State of Sustainable Fleets 2020 is the foundational assessment that laid the groundwork for the 2021 and 2022 annual updates. It provides readers with additional background and historic data and analysis on leading sustainable technologies for fleets, available at: https://www.stateofsustainablefleets.com/download-report-2020/.

GNA produced a short “Fleet Miniguide” on planning to adopt each of the four leading clean vehicle drivetrain technologies covered in the State of Sustainable Fleets. Each is available at:

- Propane Vehicles
- Natural Gas Vehicles
- Battery-Electric Vehicles
- Fuel Cell Electric Vehicles

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This assessment was prepared by clean transportation and energy consulting firm Gladstein, Neandross & Associates (GNA). The opinions and analysis expressed herein are those of the authors and do not necessarily reflect the views of project sponsors. Reference herein to any commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by sponsoring organizations or GNA. No part of this work shall be used or reproduced by any means, electronic or mechanical, without first receiving the express written permission of GNA.

Using the Findings

The State of Sustainable Fleets is a guide for fleet operators and the industry. Developments in the sustainable vehicle and fuels market for fleets are occurring so rapidly that an exact assessment is impossible. Each year, the collected fleet survey results are complimented by secondary data and input from the industry’s leading experts to improve accuracy as detailed in the Methodology chapter. While this methodology ensures the results are the most comprehensive available of the state of the industry, each fleet owner must evaluate each technology on an individual basis for fit with their specific use cases and locations.

About the 2022 Fleet Survey

Building upon a rich data source that represents a broad range of real-world fleets in every stage of technology adoption ensures this effort reflects a comprehensive representation of today’s fleet landscape. Since the initial State of Sustainable Fleets report published in 2020, the number of survey respondents who provided fleet and operation data more than doubled. By gathering real-world data directly from early adopter fleets, the State of Sustainable Fleets provides sector-specific insight into the adoption of four leading clean medium- and heavy-duty vehicle technologies – drivetrains powered with propane, compressed natural gas, electric batteries, and hydrogen fuel cells – against a baseline of diesel technology. The assessment’s comprehensive findings represent government and private sector fleets and are gathered across several sectors including school, shuttle, state/county/municipal, urban delivery, refuse, utility, transit, regional-haul, long-haul, drayage, and off-road cargo handling.
CNG, renewable diesel, and hybrid electric vehicles have successfully served as interim bridging tools on the path to decarbonization. Next generation BEVs will allow us to build upon our first generation decarbonization strategies, further reduce dependence on fossil fuels, reduce maintenance expense, and increase uptime for our operators.

— Michael Glover, Senior Director Transportation Services, Pacific Gas and Electric Company, California

The Perfect Storm for Clean Fleet Market Acceleration

In this year’s annual survey of nearly 250 early adopter fleets, one point was clear: End-users have no intention of curbing their planned procurement of sustainable technologies. Nearly 85% of fleets that have used propane, compressed natural gas (CNG), battery-electric vehicles (BEVs), and fuel cell electric vehicles (FCEVs) intend to grow their use of these technologies, a finding that has held steady each of the three years we have surveyed fleets. Many of these fleets have already begun scaling these technologies across their fleets, sometimes reaching nearly 100% conversion and environmental sustainability benefits for the end-user. Evidence of this can be seen in the data from this year’s report, where traditional alternative fuels and vehicles like natural gas have seen sustained growth and fuel production announcements suggest more...
While it has been a challenge in acceptance, the benefits outweigh the risks and our fleet is excited to transition to multiple fuel technologies to reduce our carbon footprint. — John Christian Andoh, Mass Transit Administrator, County of Hawaii Mass Transit Agency, Hawaii

Nearly 85% of surveyed fleets that are early adopters of alternative vehicles intend to grow their use, for a third consecutive year.
hydrogen, in addition to BEV charging. Shell has been pursuing a similar strategy for the last several years. To support the growth of the ZE vehicle and truck markets, a growing number of infrastructure and fuel suppliers have steadily increased their investments in EV charging infrastructure, as well as hydrogen fuel production, distribution, and fueling locations. Shell has committed to operating 500,000 chargers globally by 2025 with an ambition for 2.5 million by 2030. Never before has there been so many options and such a robust market for low-carbon fuels to support the growth of NZE and ZE fleets.

Paralleling the rise in private-sector investment, significant new government investments are planned for 2022 and in the years ahead. At the federal level, the $1.2 trillion Infrastructure Investment and Jobs Act (IIJA) has a very strong clean technology emphasis, with numerous multi-billion-dollar programs earmarked to transition specific fleet types to clean vehicles and expand national infrastructure for specific technologies. For example, the U.S. Department of Energy (DOE) will soon release an $8 billion solicitation to support the development of hydrogen hubs around the U.S., which will provide a significant boost to hydrogen production, distribution, and use, including for on- and off-road commercial vehicles. Likewise, the U.S. Departments of Transportation and Energy were allocated $5 billion through the National Electric Vehicle Infrastructure (NEVI) Formula Program to support the development of a national electric vehicle charging network. NEVI will not directly fund the deployment of MD and HD electric vehicles. However, the NEVI funding is designed to fund publicly accessible or multi-fleet recharging stations, so this funding could help broaden the network of available recharging stations for MD and HD fleets. These multi-billion-dollar programs are in addition to $3-5 billion announced in annual incentives from public agencies at the local, state, and federal levels, with California making up a large percentage of this funding.

Combined, incentive support for clean transportation technology has increased from an estimated $3 billion historic annual average to a predicted $20 billion in 2022.

With a monumental increase in the commitments and investments in clean transportation solutions being made by both buyers and sellers in the commercial fleet sector, and with significant "carrots" also being provided by the government in the form of lucrative funding programs, forward acceleration of these markets is more certain than ever. However, not taking progress for granted, 2021 also saw a meaningful increase in the adoption of clean transportation policies and regulations that will help to further hasten this market transformation.

