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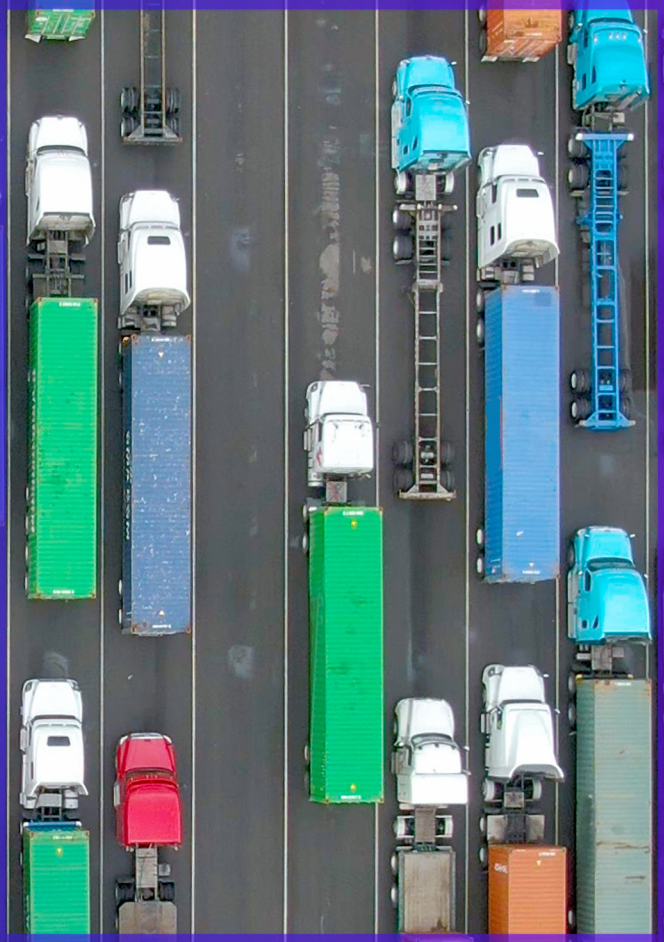
Alternative fuels for trucking? Consider hydrogen



Electric, hydrogen, or diesel? It all depends.

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29%

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Introduction

Trucks haul most of the freight in the United States and are essential to the country's transportation and logistics sector—an industry that accounts for 3.2 percent of the US's overall GDP.[1]

Diesel fuel powers the overwhelming majority of these medium- and heavy-duty trucks. It offers operators several advantages: a well-established fuel and service infrastructure, predictable support along unpredictable routes, and affordable vehicles, parts, and service.[2] And, diesel works for every application, from long-haul transport to last-mile delivery.

But as anyone who has driven behind an aging tractor trailer belching exhaust can attest, diesel has a major downside. The transportation sector contributed 29 percent of all US emissions in 2021,[3] and with transportation's share of emissions remaining relatively constant over the past decade,[4] operators are under pressure to reduce the impact of their operations on the climate.

The good news is that environmentally friendly options are available. The bad news is that the zero emission alternatives—electric and hydrogen—don't offer operators the flexibility or the affordability they get from diesel powertrains. Leaders tasked with cutting emissions must decide how to map the fuel to the application and maximize the return on their investment.

It is unlikely that any one alternative fuel powertrain will replace diesel entirely. Rather, as we argued in Place your billion-dollar bets wisely, there will be multiple fuel and powertrain options—internal combustion engines, fully electric trucks and cars, hydrogen fuel cells, and hybrids—to meet the needs of the market.[5] That might look like electric vehicles for local, light-payload deliveries; hydrogen powertrains for heavy cargo on regular and well-supported routes; and diesel for long-haul, unpredictable routes.

In this paper, we will examine the short- and long-term US outlook for alternative fuels for commercial trucking. We'll also consider the challenges faced by original equipment manufacturers (OEMs), suppliers, and infrastructure providers as they consider investing in up-and-coming fuels such as hydrogen.

