

#4: ZERO EMISSION TRUCK MARKET & TECHNOLOGY

Deployment status and performance

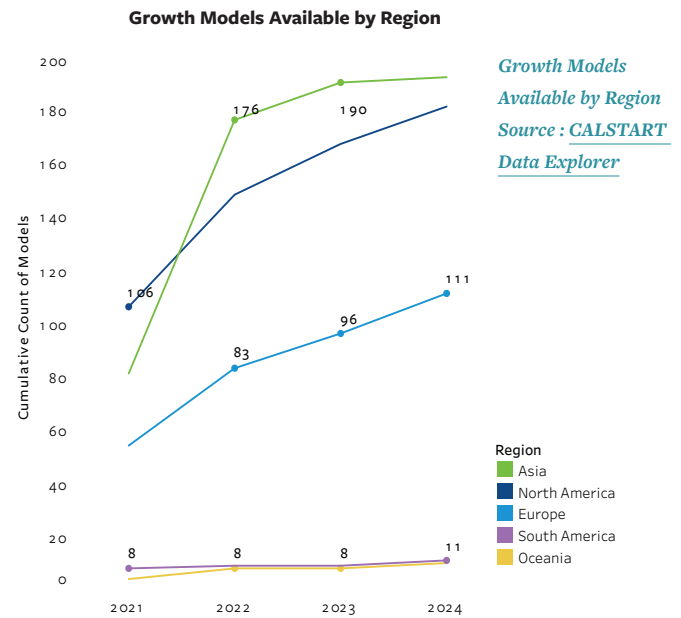
ZERO EMISSION TECHNOLOGY BASICS

There are two basic formats for zero emission trucks (ZETs): battery electric and hydrogen fuel cell. Both technologies require an electric motor, electric drivetrain, battery, and inverter. However, instead of having a bigger battery, a hydrogen-powered truck has a more complex array of hydrogen fuel cells, hydrogen tanks and hydrogen delivery equipment. Hydrogen trucks have a higher upfront cost, but offer the major benefit of requiring only 10-20 minutes to refuel (even for long-haul applications), compared to the potentially multi-hour charging

required for a battery electric truck. Fuel and maintenance costs for hydrogen trucks can be higher, as hydrogen (especially “green” hydrogen made from sustainable non-carbon emitting sources) is currently hard to come by and the technology is mechanically more complex.

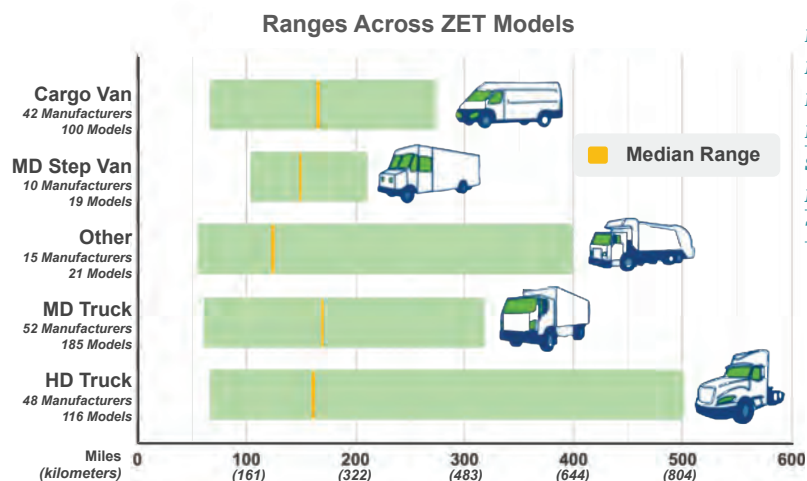
MODELS AVAILABLE FOR MOST COMMERCIAL USES

Worldwide, nearly 60 [manufacturers have developed over 450 ZET models](#) for a wide range of truck applications. Notably, most of these models are available in regions that have or are in the process of adopting supply side regulations or binding targets that accelerate ZETs. This includes the US (with state [Advanced Clean Truck \(ACT\) Rule](#) and national [Phase 3 HDV GHG Standards](#)), the EU (with [CO₂ HDV Standards](#)), and China (with [central and city-level mandates](#)). By creating economic certainty, regulations increase manufacturer [investment and innovation](#) in technology and drive a diverse and expanding supply of competitive products and services across commercial truck applications.