California's Low Carbon Fuel Standard (LCFS) continued to provide substantial financial benefits to developers and end-users of RNG, RD, and electricity, helping to progress the use of these ultra-low carbon, and sometimes carbon-negative, fuels. Meanwhile, the LCFS program in Oregon also started to gain more traction and Washington's program, once launched, will provide an important forward driver for increased clean fuel use in these markets as well.

“Culver City is one of the first cities in the nation to go to RNG with its vehicles, including transit and refuse. We are now committed to go all-electric with transit by 2028 and move forward as technology progresses.”

Culver City is one of the first cities in the nation to go to RNG with its vehicles, including transit and refuse. We are now committed to go all-electric with transit by 2028 and move forward as technology progresses.

\*5RODQGR\&UX\&KLH7UDQVSRUWDLRQ2\(FHU\&LWRI\&XOYHU\&LWIDOLIRUQLD

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1. See the text for details.
2. ACT was adopted by CARB in June 2020.
While not focused on the alternative fuel vehicle
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UXH] ODLWLRQ DGRSWHG LQ DDQ QRZ EHLQ]
ORDZGH EDVLPLDO INHGUOHUY HLQVRQ RI DFWLRQ
ZLOQFUHVDNVKHRFRWRQDQHGLHVHOHYKLFOHV
in 2024 and then again in 2027. State and federal
regulations that simultaneously require improved
YHKLFOH HI\LHQF\ DDQ GHFUHDVHG YHKLFOH

2Q WKH UH\XODWLRQ IURQW YH VWDWHV DGRSWHGLPLVVRQZLOO UDLVH WKH FRVW DDQ FRPSOH[LWH RI SHUWROH XPDVHG WUDQVRUWDWLQJ RSWLRQ OLMVLYDOLVHally helping to make alternative fuel
vehicles more cost competitive and attractive to
commercial vehicles to rapidly increase the
VDOHRI={WUXFNV DDQG EXVHV GXULQJ} WKH QHQ[H WZ VR

AFTC: $OWHUQDWLJHVXOH7D[&UHGLW
BD: Biodiesel
B5: Up to 5% biodiesel
B20: 6% to 20% biodiesel
B100: Pure biodiesel
BEV: \%DWWHULHOHFWULFY YKLFOH
CARB: California Air Resources Board
CNG: Compressed natural gas
Early adopter fleet: Fleets that have used one of
IRXUFOHDQYHKLFOHGUHYWUDLQV3*+1%\(9 FCEV)\.
FCEV: Fuel cell electric vehicle
GGE: JDVRQLQHJDOQRQHTXLYDOHGW
GHG: Greenhouse gas
HD: +HDYJGKW
HVLP: +EULGDQG=HUR[PLVVRQ7UXFNDQG\%XV
9RXFKHU,QLFHOQLYH3URMHFW
LCFS: /RZD\&EUERQXHO6WDQGDUGUHYXODWLRQ
LPG: /LTXHGSHUROHXPJ DV
MD: 0HGLXPGXW
NGV: Natural gas vehicle
NZE: 1HDUDHURHPLVLRQOHUHWULQJ WRY HKLFOHV
with low tailpipe emissions
OEM: 2ULJLQDOHTXLSPHQWPDXIDFWXUHU
RD: Renewable diesel
RNG: Renewable natural gas
Scope 1: LUHFQ*+HPLVLRQVWKRFFXUJURP
sources that are owned or controlled by the company
Scope 2: 0HWULFWRQQLULQHHUFW*+HPLVLRQV
from the generation of purchased electricity
consumed by the company
Scope 3: 0ORWKULQQLULQHHUFW*+HPLVLRQVWKRFFXUJURP
but occur from sources not owned or controlled by the company
TCO: Total cost of ownership
ZE: HURHPLVLRQ
ZEV: HURHPLVLRQHYKLFOH
Clean Vehicle Funding Sees Large Boosts

In 2021, an estimated $5 billion in public incentive funding was made available to replace vehicles or expand fleets with clean alternatives, an increase from the average $3 billion that had been made available annually in the last couple of years. This uptick in funding could be accessed through more than 175 state, federal, and local programs, including utility make-ready infrastructure and electric vehicle supply equipment (EVSE) programs.

Funding in 2022 and during the next five years will shatter all prior records, boosted in no small part by the IIJA's $1.2 trillion in federal funding and substantial increases in funding in California. With these new and expanded funding sources, available public incentives for the clean fuel and vehicle market will grow to approximately $20 billion annually across more than 230 programs.

Signatories to an MOU to achieve 100% ZE truck sales by 2050 represent roughly half the U.S. economy.

For the next few years, public funding for clean fuels and vehicles will grow to nearly $20 billion across more than 230 programs annually.

Most of the states that have either adopted or are in the process of adopting California’s Advanced Clean Trucks Rule (ACT) have adopted the rule to accelerate the sale of zero-emission (ZE) trucks and buses. Oregon, Washington, New Jersey, New York, Massachusetts, Connecticut, Rhode Island, Colorado, Maine, Vermont, Maryland, and the District of Columbia (DC) have either adopted the rule or are in the preliminary rulemaking process (Figure 1). Six other states have begun preliminary rulemaking or initiated a formal review to consider adopting the ZE truck sales mandate.

Together, the states that have either adopted or are in the process of adopting the ACT rule represent roughly half of the U.S. economy.

The adoption of the ACF rule to pair with the ACT rule in California — historically representing approximately 8% of annual truck sales — will provide a considerable boost to the market for ZEV fleet technologies.

The advanced clean trucks rule progress chart shows the status of ACT rulemaking across the U.S. as of April 2022.
‘LVWULFW RI &ROXPELD IROORZ ZLWK DV[LQDOU HUURUH DQG LVWULFV HUURUH
substantially in the coming two decades.

It is also worth noting the potential alignment between these rules and the goals of the nation’s truck manufacturers, which have invested billions of dollars into the development of ZE technologies.