[1] Source: FRED, US Bureau of Labor Statistics.

[2] Sources: The ICCT, Forbes, energy.gov, openpr.com, truckpartsandservice.com, globenewswire.com, cbc.ca, unitedworldtransportation.com, trucknews.com, noregon.com, and makeuseof.com.

[3] Source: US EPA, US Transportation Sector GHG Emissions, 1990—2021.

[4] Ibid.

[5] Source: *Place your billion-dollar bets wisely*, KPMG LLP, 2021.

Electric: good for shorter routes

OEMs have put considerable effort into electric battery power. Electric cars and their charging stations are becoming more commonplace—in fact, a record 1.2 million new electric vehicles were put into service in the US last year.[6]

But when it comes to truck transportation, the transition to electric is more complicated. On the plus side, electric trucks work well for short-haul applications with light payloads, such as last-mile delivery of consumer goods, buses, and most light commercial vehicles, which is why UPS, FedEx, and DHL have been making deliveries using electrified vans for years.[7] Their limited range—under 250 miles—means the truck is never too far from the garage or depot, making end-of-route charging easy.

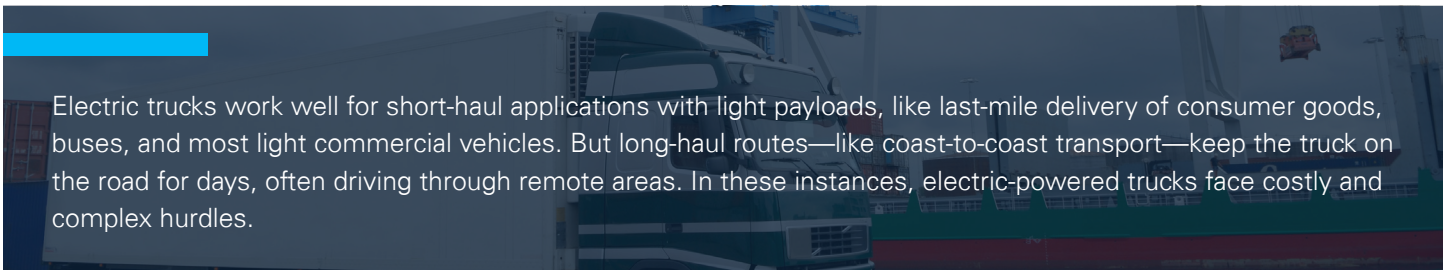
But long-haul routes—such as coast-to-coast transport—keep the truck on the road for days, often driving through remote areas. In these instances, electric-powered trucks face costly and complex hurdles:

- **Inadequate charging infrastructure:** The US electric charging infrastructure cannot support long-haul electric trucks now or soon, and the International Council on Clean Transportation (ICCT) estimates that a cumulative investment of $155 billion is necessary to accommodate the growing battery/electric truck fleet in the US by 2040. There is also the issue of real estate: Charging stations would have to be large enough to service multiple trucks simultaneously, each with their own power demand.

  Heavy-duty, electric battery semis require chargers that could deliver 1-2 megawatts of power each (compared to the current fast chargers designed for cars, which supply power at 150-250 kilowatts).[9] For context, the Schneider National Operations Center in South El Monte, California, has 16 heavy-duty chargers, each capable of charging 32 electric-battery trucks simultaneously using 6 megawatts of electricity—the same as the amount required to power 200,000 homes.

- **Long charging times:** For truck uses that require lengthy duty cycles to maintain profitability (such as port drayage or regional distribution), electric batteries take eight or more hours to charge, causing companies to lose a full shift.

- **Battery weight:** The weight of the battery pack severely restricts the payload capacity of heavy-duty trucks.[10] A semi-truck can weigh up to 80,000 pounds, including 42,000-48,000 pounds of cargo. In the case of an electric semi, its battery could weigh as much as 10,000 pounds, or nearly a fourth of its payload. After accounting for fuel and the engine, an electric battery-powered truck could be more than 5,000 pounds heavier than its diesel counterpart.[11] This weight penalty would further squeeze trucking companies' profit margins, which currently range between 2.5 percent and 6 percent,[12] even after accounting for 2,000 pounds additional weight provision for electric vehicles.



