manufacturer Web site: www.newflyer.com
- Application: Transit bus, electric trolley
- Fuel Type Option: CNG, LNG, diesel electric hybrid, gasoline electric hybrid, hydrogen electric hybrid, electricity
- Vehicle Class: Class 8 (over 33,000 lb)
- Maximum Seating Capacity: Varies with model
- Description: New Flyer's Restyled bus model is available in 30-, 35-, 40-, and 60-ft articulated models with drive systems fueled by diesel electric hybrid, gasoline electric hybrid, fuel cell technology, or CNG or LNG. New Flyer's Restyled trolley is a rubber-tire vehicle that operates as a trackless trolley. It is available in 30-, 35- and 40-ft models and a 60-ft articulated model that use catenary wires to power the trolley with electricity from overhead electric wires.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp
- Compatible Hybrid Propulsion Systems:
 - › Allison EP 40 System



Manufacturer: New Flyer of America

- Model: Xcelsior
- Manufacturer Phone: 204-224-1251
- Manufacturer Web site: www.newflyer.com
- Application: Transit bus, electric trolley
- Fuel Type Option: CNG, LNG, diesel electric hybrid, gasoline electric hybrid, hydrogen electric hybrid, electricity
- Vehicle Class: Class 8 (over 33,000 lb)
- Maximum Seating Capacity: Varies with model
- Description: New Flyer's Xcelsior bus is available in 35-, 40-, and 60-ft platforms with drive systems fueled by diesel electric hybrid, gasoline electric hybrid, fuel cell hybrid technology, or CNG or LNG. New Flyer's Xcelsior trolley is a rubber-tire vehicle that operates as a trackless trolley. It is available in 30- and 40-ft models and a 60-ft articulated model that use catenary wires to power the trolley with electricity from overhead electric wires.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp
- Compatible Hybrid Propulsion Systems:
 - › Allison EP 40 System



Manufacturer: Nova Bus

- Model: LFS HEV
- Manufacturer Phone: 800-350-6682
- Manufacturer Web site: www.novabus.com
- Application: Transit bus
- Fuel Type Option: diesel electric hybrid
- Vehicle Class: Class 8 (over 33,000 lb)
- Maximum Seating Capacity: Varies with model
- Transmission Make: Allison EP40
- Description: The LFS HEV is based on Nova Bus's low-floor heavy-duty platform and is offered in a hybrid electric configuration.
- Compatible Hybrid Propulsion Systems:
 - › Allison EP 40 System

Photos courtesy of manufacturers



Manufacturer: Nova Bus

- Model: LFS Artic HEV
- Manufacturer Phone: 800-350-6682
- Manufacturer Web site: www.novabus.com
- Application: Transit bus
- Fuel Type Option: Diesel electric hybrid
- Vehicle Class: Class 8 (over 33,000 lb)
- Maximum Seating Capacity: Varies with model
- Transmission Make: Allison EP50
- Description: The LFS Artic HEV is a 60-ft articulated vehicle based on Nova Bus's low-floor heavy-duty platform and is offered in a hybrid electric configuration.
- Compatible Hybrid Propulsion Systems:
 - › Allison EP 50 System



Manufacturer: Van Hool

- Model: A300L Fuel Cell bus
- Manufacturer Phone: 800-222-2875
- Manufacturer Web site: www.vanhool.be
- Application: Transit bus
- Fuel Type Option: Hydrogen fuel cell electric hybrid
- Vehicle Class: Class 8 (over 33,000 lb)
- Maximum Seating Capacity: 28
- Transmission Make: Siemens Electric Propulsion/ZF Rear Axle
- Description: The Van Hool A300L is a 40-ft low-floor hydrogen fuel cell hybrid electric transit bus.
- Compatible Hybrid Propulsion Systems:
 - › Siemens - ELFA Electric Drive System

Refuse Truck



Manufacturer: Heil Environmental

- Model: Automated Python
- Manufacturer Phone: 800-824-4345
- Manufacturer Web site: www.heil.com
- Application: Refuse truck
- Fuel Type Option: CNG
- Vehicle Class: Class 8 (over 33,000 lb)
- Description: CNG refuse vehicle is available from Heil's single point-of-contact purchasing based on customer's specifications. The CNG-powered refuse haulers are EPA and CARB 2010 compliant.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp



Manufacturer: Heil Environmental

- Model: Automated RapidRail
- Manufacturer Phone: 800-824-4345
- Manufacturer Web site: www.heil.com
- Application: Refuse truck
- Fuel Type Option: CNG
- Vehicle Class: Class 8 (over 33,000 lb)
- Description: CNG refuse vehicle available from Heil's single point-of-contact purchasing based on customer's specifications. The CNG-powered refuse haulers are EPA and CARB 2010 compliant.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp



Manufacturer: Heil Environmental

- Model: Rear Loader
- Manufacturer Phone: 800-824-4345
- Manufacturer Web site: www.heil.com
- Application: Refuse truck
- Fuel Type Option: CNG
- Vehicle Class: Class 8 (over 33,000 lb)
- Description: CNG refuse vehicle available from Heil's single point-of-contact purchasing based on customer's specifications. The CNG-powered refuse haulers are EPA and CARB 2010 compliant.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp

Photos courtesy of manufacturers



Manufacturer: McNeilus

- Model: CNG Refuse Hauler
- Manufacturer Phone: 507-374-6321
- Manufacturer Web site: www.mcneilusrefuse.com
- Application: Refuse truck
- Fuel Type Option: CNG
- Vehicle Class: Class 8 (over 33,000 lb)
- Description: McNeilus CNG-powered refuse haulers are EPA and CARB 2010 compliant.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp



Manufacturer: Peterbilt Motors

- Model: Model 320 Hybrid HLA
- Manufacturer Phone: 940-591-4000
- Manufacturer Web site: www.peterbilt.com
- Application: Refuse truck
- Fuel Type Option: Hybrid hydraulic
- Vehicle Class: Class 8 (over 33,000 lb)
- Transmission Make: Allison
- Description: HLA hybrid refuse truck has a parallel hybrid drivetrain that captures the truck's kinetic energy during braking to assist in launching and accelerating the vehicle.
- Compatible Hybrid Propulsion Systems:
 - › Eaton - Hybrid HLA

Tractor



Manufacturer: Balqon

- Model: Nautilus E20
- Manufacturer Phone: 310-326-3055
- Manufacturer Web site: www.balqon.com
- Application: Terminal tractor
- Fuel Type Option: Electricity
- Description: The Nautilus E20 is an all-electric vehicle using lead acid batteries designed to transport cargo containers within terminal facilities. It has a 95-mile range on a single charge.



Manufacturer: Balqon

- Model: Nautilus E30
- Manufacturer Phone: 310-326-3055
- Manufacturer Web site: www.balqon.com
- Application: Tractor
- Fuel Type Option: Electricity
- Description: The Nautilus E30 is an all-electric vehicle using lead acid batteries designed to transport cargo containers within terminal facilities or for on-road trailer work.



Manufacturer: Capacity of Texas

- Model: PHETT Pluggable Hybrid
- Manufacturer Phone: 800-323-0135
- Manufacturer Web site: <http://capacitytexas.com>
- Application: Terminal tractor
- Fuel Type Option: Electricity
- Description: The PHETT is a plug-in hybrid electric vehicle for terminal cargo transfer.



Manufacturer: Capacity of Texas

- Model: TJ9000
- Manufacturer Phone: 800-323-0135
- Manufacturer Web site: <http://capacitytexas.com>
- Application: Terminal tractor
- Fuel Type Option: CNG, LNG
- Description: The TJ9000 is a terminal tractor for hauling cargo that operates on either CNG or LNG.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp

Photos courtesy of manufacturers



Manufacturer: Cargotec Solutions LLC

- Model: Ottawa 4x2
- Manufacturer Phone: 785-242-2200
- Manufacturer Web site: www.cargotec.com
- Application: Terminal Tractor
- Fuel Type Option: CNG, LNG
- Description: The natural gas-powered Ottawa 4x2 is designed for moving trailers and containers within a terminal setting.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp



Manufacturer: Freightliner

- Model: Business Class M2 112 tractor
- Manufacturer Phone: 800-385-4357
- Manufacturer Web site: www.freightlinertrucks.com
- Application: Tractor
- Fuel Type Option: CNG, LNG
- Vehicle Class: Class 7-8 (26,001-over 33,000 lb)
- Description: Freightliner M2 112 is a heavy-duty Class 8 tractor that operates on CNG or LNG.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp



Manufacturer: Kenworth

- Model: T370 Diesel Electric Tractor
- Manufacturer Phone: 425-828-5000
- Manufacturer Web site: www.kenworth.com
- Application: Tractor
- Fuel Type Option: Diesel electric hybrid
- Vehicle Class: Class 7 (26,001-33,000 lb)
- Description: The T370 is a Class 7 medium-duty hybrid truck with PACCAR PX-6 engine and the Eaton diesel-electric hybrid power system.
- Compatible Hybrid Propulsion Systems:
 - › Eaton Diesel Electric



Manufacturer: Kenworth

- Model: T800 LNG tractor
- Manufacturer Phone: 425-828-5000
- Manufacturer Web site: www.kenworth.com
- Application: Tractor
- Fuel Type Option: LNG
- Vehicle Class: Class 8 (over 33,000 lb)
- Description: The LNG-powered T800 tractor is designed for heavy-duty port, freight, and vocational applications and has an operating range of 300-500 miles.
- Compatible Power Sources:
 - › Westport GX 15L LNG Engine

Photos courtesy of manufacturers



Manufacturer: Peterbilt Motors

- Model: Model 384 NG
- Manufacturer Phone: 940-591-4000
- Manufacturer Web site: www.peterbilt.com
- Application: Tractor
- Fuel Type Option: CNG, LNG
- Vehicle Class: Class 8 (over 33,000 lb)
- Transmission Make: Allison
- Description: The Peterbilt Model 384 NG is a heavy-duty tractor equipped with a Cummins Westport ISL G engine designed for tanker, bulk and regional hauling applications.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp



Manufacturer: Peterbilt Motors

- Model: Model 386DC LNG Tractor
- Manufacturer Phone: 940-591-4000
- Manufacturer Web site: www.peterbilt.com
- Application: Tractor
- Fuel Type Option: LNG
- Vehicle Class: Class 8 (over 33,000 lb)
- Transmission Make: Eaton
- Description: Peterbilt's Model 386DE tractor is fueled with LNG.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp



Manufacturer: Peterbilt Motors

- Model: Model 386HE Tractor
- Manufacturer Phone: 940-591-4000
- Manufacturer Web site: www.peterbilt.com
- Application: Truck
- Fuel Type Option: Diesel electric hybrid
- Vehicle Class: Class 8 (over 33,000 lb)
- Transmission Make: Eaton
- Description: Peterbilt's Model 386 Hybrid Electric tractor uses recovered energy from braking to provide torque to the truck's driveline. This process improves vehicle performance, operating the engine in a more fuel-efficient range.
- Compatible Hybrid Propulsion Systems:
 - › Eaton – Diesel Electric

Photos courtesy of manufacturers



Manufacturer: Vision Motor Corp.

- Model: Tyrano
- Manufacturer Phone: 310-450-0299
- Manufacturer Web site: www.visionmotorcorp.com
- Application: Tractor
- Fuel Type Option: Fuel cell electric hybrid
- Vehicle Class: Class 8 (over 33,000 lb)
- Transmission Make: Eaton
- Description: The Tyrano is a Class 8 zero emission, plug-in electric/hydrogen fuel cell hybrid tractor. Vision's proprietary electric/hydrogen hybrid drive system combines the superior acceleration of a battery powered electric vehicle with the extended range provided by a hydrogen fuel cell. The Tyrano has 402 HP and up to 3,200 LB/FT of torque available.
- Compatible Hybrid Propulsion Systems:
 - › Eaton Hybrid Drive System



Manufacturer: Vision Motor Corp. / Capacity of Texas

- Model: ZETT Zero Emission Terminal Tractor
- Manufacturer Phone: 310-450-0299
- Manufacturer Web site: www.visionmotorcorp.com
- Application: Tractor
- Fuel Type Option: Hydrogen fuel cell electric hybrid
- Vehicle Class: Class 8 (over 33,000 lb)
- Transmission Make: Eaton
- Description: The ZETT is Vision's proprietary electric/hydrogen hybrid drive system developed in conjunction with Capacity of Texas, which combines the superior acceleration of a battery powered electric vehicle with the extended range provided by a hydrogen fuel cell.
- Compatible Power Sources:
 - › Vision proprietary Electric/Hydrogen Hybrid Drive System

Van



Manufacturer: Boulder Electric Vehicle

- Model: Delivery Truck
- Manufacturer Phone: 303-956-7527
- Manufacturer Web site: <http://boulderev.com>
- Application: Step van
- Fuel Type Option: Electricity
- Description: Boulder Electric Vehicle's delivery truck operates on lithium iron phosphate batteries and has a range of 120 miles per eight-hour charge.