Critical to the successful implementation of these rules, however, will be the ability for commercial ZEVs to demonstrate an equal or positive total cost of ownership (TCO) for the end-use fleet customer – a milestone that has yet to be sufficiently documented, especially in the MD and HD truck sectors. As California’s LCFS incentives have been essential to achieving a TCO goal, the decrease in the credit value in recent months could make it a more challenging objective.

The supply of RD has risen dramatically, causing 84% growth in the volume of RD credits exchanged between Q1 2020 and Q4 2021 on California’s LCFS. The oversupply resulted in a steep decline in the price of California LCFS credits falling as low as $112/MT on March 23, 2022. That reflects a nearly 50% drop in the market’s peak of $218/MT on February 3, 2020.

Low Carbon Fuel Standard Prices Drop, Pauses in Advancing to More States

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first quarter of 2022, falling as low as $112/MT on
March 23, 2022. That reflects a nearly 50% drop
in value from the market’s peak of $218/MT on

At the time of the 2021 State of Sustainable Fleets
report, it also appeared that low-carbon fuel
programs would be proliferating around the
country. Washington State had just adopted their
Clean Fuel Program, and similar bills had
introduced in Minnesota, New Mexico, and New
York. Although there remains a continuous push
in these states for their version of a low-carbon
fuel program, this momentum appears to have
slowed. This past February, legislation introduced
in New Mexico failed to pass by one vote, and
measures in other states have been held up.
Post-pandemic inflation exacerbated by soaring
gasoline and diesel prices has made most state
legislatures wary of any new laws that would
appear to increase costs to consumers.

A New Local Emissions Standard Gets State-
Level Attention

Battling some of the worst air quality in the nation,
the South Coast Air Quality Management District
(South Coast AQMD) in Southern California passed
a new regulation in June 2021, the Warehouse
Indirect Source Rule (WAIRE), that will provide an
important impetus for the forward growth of the
clean fuel fleet vehicle market. The rule requires
operators of warehouses with 100,000 square
feet or more (of which there are approximately
3,000 in the South Coast AQMD’s jurisdiction)
to mitigate the air quality impact of the diesel
trucks coming to and from their facility. Designed
as a points system, warehouses generate point
deficits based upon the number of diesel truck
trips. These deficits must then be offset with points
earned from a menu of emission-reducing or
technology-enabling actions, such as installing
low-emission energy and vehicle technology on-
site and/or requiring visits of ZE and NZE trucks to
the facility.

The Warehouse Indirect Source Rule (WAIRE) requires operators of approximately 3,000 warehouses in Southern California to mitigate the air quality impact of the diesel trucks coming to and from their facilities. It covers one of the busiest cargo hubs in the country.
WAIRE covers one of the busiest cargo hubs in the country, and the South Coast AQMD is now evaluating whether to establish similar requirements for the Ports of Long Beach and Los Angeles. These rulemakings have attracted national attention, as bills were recently introduced in the New Jersey and New York legislatures to implement a similar emission-reduction program targeting logistics on a statewide basis. These bills represent an ongoing case seeking to address indirect sources of air pollution and replicated in other states.

Reduced Support for CNG and Propane

Today, natural gas and propane vehicles provide a cost-effective means for fleets to replace diesel trucks and achieve significant NOx and particulate matter (PM) emission reductions from MD and HD vehicles. CNG and propane were the original favorites of policymakers and the agencies that administer incentives, and while some of that support continues, there is also a growing preference among policymakers to limit funding to ZEVs as detailed above.

The federal Alternative Fuel Tax Credit (AFTC) provides a 50 cent per gasoline-gallon equivalent (GGE) tax credit for CNG and 36-cent rebate for propane fuel, plus an additional benefit of a 30% or up to $30,000 investment tax credit for infrastructure. However, the AFTC expired at the end of December 2021, marking the ninth year of the last 12 that it was only renewed on a single-year basis. Furthermore, California removed fossil-derived propane used in transportation from a credit-generating fuel to a deficit generating fuel in the California LCFS program, imposing a cost penalty on traditional propane in the state. Renewable propane remains a credit generator in the LCFS program.
While incentive funding for NGVs and propane vehicles is declining, incentive funding is generally no longer required for adoption with a positive TCO.
Sustainability has gained increasing momentum in the transportation industry over the last several years. For-hire fleets will need to set a net-zero or science-based target for GHG emission reductions to meet growing expectations and pressure from shippers. Efficiency is a critical foundation of sustainability, but low-carbon renewable fuels and clean fuel vehicles are essential to reaching aggressive GHG-reduction targets.
Sustainability Targets GHG Emissions from Transportation

A robust set of practices and frameworks honed by companies publish sustainability reports.\(^8\) GHG emissions contribute to climate change. Established sustainability practices include identifying core areas of focus, setting targets, building strategies and management plans to meet goals, and publicly reporting on progress through popular standards such as the Global Reporting Initiative (GRI), the Carbon Disclosure Project (CDP), or the Global Emissions Logistics Council (GLEC) Framework.\(^10,11,12\)

Fleets already manage numerous social and environmental risks through worker and driver safety programs, community investment projects, and air quality emissions compliance initiatives which can be used, in part, to comply with globally recognized sustainability standards.

The practice of sustainability is focused on addressing the largest unmitigated social and environmental factors, and for the transportation industry, there is no gap larger than the GHG emissions that contribute to climate change. Transportation is the top source of U.S. greenhouse gas (GHG) emissions. Fleet size has grown over 40% in that time, but our carbon emissions are lower than 2007 levels.\(^*\)

\[\text{Sustainability targets for GHG emissions from transportation.}\]
A science-based or net-zero target generally requires 80-100% fleet GHG emission reductions by 2050.

Emission standards focus specifically on GHG emissions because these are the set of emissions that contribute to the warming of the planet and have the most direct impact.

The term “net zero” is defined in the global climate treaty referred to as the Paris Agreement, which was adopted by nearly all of the world’s governments in 2015. Net zero refers to a state in which emissions of GHGs are equal to the global capacity to remove those emissions.