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[6] "A record 1.2 million EVs were sold in the US in 2023, according to estimates from Kelly Blue Book," Cox Automotive website. January 9, 2024.

[7] "Top EV Truck and Van Companies to Wath in 2023," EV Industry Blog website. (No date)

[8] Source: Amazon company website. April 17, 2024.

[9] "Electric truck fleets will need a lot of power, but utilities aren't planning for it," GreenBiz website. August 2020.

[10] "Electric car battery weight explained," EVBOX blog website. May 5, 2023.

[11] "Electrifying trucking will mean sacrificing critical weight for heavy batteries, eating into already slim margins," Business Insider website. February 2, 2023.

[12] Sources: The International Council on Clean Transportation; Business Insider; Freight waves.

Hydrogen looks promising

Hydrogen powertrains, sometimes referred to as fuel cell electric vehicles (FCEVs), address some of the shortcomings around electric batteries. FCEVs transform hydrogen's chemical energy to electric energy, which in turn powers an electric motor. Hydrogen gas has a higher energy density compared to lithium batteries, which means it can store more energy per unit of weight. That makes it more suitable for heavier payloads. Moreover, hydrogen-powered trucks can refuel in minutes—much closer in time to a gas or diesel fill up. And because they produce only water as a byproduct, they don't emit greenhouse gases,[13] assuming the hydrogen gas is generated using clean energy.

Hydrogen's potential makes it an alternative fuel to watch for long haul trucking, but there are a few use cases where the transition to hydrogen could occur sooner rather than later. One is hauling heavy cargo along short, regular routes, such as delivering heavy appliances or construction materials. Another is port drayage, in which multiple trucks transport cargo containers from maritime ports to other transportation hubs on a nearly around-the-clock basis. Are electric trucks a possibility on these routes? Not yet: If operators tried to use electric battery-powered trucks, they would take too long to charge and limit the trucks' usage. In addition, the current electric grid can't support charging fleets of electric trucks—there are 30,000 trucks that provide drayage service to the ports in Southern California alone. Add in heavier payloads, and electric trucks cease to be a viable option.