Manufacturer: Electric Vehicles International

- Model: WI EVI
- Manufacturer Phone: 209-939-0405
- Manufacturer Web site: www.evi-usa.com
- Application: Walk-in van
- Fuel Type Option: Electricity
- Transmission Make: Eaton Ultrashift Six-Speed
- Transmission Type: Automatic
- Description: The WI EVI is an all-electric walk-in van based on a Freightliner chassis.



Manufacturer: Enova Systems

- Model: Enova Ze step van
- Manufacturer Phone: 310-527-2800
- Manufacturer Web site: www.enovsystems.com
- Fuel Type Option: Electricity
- Application: Walk-in van
- Transmission Type: Automatic
- Description: The Enova Ze is a zero emissions, all-electric walk-in van built on the Freightliner Custom Chassis MT-45 chassis.



Manufacturer: Ford Motor Company

- Model: Transit Connect
- Manufacturer Web site: www.fordvehicles.com/transitconnect
- Fuel Type Option: CNG, propane, electricity
- Application: Cargo van
- Transmission Type: Automatic
- Description: The Transit Connect all-electric van uses Azure Dynamics Force Drive battery electric powertrain and Johnson Controls-Saft's lithium-ion battery technology. CNG and propane models will be available from contract converters using Ford's engine prep package.

Photos courtesy of manufacturers

Vocational Truck



Manufacturer: Balqon

- Model: Mule M150
- Manufacturer Phone: 310-326-3055
- Manufacturer Web site: www.balqon.com
- Application: Vocational truck
- Fuel Type Option: Electricity
- Description: The Mule M150 is an electric truck with heavy-duty transmission for off-highway applications. The Mule uses Balqon's lithium-ion batteries and has a 150-mile range on a single charge and is a zero emission vehicle.



Manufacturer: Electric Vehicles International

- Model: MD EVI
- Manufacturer Web site: www.evi-usa.com
- Application: Truck
- Fuel Type Option: Electricity
- Vehicle Class: Class 4 (14,001-16,000 lb)
- Transmission Make: Eaton Ultrashift Six-Speed
- Transmission Type: Automatic
- Description: The MD EVI is a medium-duty Freightliner M2-based truck using Valence U-Charge XP lithium iron phosphate batteries.



Manufacturer: Freightliner

- Model: Business Class M2 106 Hybrid
- Manufacturer Phone: 800-385-4357
- Manufacturer Web site: www.freightlinertrucks.com
- Application: Vocational truck
- Fuel Type Option: Diesel electric hybrid
- Vehicle Class: Class 6-8 (19,501-over 33,000 lb)
- Description: The Freightliner M2 106 Hybrid is a medium- to heavy-duty diesel electric vocational truck suitable for beverage delivery, dump or boom truck operations, or standard box truck configuration.
- Compatible Hybrid Propulsion System:
 - › Eaton Parallel Electric Hybrid System



Manufacturer: Freightliner

- Model: Business Class M2 112
- Manufacturer Phone: 800-385-4357
- Manufacturer Web site: www.freightlinertrucks.com
- Application: Vocational truck
- Fuel Type Option: CNG, LNG
- Vehicle Class: Class 7-8 (26,001-over 33,000 lb)
- Description: Freightliner's M2 112 is a natural-gas powered vocational truck suitable for dump truck or standard box truck configuration.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp

Photos courtesy of manufacturers



Manufacturer: Kenworth

- Model: T270
- Manufacturer Phone: 425-828-5000
- Manufacturer Web site: www.kenworth.com
- Application: Vocational truck
- Fuel Type Option: Diesel electric hybrid
- Vehicle Class: Class 6 (19,501-26,000 lb)
- Description: The Kenworth T270 is a Class 6 medium-duty hybrid truck powered by a PACCAR PX-6 engine with an integral transmission-mounted motor/generator and a frame-mounted 340-volt battery pack.
- Compatible Hybrid Propulsion Systems:
 - › Eaton Hybrid Drive System



Manufacturer: Kenworth

- Model: T370
- Manufacturer Phone: 425-828-5000
- Manufacturer Web site: www.kenworth.com
- Application: Vocational truck
- Fuel Type Option: Diesel electric hybrid
- Vehicle Class: Class 7 (26,001-33,000 lb)
- Description: The Kenworth Class 7 T370 is powered by a Cummins diesel engine and features an integral transmission-mounted motor/generator and a frame-mounted 340-volt battery pack.
- Compatible Hybrid Propulsion Systems:
 - › Eaton Hybrid Drive System



Manufacturer: McNeilus

- Model: CNG Cement Mixer
- Manufacturer Phone: 507-374-6321
- Manufacturer Web site: www.mcneiluscompanies.com/Home.html
- Application: Vocational truck
- Fuel Type Option: CNG
- Vehicle Class: Class 8 (over 33,000 lb)
- Description: The McNeilus CNG-powered cement mixer was the first commercially manufactured alternative fuel mixer on the market.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp



Manufacturer: Peterbilt

- Model: Model 337 Hybrid
- Manufacturer Phone: 940-591-4000
- Manufacturer Web site: www.peterbilt.com
- Application: Vocational truck, utility truck
- Fuel Type Option: Diesel electric hybrid
- Vehicle Class: Class 7 (26,001-33,000 lb)
- Description: Useful in applications ranging from pickup and delivery, fire and rescue, beverage delivery to utility service.
- Compatible Hybrid Propulsion Systems:
 - › Eaton Hybrid Drive System

Photos courtesy of manufacturers



Manufacturer: Peterbilt Motors

- Model: Model 365 NG
- Manufacturer Phone: 940-591-4000
- Manufacturer Web site: www.peterbilt.com
- Application: Vocational truck
- Fuel Type Option: CNG, LNG
- Vehicle Class: Class 8 (over 33,000 lb)
- Transmission Make: Allison
- Transmission Type: Auto
- Description: The Peterbilt Model 365 NG is equipped with a Cummins Westport ISL G 320 engine and is available in both set-forward and set-back axle configurations.
- Compatible Power Sources:
 - › Cummins Westport ISL G 250-320 hp



Manufacturer: ZeroTruck

- Model: ZeroTruck
- Manufacturer Phone: 714-675-7117
- Manufacturer Web site:
- Application: Vocation truck; van
- Fuel Type Option: Electricity
- Vehicle Class: Class 5 (16,001-19,500 lb)
- Transmission Type: Auto
- Description: ZeroTruck is an all-electric zero emission medium-duty truck based on the Isuzu N series chassis. The vehicle is available as a cab chassis in GVWR Classes 4, 5 or 6; an optional crew cab or a walk-in van. The ZeroTruck has full highway capability and up to a 100-mile range.
- Compatible Power Sources:
 - › UQM PowerPhase 100 advanced electric motor

Glossary

AFDC	Alternative Fuels and Advanced Vehicles Data Center	G/BHP-HR . . .	Grams per brake horsepower hour
APU	Auxiliary power unit	GVWR	Gross vehicle weight rating
B20	20% biodiesel and 80% petroleum diesel fuel	HLA	Hydraulic launch assist
BRT	Bus Rapid Transit	ICE	Internal combustion engine
CARB	California Air Resources Board	LF	Low Floor
CNG	Compressed natural gas	LNG	Liquefied natural gas
CO	Carbon monoxide	LPG	Liquefied petroleum gas (propane)
CO₂	Carbon dioxide	LPI	Liquid propane injection
EGR	Exhaust gas recirculation	NGV	Natural gas vehicle
EPA	U.S. Environmental Protection Agency	NMHC	Non-methane hydrocarbons
FFV	Flexible fuel vehicle	NO_x	Oxides of nitrogen
GHG	Greenhouse gas	OEM	Original equipment manufacturer
		PM	Particulate matter
		SCR	Selective catalytic reduction

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