An SBT refers to setting a target that is aligned with emissions reductions needed to meet the goals of the Paris Agreement to avoid warming the planet to life-threatening conditions. The Science Based Targets Initiative (SBTI) is a partnership of four non-governmental organizations that established standards and verifies that the targets that companies and governments set align with the Paris Agreement.

Numerous companies in the transportation supply chain have set either an SBT or a NZT, including Amazon, Walmart, PepsiCo, Target, Sysco, Waste Management (WM), Ford, GM, Toyota Motor, Volvo, Daimler AG, Hyundai Motor Co., Cummins, Shell, and many others.

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Efficiency is a Starting Point, but Cannot Get There Alone

Most fleets begin working toward GHG emission reductions via increased efficiency, which leads to cost and fuel savings, a reduction in times for routes and deliveries, and an overall decrease in capital-intensive assets. Of course, efficiency improvements also afford GHG emission reductions, providing greater alignment between benefits for both the fleet and its customers’ sustainability goals. In contrast to their record on setting NZTs or SBTs, all the top 25 for-hire carriers have reported efficiency gains in the past decade.

Participation in the U.S. EPA SmartWay Program has been the most common way that shippers and carriers align on efficiency goals. Efficiency is also essential to right-sizing the fleet to adopt renewable fuels, NZEs, and/or ZEVs. For example, in 2006, after being one of the first companies to commit to operating entirely on renewable energy, Walmart first planned to cut $1 billion in fuel use and double its fleet efficiency. This first step in fleet sustainability establishes an important foundation and reduces the overall need that other sustainable technologies would then have to fill.

While efficiency measures provide important benefits, they alone are not nearly enough to reach an NZT or an SBT without being paired with other more aggressive GHG emission reduction approaches. In its analysis of scenarios for the transportation sector to reach NZTs or SBTs by 2050, the International Energy Agency (IEA) found that efficiency could only get MD and HD road transportation just over one-third (34%) to the goal.

Some limits to efficiency are already apparent. While today’s diesel engines operate at an incredibly high rate of thermal efficiency and gains of roughly 20% are theoretically possible, further gains will eventually be limited by thermodynamics, as well as the complexity of near-term criteria pollutant emission control regulations.

SBTs and NZTs can require that fleets achieve the halfway point of their goal by 2030 or 2035. In its analysis of HD on-road transportation, IEA finds that renewable fuels, hydrogen, and electricity are all critical to reaching this level of GHG emissions reduction.

Biofuels play an initial role in achieving emission reduction gains for MD and HD transportation throughout the 2020s when ZEVs then become increasingly critical the following decade until nearly 100% of truck sales in 2050 are ZEVs.

While the IEA evaluates the on-road transportation sector as a whole, every fleet must create its own sustainability goals. In its analysis of scenarios for the

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22 Ibid
23 DOPDUVDQDOO PVDBVLVHULQHODQGRQY DQY VROHPQHOGDOX DVWULQJOLW DQGDFFHHVVH WHUJHFWXWLYH
24 TLQNHU=RWK\W+l R=ULHV+HOSGHPXPSVWDU DQPDWyVJOHWW\EQLQQGRQY DQPDWyVHFPHPRUDFFHHVHVGHG XVDWULQJOLW DQGDFFHHVVH WHUJHFWXWLYH
25 1SDQDOVDLVRJ=65XVWULQDOE\HHVHORPHQPHFQHDURLDFDFHHVHG DQY VROHPQHOGDOX DVWULQJOLW DQGDFFHHVVH WHUJHFWXWLYH
26 1SDQDOVLYR=56XVWULQDOE\HHVHORPHQPHFQHDURLDFDFHHVHG DQY VROHPQHOGDOX DVWULQJOLW DQGDFFHHVVH WHUJHFWXWLYH
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approach to sustainability. Fortunately, a growing number of renewable fuels, NZEs, and ZEVs offer the dramatic emissions reductions needed to achieve net-zero operations and SBTs. California’s LCFS program, which reached $4.7 billion in transactions last year, is the largest market to quantify emissions benefits of these fuels and it provides the clearest picture of currently available low-carbon technologies and their emission reduction potential. Credits are generated by the use of low carbon fuels in transportation to reduce emissions relative to gasoline or diesel fuel. Emissions reductions are calculated

“Our diverse fueling enabled us to reduce our carbon footprint by 23% in the last three years. We will continue to reduce our carbon emissions through all these technologies.”

— Kelly Reagan, Fleet Administrator, City of Columbus, Ohio

Experiences by early adopter fleets, and the state of the market for these various fuel and technology choices, are covered in detail in the rest of the State of Sustainable Fleets report.

The LCFS and EPA data show relative Scope 1 (direct) and Scope 2 (purchased electricity) emission reductions for each technology compared to diesel, as fleets would account for and report them in adherence to the GHG Protocol’s Corporate Standard.
Sustainability leaders with their own fleets are already showing the way. Many large corporate fleet owners, such as UPS, PepsiCo, and WM, have had sustainability programs for more than a decade, all with ambitious GHG goals. They prioritize efficiency and utilize a portfolio of other solutions, including RD (UPS, PepsiCo) and NGVs operating on RNG (UPS, PepsiCo, WM). Additionally, they are all piloting or purchasing ZEVs and consider that technology critical to meeting their long-term goals.

For fleets that are new to sustainability, a good place to start when trying to determine how to best reduce GHG emissions is to first calculate the total annual GHG emissions from the operation, thereby establishing a baseline. From here, GHG emission reductions achieved from efficiency programs, and the use of renewable fuels and clean fuel vehicles can be evaluated to determine the potential gains that can be realized from each option, and when combined. Making the leap to evaluating the viability of an SBT or NZT typically involves a comprehensive review of the fleet, often facility-by-facility, to compare to emerging NZE, ZE, and renewable fuel alternatives and forecasting their development and costs to set an NZT or SBT.
Finding clear evidence that GHG emissions from burning fossil fuels are threatening the planet and present existential risks to humanity, the United Nations formally declared in 2021 that fossil fuel is incompatible with a sustainable global future by an Intergovernmental Panel on Climate Change (IPCC) Working Group report, authored by a body of more than 1,000 scientists worldwide that provide the data, science, modeling for the Conference of Parties (COP). COP represents the most structured, established, and recognized global authority on climate change data.