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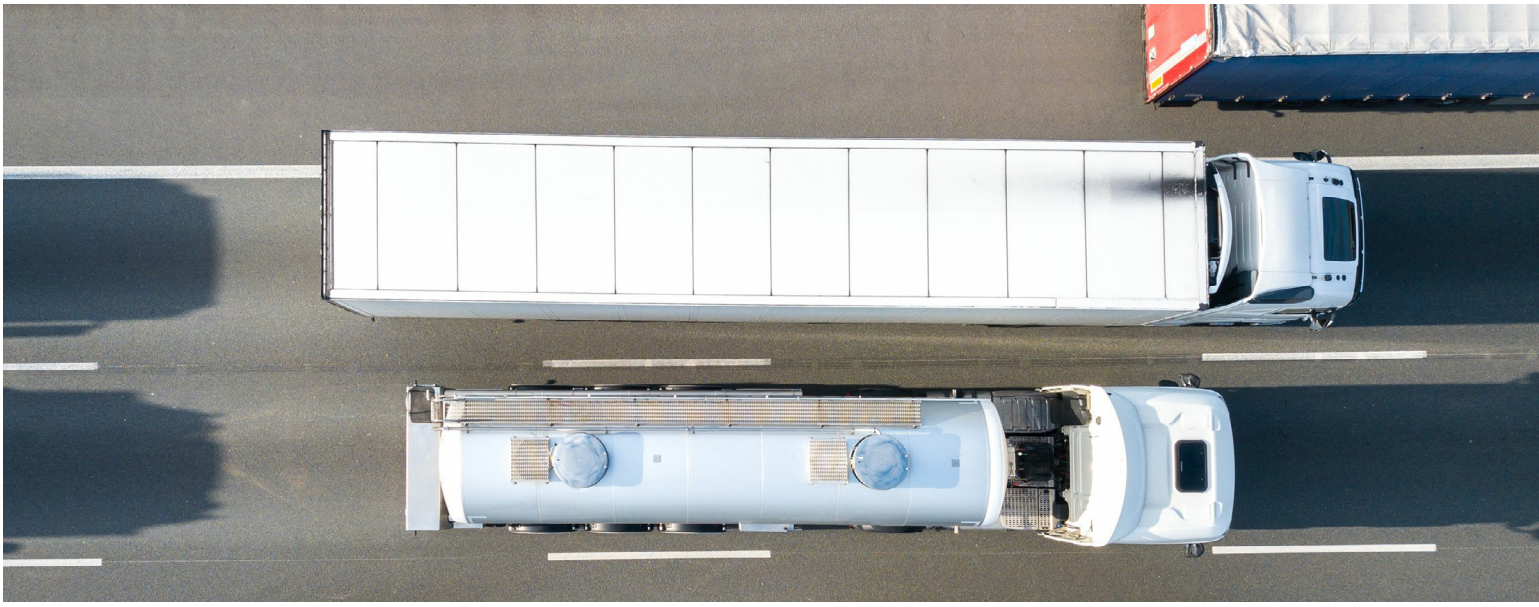
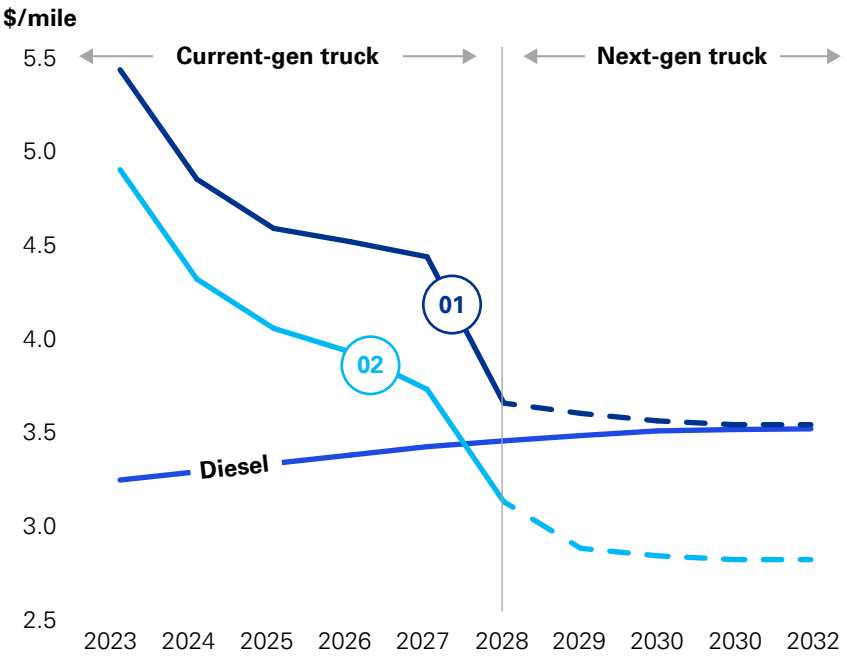


[13] Source: Alternative Fuels Data Center, US Department of Energy (DOE) website. (undated)

Unfortunately, despite the relative ease of standing up hydrogen fueling stations and service centers, the short-term outlook for hydrogen outside these use cases is less than favorable. Upfront costs for FCEVs are higher than those of diesels, primarily due to the cost of the fuel cell unit and hydrogen storage systems. Total cost of ownership (TCO) is also higher, given that a hydrogen fuel cell powered Class-8 truck is three or four times that of a conventional diesel version. There's also the uncertain residual value of hydrogen vehicles, making the prospect of selling older equipment a challenge.