CAPABLE OF NECESSARY RANGE

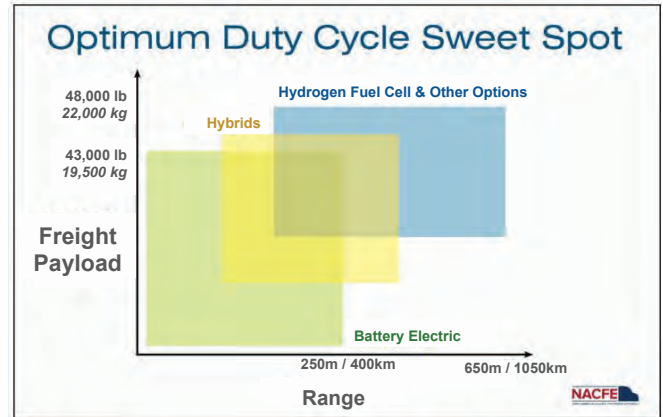
Current ZET technology meets the daily travel needs of most commercial trucks. Trucks often travel to predictable destinations with consistent mileage and a majority operate over short urban routes and stop frequently. In the US, more than 80% of trucks have an operating range of [less than 100 miles](#) (160 km) from their home base; nearly 70% have an operating range of less than 50 miles (80 km).



Ranges Across ZET Models, Source 1: Range Data: CALSTART ZETI Data Explorer
Source 2: [Manufacturer Model Data ICCT TCO Tracker](#)

PAYLOAD RESTRICTIONS ARE MANAGEABLE

Compared to diesel trucks, some ZETs have payload limitations due to heavy batteries or large hydrogen tanks. For most trucks, especially those with urban deliveries or short-haul routes under 250 miles (400 km) per day, this is not a concern and battery electric trucks are often a cost-saving option. Many trucks that carry large payloads can be more limited by volume than by weight. For trucks with heavier payloads, longer routes, and brief, infrequent stops, megawatt-level (e.g. ultra-fast) charging or quick-fueling hydrogen can be suitable solutions. For now, regulators can offer exemptions for dimensions or weight to mitigate payload restrictions. The EU allows electric trucks an additional 4 tonne, while California in the U.S. allows up to 2,000 lb. However, with expected advancements in battery energy density, hydrogen storage, and more light-weight, efficient truck designs [ZETs will eventually catch up with and even exceed](#) the payload of diesel trucks.



Optimum Duty Cycle Sweet Spot
Source : [NACFE\(2023\)](#)

EXTREME TEMPERATURE

The range of battery electric vehicles is [reduced](#) in extremely high or low temperatures, due to impacts on battery chemistry and the driver's heating and cooling needs. Multiple analyses have found that average speed has a greater impact on driving range than temperature. Thus, driving behavior training to encourage eco-driving that optimizes range can help offset environmental factors. Although some amount of weather-related range loss is unavoidable, fleets have demonstrated [solutions and strategies](#) to maintain effective performance. Cold weather tactics include: switching from resistance heaters to more efficient heat pumps and vehicle pre-heating while plugged-in. Ongoing improvements in electric truck range will reduce these impacts over time.

ALREADY ON THE ROAD

Many ZETs are already in operation around the world. Run on Less (map right) is an initiative of the [North American Council for Freight Efficiency](#) (NACFE). They track electric trucks operated by private fleets in a variety of commercial use-cases across North America. They've shown that electric trucks are already feasible and cost competitive alternatives for fleet vehicles operating defined routes, especially those with central depots. Market segments ready for electrification now include: vans and step vans, medium-duty box trucks, terminal tractors, and heavy-duty regional haul tractors.



Source : [NACFE\(2022\)](#)