**MARKET SNAPSHOT**

Globally, Governments Call for an End to Fossil Fuel Era

Driven in part by government incentives such as the Renewable Fuel Standard (RFS) and various state-level clean fuel standards, RD is poised for big growth in the U.S., with biodiesel (BD) production declining.

New ultra-low exhaust emission standards for HD vehicles adopted by California in 2021 may be unattainable for diesel engine technology without ancillary components which are costly and can reduce fuel economy.
In mid-2021, three multinational oil and gas companies faced major actions pushing them to take responsibility for their burden of the climate crisis, take leadership in the clean energy transition, or both. Exxon shareholders appointed three board members put forth by climate activist investors; Chevron shareholders supported a motion to incorporate emissions from fuel sold in future reduction targets (Scope 3 emissions), against board wishes; and a Dutch court ordered Shell to cut GHG emissions by 45% by 2030, a more aggressive target than initially proposed by the oil company.

Collectively, oil and gas companies of all sizes are facing immense pressure to make significant and tangible commitments towards emissions reductions while increasing transparency around their activities to meet those commitments, Shell and bp have taken steps to diversify their businesses by acquiring electric vehicle service provider companies and investing in their respective charging networks' growth in the U.S. and E.U.

Regulation passed in late 2021 that requires trucks to comply with progressive emission reduction standards passed in late 2021 that requires trucks to comply with progressive emission reduction standards.

Energy Majors Move Decisively into Clean Technologies

As governments and global agencies continue to declare that fossil fuels do not have a role in a sustainably managed future, several of the world's largest and most influential energy majors made moves to further diversify their portfolios.

Governments Make Commitments at all Levels to Cut GHG Emissions from Transportation

Spurred in part by the 2021 UN Climate Change & Rio+20, work is aggressively to increase U.S. commitments on climate change mitigation.

Shell and bp have taken steps to diversify their businesses by acquiring electric vehicle service provider companies and investing in their respective charging networks’ growth in the U.S. and E.U.

Beyond leveraging the scale of the federal government’s purchasing power, the Biden Administration and Congress are taking a multi-faceted approach to emissions reductions including providing significant funding under the IIJA and proposing new NOx and GHG emissions standards under the EPA’s Clean Trucks Plan. The proposed standards are based in part on regulation passed in late 2021 that requires trucks to comply with progressive emission reduction standards.

President Biden issued an Executive Order establishing national goals for procuring carbon-free electricity and declared that each federal agency must achieve a 100% ZEV acquisition standard by 2035.


 Diesel and Gasoline Fuel and Vehicle Markets Experience Volatility and Disruption

2022 saw the world change for big oil. Emissions regulations, higher costs of conventional diesel and gasoline fuel increased due to a range of factors including supply chain disruptions and increased demand for fuel. In mid-October, a gallon of diesel cost $1.20 more on average than at the same time the previous year. Gasoline prices followed a similar trend, exceeding their 2020 annual average by 19% higher in 2021; in mid-October, a gallon of diesel cost $1.20 more on average than at the same time the previous year. Gasoline prices followed a similar trend, exceeding their 2020 annual average by 19% higher in 2021; in mid-October, a gallon of diesel costs $1.20 more on average than at the same time the previous year.

Experience Volatility and Disruption

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Engine and Fleet Efficiency Gains Continue to Advance, Explore Limits of Innovation

To that end, in the past few years, Shell and bp have taken steps to diversify their businesses by acquiring electric vehicle service provider companies and investing in their respective charging networks’ growth in the U.S. and E.U.

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Diesel Engines Needed Near-Term, May Never Meet Ultra-Low Emissions Standards

While diesel engine producers are under pressure to reduce emissions, technology faces a clear physical limit in meeting and maintaining increasingly aggressive emission standards. Diesel engines today can meet California's MY2025 NOx emissions standard of 0.05 g/bhp-hr, however, the industry has not yet achieved the MY2027 NOx emission standard of 0.02 g/bhp-hr through design alone, nor as EPA-demonstrated technical feasibility. Similar NOx and GHG emission standards have since been proposed by the U.S. EPA under the Clean Trucks Plan. Manufacturers have observed that hardware and software changes must be paired with multiple aftertreatment systems to approach the 2027 standard — and that this negatively affects fuel efficiency and TCO of diesel vehicles.

While the road ahead for diesel engines will be paved with increasingly complex and costly technology requirements, market leaders have signaled that diesel engines will continue to play an important role during the decades-long transition to zero emissions. Engine manufacturer Cummins will invest in developing fuel agnostic internal combustion technology to serve all liquid and gaseous fuels. Daimler Truck AG projects that 60% of its global sales will be ZEVs by 2030 and recognizes that it will continue to sell plenty of diesel engines through this time. Renewable Diesel Growth Very Strong, Adoption Led by Specific Fleet Types

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A 58% increase in nine-month sales revenue from January 2021 to September 2021 was largely attributed to higher sale prices instead of volume. BD is typically used as a blending fuel with diesel in low ratios (up to 20%) and fleets’ demand is largely driven by state blending requirements. While these requirements remain steady, the demand is expected to remain steady. In California, consumption increased a modest 9% since 2020, but occupied a smaller portion of the bio-based diesel market (25% compared to 31% in 2020), while RD became more dominant with 75% of the market share.

In California, BD consumption increased a modest 9% since 2020 but occupied a smaller portion of the bio-based diesel market (25% compared to 31% in 2020), while RD became more dominant with 75% of the market share.