Logistics are another issue: The number of hydrogen fueling stations is extremely limited. As of 2023, there were only 59 open retail hydrogen stations in the US, with about 50 stations in various stages of planning or construction. Most of the existing and planned stations are in California, with one in Hawaii and five planned in the Northeast.[14]

Total cost of ownership comparison for Class-8 trucks, H2 FCEV vs conventional diesel/CNG solutions



01 **Base case: Current gen**

- Efficiencies primarily driven by H2 cost
- OEMs must develop a next-gen truck with:
  - Low vehicle price
  - Improved fuel cell durability
  - Higher residual value

02 **Role of incentives**

- Until a next-gen truck is available, incentives could potentially improve TCO gap
- Potential incentives are:
  - HVIP in CA[(3)]
  - H2Hubs: Up to 50% of truck cost when approved

In 2022, the Oregon Department of Environmental Quality conducted a survey to explore attitudes among medium- and heavy-duty (MHD) truck fleet owners about transitioning from gasoline or diesel as their primary fuel to alternative fuels such as electricity, hydrogen, renewable natural gas, etc.

In the survey:

79% respondents indicated that they are aware of alternative fuel options for their fleet

34% said they had made a switch to any of those options

The top reasons cited for not making a change are:

52% fueling infrastructure costs and access

51% vehicle cost

46% vehicle range concerns

62% respondents said incentives for equipment and vehicles

58% grant funds for infrastructure

54% fuel availability.[15]

[14] Source: US DOE; Auto News; S&P Global; Center for Strategic and International Studies (CSIS).

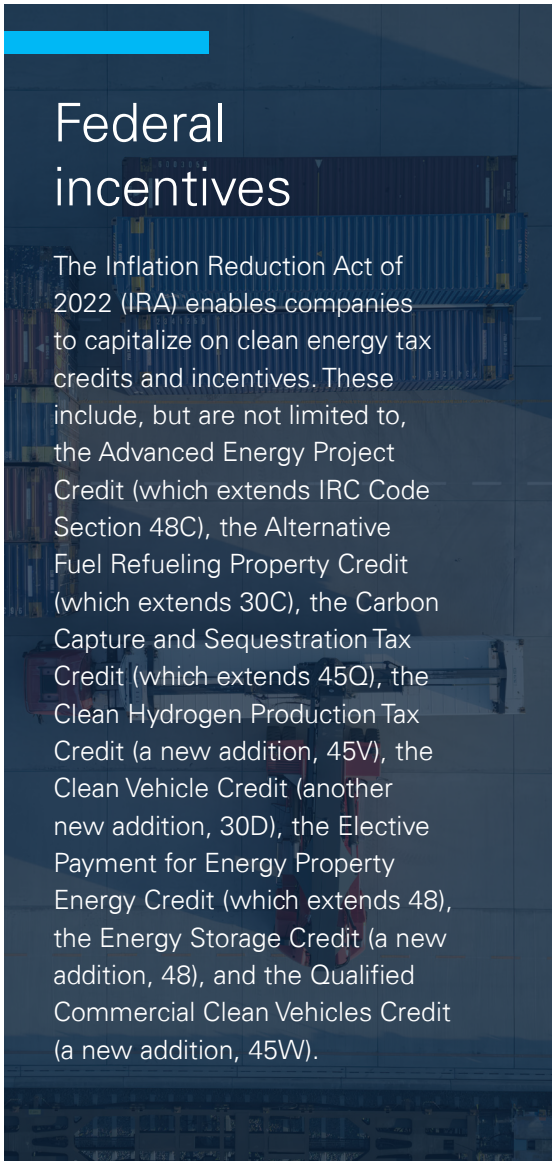
[15] Source: Alternative Fuels Report, Oregon DEQ, March 2022.

The long term outlook for hydrogen is positive

The current cost and infrastructure environments are likely to change. Improvements in technology and economies of scale are expected to increase adoption as the cost between hydrogen-power trucks and diesel-power trucks reaches parity. Already, fuel cell system costs have fallen by about 70 percent since 2008. Other major components are expected to see their largest price drop between 2025 and 2030. These include fuel cell propulsion systems (30 percent), hydrogen storage systems (21 percent), motor invertor and transmission (49 percent) and battery pack (32 percent). At the same time—and perhaps more importantly—the cost of retail hydrogen is expected to decrease from more than $35 per kilogram (kg) to $4-$6 per kg by 2030.[16]

Currently, refueling logistics are a major obstacle to using hydrogen-powered vehicles. But governments and industry are taking steps to expand the development of hydrogen production and technology: Overall, hydrogen technologies receive about 5 percent of the total US government research and development budget for clean-energy technologies. In the US, hydrogen infrastructure is expected to require annual investments of $52 billion between 2026 and 2030.[17] To address that need, the US Congress appropriated $8 billion for the development of 6-10 Regional Clean Hydrogen Hubs across the country as part of the 2021 Infrastructure Investment and Jobs Act, which also provides $1 billion for hydrogen electrolysis and $500 million for manufacturing clean hydrogen technologies. In addition, various tax breaks and state incentives help offset some of the costs of setting up the required infrastructure, and a number of states, led by California, are enforcing mandates to accelerate reduction of tailpipe emissions. The Advanced Clean Fleets (ACF) and Advanced Clean Trucks (ACT) are two such initiatives.

Governments aren't alone in their push to encourage hydrogen development. Major energy players are also ramping up efforts around hydrogen production, transportation, and storage, and OEMs are collaborating and using grants to develop their own technologies. For example, ExxonMobil announced in 2023 a plan to build a low-carbon hydrogen production facility in Baytown Refinery near Houston. The plant could generate up to 1 billion cubic feet of hydrogen per day.



Federal incentives

The Inflation Reduction Act of 2022 (IRA) enables companies to capitalize on clean energy tax credits and incentives. These include, but are not limited to, the Advanced Energy Project Credit (which extends IRC Code Section 48C), the Alternative Fuel Refueling Property Credit (which extends 30C), the Carbon Capture and Sequestration Tax Credit (which extends 45Q), the Clean Hydrogen Production Tax Credit (a new addition, 45V), the Clean Vehicle Credit (another new addition, 30D), the Elective Payment for Energy Property Energy Credit (which extends 48), the Energy Storage Credit (a new addition, 48), and the Qualified Commercial Clean Vehicles Credit (a new addition, 45W).

[16] Sources Statista; Atlas Policy; Recharge News; US DOE.

[17] Sources: Global Hydrogen Review 2022 – IEA; Energy Technology Perspectives 2023 – IEA.

Several developments overseas may nurture hydrogen adoption in the US

European companies have taken steps to ramp up hydrogen use and provide an example for US-based operators to follow. For example, Shell invested in a renewable hydrogen plant in Rotterdam that will produce 60,000-80,000 kg of renewable hydrogen per day. And Total Energies is collaborating with multiple companies to develop an investment fund dedicated to clean hydrogen infrastructure solutions.

OEMs are also moving forward with FCEV development:

- Hyundai announced the successful delivery of first units of its hydrogen-powered heavy-duty truck in Switzerland. The company also deployed 30 XCIENT Class 8 hydrogen fuel cell electric trucks at the Port of Oakland, as part of the NorCAL Zero project funded by California Air Resources Board (CARB) and The California Energy Commission (CEC). It is by far the largest FCEV truck deployment for the company in the world.
- Toyota and Daimler Truck Holding agreed to cooperate on hydrogen technology and reached a preliminary deal to combine their truck businesses in Japan.
- In July 2023, Toyota also launched its dedicated fuel cell unit, the Hydrogen Factory, with 1,350 employees.
- Daimler Trucks and Volvo agreed to collaborate on the manufacture of fuel cells and are working toward hydrogen-powered mobility.