The average price of B20 increased 17% year-over-year, reaching a peak of $2.74 in Q3 of 2021. While biofuel incentives remain strong, feedstock prices continue to increase due to international trade dynamics and domestic competition between the fuel and food industries. In the U.S., the price of soy rose dramatically in 2021 due to U.S. export/import dynamics, primarily with China. Environmental groups remain critical of the incentives for increased domestic soy production due to the crop’s negative environmental externalities.

In the annual fleet survey, RD adoption by fleets is high, especially among government fleets with nearly half of state, county, or municipal fleets (45%) reporting using RD. Nearly a quarter (23%) of regional goods movement fleets operating less than 250 miles per day reported using RD.

The U.S. EPA is considering a modification to the RFS program that would allow RD producers to receive renewable identification number (RIN) credits for using bio-intermediates, or renewable biomass feedstocks such as corn and soybean oil that are processed at one facility and transported to another to produce RD. If approved, RIN generation for use of these bio-intermediates could lower the costs for advanced RD production, making RD more affordable to consumers outside of California.

BD has not experienced the dramatic growth currently seen in the RD market — BD production capacity declined from 91 to 75 active facilities in...
Furthermore, more than half of private sector fleets (50%) report using BD blends. When asked about future use, three-quarters of fleets in our survey intend to use BD blends in the next 12 months, suggesting future demand that is higher than the ratio of fleets that have used this technology recently.

Logistics and goods movement fleets reported the highest adoption of BD at 34%; followed by state, county, or municipal fleets (excluding refuse and transit) at 28%, and regional logistics and goods movement fleets operating less than 250 miles per day at 27%.

According to the State of Sustainable Fleets annual survey, BD is most commonly used by fleets with more than 100 vehicles, with 27% of fleets with 100-1,000 vehicles and 28% of fleets with more than 1,000 vehicles using it. Among the barriers to adoption listed by users of BD blends, fuel cost led with 29% of users of drop-in BD blends citing it as a challenge.

Among existing users of clean technologies surveyed, growth in adoption is expected, with three-quarters of survey respondents intending to use BD blends in the next 12 months.

RD is even attractive to smaller fleets: 30% of small fleets with 11-50 vehicles report using RD, followed by 28% of larger fleets operating 100-1,000 vehicles. Fleet demand for RD in the future is very high, with 98% of fleets in the annual survey planning to use RD in the next 12 months.

Fleets that have used RD report operational perks. A vast majority of surveyed fleets that have used RD to replace diesel say that it provides equal or better performance on maintenance cost (95%). The effect is due to a high cetane number and other beneficial qualities that collectively enable HD vehicles to measurably reduce their engine-out NOx and PM emissions, respectively, while providing equivalent vehicle performance and near-equivalent fuel efficiency.

RD appears to improve performance and reduce life-cycle costs of diesel particulate filters, which are widely used to control PM emissions on post-2006 on-road HD vehicles (and some off-road HD vehicles). While RD supply is growing substantially, cost and availability remain a challenge for surveyed fleets, with 43% of fleets reporting availability and 23% reporting cost as challenges to further adoption.

Fleet Adoption and Insights: Biodiesel

BD blends are common at low blending levels (5%, or B5) due to requirements by some agencies. For example, the Federal RFS requires oil refiners to blend billions of gallons of biofuels into the fuel mix or buy RINs from those that do, and states such as Minnesota and Pennsylvania have laws for minimum levels of blending. Given these requirements, an estimated 62% of vehicles operated by fleets that participated in the annual survey report using some type of BD.

EOHQG IXUWKHUPRUH PRUH WKDQ KDOI RI SULYDWH VHFWRU (HHWV USHRUWXVLOQ) %EOHQGV


This is good news for communities and truckers. In the commercial trucking sector, the use of renewable diesel and biodiesel fuels offers an important and growing opportunity that ensures diesel's place in the future mix of powertrain options, offering fleets and communities a near-term and affordable decarbonization strategy; one that doesn't require new vehicles or fueling infrastructure. Last year in the US, about 3 billion gallons of biodiesel and renewable diesel fuels were produced, helping reduce GHG anywhere from 50 to 85%.

The next chapter for diesel technology is being written at the U.S. EPA right now with the Cleaner Trucks Initiative. It proposes to further reduce emissions from new diesel engines starting this year. Achieving further reductions in emissions will be achieved with technologies like cylinder deactivation, waste heat recovery, and more advanced emissions control systems. Even as interest in zero emission technologies grows, diesel continues to dominate investments in new trucks.

Industry Perspective: Diesel Technology Forum

Diesel technology continues to dominate the commercial trucking sector, with truckers investing in more new diesel trucks than ever before. According to the most recent data from IHS Markit, as of December 2021, 53% of all commercial trucks in operation across the US are powered by the newest generation, 2011 and later model year (MY) advanced diesel technology; an increase of 4.2% over 2020.

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• Propane continues to offer a very low fuel cost, remaining below $2 per gasoline-gallon equivalent, and more than 67% of fleets that use it report superior fuel cost in the fleet survey.
• Propane fuel demand in the transportation sector reached an all-time high in 2021, likely due to school re-openings and users of bi-fuel vehicles switching to propane due to high gasoline costs.
• Sales of propane vehicles declined for the second year, likely due to significant drops in demand in markets that were especially hard hit by COVID-19, such as school bus and paratransit.
• Cummins is introducing a new 6.7-liter engine signaling that the world's largest engine OEM continues to see a strong future for propane vehicles.
• Renewable propane remains a niche option for fleets, with fewer than 8% of propane users in the annual survey reporting availability, which indicates opportunity for market growth with increases in supply.

THE FLEET TYPES LEADING PROPANE VEHICLE ADOPTION

Vehicle Sales Drop, Likely Linked to COVID-19 and Supply Challenges

Vehicle Sales Drop, Likely Linked to COVID-19 and Supply Challenges
As production constraints ease, the delivery backlog will improve and customers can place orders that have been delayed, leading to more opportunities to replace vehicles that have been kept in service past their useful life.