The likely future result: Taken together, increased investments in vehicle production, along with decreases in fuel and fuel delivery mechanisms, should make hydrogen trucks cost competitive compared to their internal-combustion engine counterparts.

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[16] Source: Statista; Atlas Policy; Recharge News; US DOE

[17] Source: Global Hydrogen Review 2022 – IEA; Energy Technology Perspectives 2023 – IEA

Government regulations play an important role in encouraging green investments

Although significant hurdles remain to the adoption of either electric or hydrogen as a fuel for trucks, the push for greener energy continues unabated. Manufacturers and fleet owners will need to decide a path forward, as major economies across the globe enact regulations to accelerate decarbonization. In February 2023, for example, the European Union proposed new carbon dioxide (CO_2) standards for new trucks and coaches (90 percent emissions reduction by 2040) and urban buses (100 percent zero-emission city bus sales by 2030). The US announced a new direction at the United Nation's 27th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP27). The US committed to 30 percent zero-emission truck sales nationwide in 2030 and 100 percent in 2040.

At the state level, California has extensively defined policy on the sale and fleet composition of trucks: Beginning in 2036, 100 percent of truck sales are expected to be zero-emission vehicles. Texas has also implemented many laws and regulations as well as incentives related to the use of hydrogen as a fuel. Given these mandates, global commercial hydrogen vehicle production is forecast to increase 56 percent between 2027 and 2033.[18]

State incentives

While federal incentives are a good first step, they alone will not fully support the launch and adoption of hydrogen. It will require state and local government support to help offset the initial capital investment in both trucks and refueling infrastructure. As most state and local incentives are geared toward job creation rather than capital investment, some rethinking of state incentive portfolios may be necessary. In our view, states should focus on offering monetizable tax credit programs that address the significant upfront capital investment, along with employee training, to support the launch of this new industry. State and local governments may also need to evaluate current statutory programs, such as sales tax and local property tax abatements, to ensure the industry can take full advantage. Some states—including California, Texas, New York, Pennsylvania, and Washington—offer generous incentives for alternative fuel development, although qualifying is sometimes complicated. But ultimately, we believe this support will be critical to hydrogen adoption.

[18] Source: LMCA, nacfe.org, c2es.org, theicct.org, iea.org, gridblock.com

Is early adoption hydrogen right for you?

Despite the potential benefits of hydrogen, availability of investment dollars, and enactment of new regulations, weighing the advantages of early adoption against the challenges is a significant task.

Being an early adopter brings certain advantages and disadvantages. On the positive side, early adopters can reduce their CO2 footprint, gain first mover advantage, establish industry standards, retain ownership of intellectual property, enjoy the benefit of government incentives, and acquire large amounts of data that can be used to refine future offerings. They also enhance their "green" image by lowering their carbon footprint. On the negative side, early adopters incur high initial costs, face market uncertainty, risk failing to adapt to technological change, bear the brunt of building new infrastructure, and are among the first to navigate regulatory hurdles.

OEMs, suppliers, infrastructure providers, and governments looking at an alternative fuel for trucks will need to consider several variables to make their decision:

Cost of production and implementation: Manufacturing fuel cell trucks and incorporating them into an existing fleet will be expensive. You will need to determine future benefits or calculate savings to understand and justify the cost.

Market acceptance: Consumers and fleet owners will need to be convinced to purchase and use fuel cell commercial vehicles. Will you need a program to educate your customers about the benefits of these vehicles?

Regulatory environment: Policy frameworks and laws around hydrogen as a fuel source are complex and compliance is costly and time consuming. You may need to rely on incentives or subsidies that may expire.

Infrastructure availability: The existing refueling infrastructure is currently inadequate to support the use and maintenance of hydrogen-powered vehicles. A part of the funds to upgrade or create the necessary infrastructure may have to come from your pocket.

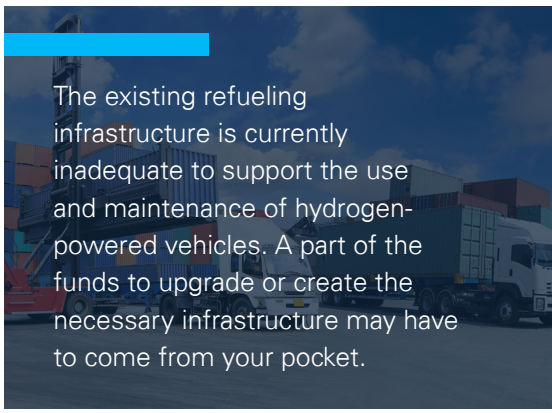
Technological challenges: There are technological hurdles that need to be overcome, such as the storage and transportation of hydrogen.

Supply chain: Questions remain about how hydrogen will be produced and by whom, as well as whether there is enough capacity to meet projected demand.

Safety: Safety implications must be considered, understanding that hydrogen is a highly flammable gas.

Training and skills: Your workforce will need to be trained to manage, maintain, and repair hydrogen-powered vehicles.

Environmental impact: How the production, distribution, and consumption of hydrogen will ultimately impact the environment remains an open question. The advantages and disadvantages need to be weighed against other alternative fuels and traditional fossil fuels.



Alternative fuels are the key to a sustainable and efficient transportation sector

Hydrogen and electric promise to reduce greenhouse gas emissions and dependency on fossil fuels in transportation.

While electric trucks offer a viable solution for short-haul and last-mile delivery services, hydrogen-powered trucks hold significant promise for heavy-duty applications now and long-haul use cases in the future. Despite current challenges, including high upfront costs, limited refueling infrastructure, and technological hurdles, the outlook for hydrogen in commercial trucking is optimistic. The cost of hydrogen production and fuel cell technology is expected to decrease significantly, driven by technological advancements and economies of scale. Moreover, concerted efforts by governments and industry players to expand hydrogen infrastructure, alongside incentives for green energy investment, are laying the groundwork for the increased adoption of hydrogen trucks.

As the market evolves, truck manufacturers, fleet owners, and infrastructure providers must carefully weigh the benefits of early adoption against the challenges, considering factors such as cost, market acceptance, regulatory environment, and the environmental impact of hydrogen production and use. Nonetheless, the collaborative efforts of OEMs, energy companies, and government bodies illustrate a strong commitment to decarbonizing the trucking industry and highlight the potential of hydrogen as a key player in achieving a more sustainable and efficient transportation sector.

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How KPMG can help

KPMG LLP helps many clients in the public and private sectors to develop and execute their plans to decarbonize transportation. Examples include:

- Analyzing investment opportunities in the electric and hydrogen ecosystem and helping clients set up partnerships and joint ventures to share the upside and risks
- Conducting diligence on companies that participate in the alternative powertrain ecosystem
- Identifying federal, state, and local incentives to offset the high cost of investment in alternative powertrains and infrastructure
- Crafting and executing an effective tax incentive methodology that is customized to the business's specific needs, such as deciphering the implications of the Advanced Energy Project Credit or strategizing on how to best utilize the new Clean Hydrogen Production Tax Credit
- Developing detailed TCO estimates for fleets to aid in decision making between various powertrain options
- Deploying our proprietary Electric Vehicle Infrastructure Geospatial Tool (KELVIN) to help clients develop strategies for zero-emission vehicles based on location, emissions reduction potential, and TCO.

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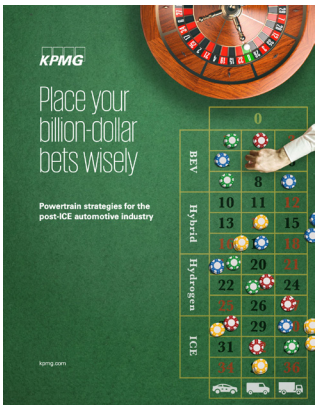

Place your billion dollar bets wisely

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