### New Engine to Expand MD Applications

As part of Cummins’ Destination Zero program, the new Cummins B6.7L propane engine will offer fleets a uniquely robust option for low-emission Class 7 applications, including beverage, school bus, and potentially future use in off-road markets, such as construction.

Using a standard cylinder design across its fuel-agnostic engines, Cummins intends to achieve efficiencies with production and vehicle fit so that OEMs can easily provide multiple engine options to meet customers’ fuel needs without losing production efficiencies. The first engines under the Destination Zero program are due out for MY2024, although as of the writing of this market brief, the production timeline for the propane B6.7L has not yet been announced.

Vehicle offerings saw very few changes from 2020 to 2021, further reinforcing manufacturers’ focus on propane as a solution for MD and school bus fleets (Figure 3).

> “Propane buses have saved the district thousands of dollars in terms of fuel cost and maintenance costs. In my experience, propane engines are an ideal fit for the stop-and-go school bus operations, especially in the colder climates we experience in Nebraska.”

— Richard Casey, Director of Transportation, Bellevue Public Schools, Nebraska

### THE PROPANE VEHICLE MARKET

<table>
<thead>
<tr>
<th>Body Type</th>
<th>Base Price</th>
<th>Number of Models</th>
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<tbody>
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<tr>
<td>PICKUP</td>
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<tr>
<td>CHASSIS CAB (MD)</td>
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<td>STRAIGHT TRUCK (MD)</td>
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<tr>
<th>Vehicle Manufacturers</th>
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<td>FCCC</td>
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<tr>
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<tr>
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<tr>
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Vehicle offerings saw very few changes from 2020 to 2021.
Fuel Sales Peak, Fuel Demand Growth Is Expected

Propane fuel demand in the transportation sector reached an all-time high in 2021, according to the Propane Education and Research Council (PERC), and experts claim that it could have been even higher if vehicle production had met expectations. The peak is likely due to school re-openings that brought renewed demand from propane school buses and use of propane by bi-fuel vehicles switching from high-cost gasoline.

The U.S. transportation fuel segment demand has continued a relatively consistent trend. Forecasts from PERC suggest that demand will grow broadly across the U.S., given the fuel’s accessibility and competitive pricing.

We have used propane for years and have found that it benefits our needs the most.

— Dr. Sheryl Alden, Director of Transportation, Denton Independent School District, Texas

Propane fuel prices have remained very competitive — below $2 per GGE — since 2020.

Fuel Cost Remains Competitive Despite Price Increases

Propane fuel prices have remained very competitive — below $2 per GGE — since 2020.

Fuel cost remains competitive despite price increases, with propane prices remaining significantly lower than gasoline and diesel. The overall cost of operating propane vehicles remains attractive, with propane prices jumping 125% as compared to fuel sales peak, fuel demand growth is expected.

Four states — California, Florida, Michigan, and Texas — accounted for about 30% of national demand for propane vehicle fuel, continuing a relatively consistent trend. Forecasts from PERC suggest that demand will grow broadly across the U.S., given the fuel’s accessibility and competitive pricing.

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New Renewable Diesel Production Could Grow Renewable Propane Supply

As 2022 began, energy market disruption added further upward pressure on the price of all transportation fuels. Prices for diesel and gasoline throughout the country will also increase supply, with renewable diesel (RD) leading the way. RD producers have invested heavily in expanding production capacity, and new plants will be online in the near future. These new RD production facilities will also produce renewable propane, which can reduce greenhouse gas (GHG) emissions by as much as 80%.

The California propane industry has its own goal of transitioning to 100% renewable propane in the state by 2030. With renewable propane being used in transportation, the future of renewable propane in the California market is bright.

More than 35% of smaller fleets with 101-500 vehicles reporting use of propane vehicles.

Propane: Fleet Adoption and Insights

Despite industry interest, it is not yet clear that transportation will be the end-use for renewable propane. Market conditions such as the size of the market and the value that RD producers can secure for other uses such as on-site use or sale to other markets, as well as the benefits of sales in transportation to generate credits on low-carbon fuel markets like California’s Low Carbon Fuel Standard (LCFS), will determine whether this technology can scale to aid fleets that use propane in realizing more significant GHG reduction benefits from switching to renewable propane.

“More than 35% of smaller fleets with 101-500 vehicles reporting use of propane vehicles.”

“Our drivers have been pleased with the lower engine noise and cleaner emissions of our propane buses over our diesel buses. They are also impressed with the performance and ease of fueling.”

Robert Williams, Assistant Director of Fleet Services, Cypress Fairbanks School District, Texas
Propane adoption is more common among small and midsize fleets. Smaller fleets, those with 101-500 vehicles, lead among fleets when grouped by size, with more than one-third (35%) reporting its use, followed by fleets with 1,001-10,000 vehicles (28%). Among all other fleet sizes that were assessed, fewer than 5% of respondents reported using the technology.

Fleets that have piloted or purchased propane in the past 24 months confirm that the fuel provides reduced cost benefits among other positive operational gains (Figure 4). Most fleets that have piloted or purchased propane vehicles report equal or better performance on emissions (92%), noise (88%), fuel cost (86%), and odor (84%).

"Propane-powered vehicles are lower maintenance, cleaner emissions, and lower cost."
— Laurie A. Cleaver, Director, Ottawa County Transportation Agency, Ohio

As noted above, the use of renewable propane is expected to climb in the years ahead. Presently, only about 8% of fleets operating propane vehicles report using renewable propane in the past two years. However, 29% of fleets in the survey reported they will implement renewable propane in the next 12 months if they can secure supply. With the supply of renewable propane expected to expand in 2022, this increased market demand could be satisfied. Further, given the growing number of public and private fleets adopting increasingly ambitious sustainability goals, and with 92% of surveyed propane vehicle users recognizing the emissions reductions benefit of propane, demand from fleets for a lower carbon version of the fuel should remain strong.
Industry Perspective: Propane Education and Research Council (PERC)

Propane continues to be the proven alternative fuel option for school transportation. Propane buses reduce lifecycle costs while safely and reliably carrying 1.3 million children to school each day. Today’s propane engine technology meets or exceeds customer expectations for performance, fuel efficiency, and durability.

Propane’s performance is not limited to school transportation. Propane continues to drive the Class 3-7 market with gains in paratransit, postal contractor, delivery, and food and beverage. In February, Cummins announced its exciting new B6.7L propane offering. In testing, the Cummins engine technology demonstrates propane’s role in a near-zero future in the MD market.

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In California, RNG production and consumption grew, with low- or negative-carbon RNG making up 98% of CNG for transportation in the state. In 2021, the average carbon intensity of all the natural gas reported in the California LCFS was below zero, making NGVs the only carbon-negative transportation option for fleets. Cummins announced a new 15-liter NZE natural gas engine, the X15N, that is more powerful and lighter than the current Cummins 12-liter engine. It will enable even the heaviest of work trucks — including long-haul trucks and liquid tankers — to adopt CNG and is expected to increase fleet adoption.

Throughout 2021, CNG maintained a clear cost advantage and relative price stability compared to diesel fuel. On average, diesel fuel was 25% higher than CNG, although the spread increased from 10% to nearly 30% between January and mid-October.

Transit buses, straight trucks (including refuse), and Class 8 tractors continue to dominate NGV sales, which helped to show a small growth in 2021 sales compared to 2020.

**THE FLEET TYPES LEADING CNG VEHICLE ADOPTION**

<table>
<thead>
<tr>
<th>REFUSE</th>
<th>REGIONAL</th>
<th>LONG-HAUL</th>
<th>TRANSIT</th>
<th>CARGO</th>
<th>MUNICIPAL</th>
<th>PUBLIC UTILITY</th>
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### Estimated Medium- and Heavy-Duty Vehicles in Operation

<table>
<thead>
<tr>
<th>TENS OF THOUSANDS</th>
<th>THOUSANDS</th>
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</thead>
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MARKET SNAPSHOT

Cummins Announces Larger Engine, Opening Door to CNG for New Fleets

"Having CNG at our fueling station has been a great choice for our city, maintenance cost are a great deal cheaper because of extended time between performing preventive maintenance. Plow trucks have performed as well with CNG as they do with diesel fuel — huge savings in fuel cost."

— John Hyatt, Fleet Manager, City of Dublin, Ohio

RNG Nearly Replaces Fossil CNG in California, Production Grown Nationally

RNG has made a leap forward in states like California where it has become the dominant form of CNG consumed by the transportation industry. According to data reported into California’s LCFS program, RNG made up 98% of total natural gas vehicle fuel consumption in 2021 (up from 92% in 2020), with traditional CNG contributing the final 2%. Nationwide, 64% of natural gas fuel used in on-road transportation in 2021 was RNG, according to Natural Gas Vehicles America.

As part of the company’s Destination Zero strategy, Cummins will develop its B-, L-, and X-Series engines with a fuel-agnostic approach. Dedicated variations of each engine will be designed to support diesel, natural gas, or hydrogen fuel. This will be accomplished using a single engine block and common core components but different fuel systems and parts above the head gasket for the different fuel options to create production efficiencies and potentially reduce cost differences between the end vehicle types. This strategy will allow Cummins to not only offer the X15N in a natural gas configuration but in an internal combustion hydrogen version as well, creating a possible bridge for the trucking industry to meet potential ZEV standards in the future.

The announcement of the X15N was met with very strong fleet customer interest, with dozens of over-the-road fleets asking to take part in the field trials. Ultimately, Cummins announced that Werner Enterprises would be participating in the initial field trials in the first half of 2022. It was also announced that Werner will test the hydrogen version of this 15-liter Cummins engine at a future date.


According to California’s LCFS program, RNG made up 98% of total natural gas vehicle fuel consumption in 2021 (up from 92% in 2020).

US Gain supported the development of two new ODQG0Q JDVWRS51* IDFLOLWLQHV ZLWK RQH opening in July to support Republic Services’ IHOLOQ(VHHGVLO+RXVWRRQ7[DF. Another facility is under construction in South Carolina that will support the local department of public works. US Gain also announced that its RNG supply will be a feedstock for hydrogen production in the California transportation market. Renewable feedstocks for hydrogen fuel for transportation LQFUHDVLWHVYDOXHQLQWKH&J6PDUNHW

Two states are leading the way in terms of RNG SVRI*HFPEHUS1*SURMHFWVZUHURRHMFWHWRHELQSHUDWLQRDURVWVWKH86+PRUHWKDWLOQ2QHWKLUQIRWKH51*produced was intended only for vehicle fuel FRQVXPSWLRQZKLOHWKHHUPDLOQHUVZDQLQHMFHWGLQWWLSSLOQLQIUDYDULWHWJXVHJJHDWSRZHUWUDQVSRUWDLQRQDOLIRUQLDGRQFLQWHVWRUDQJLQVWLQHUPRVQXPEHURSRHDWLQRQDQ51*SURMHFWVWKLQHDVWHDVZDQJRURWKHZLQURPSURMHFWVWVR

We continue to see renewable natural gas vehicles as the best current solution to meet range, fueling, and emissions reduction requirements.

*DDW+DUULV6XVWDLQDELOLSURUHDQDJHU HQPDQVRIRQDQ0UGHVW1HZRUN

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The trend is expected to continue nationally and become a larger share of total biofuel production, in line with global projections by the IEA that RNG production is expected to grow from 1% of global biofuel production in 2020 to nearly 20% by 2050, becoming one of the fastest-growing types of fuel within the segment.

Emissions Reductions in RNG Supply Continue to Decline, Remain Negative in California Throughout 2021

In California, RNG's carbon intensity (CI) continued its downward trend into negative numbers over the course of 2021. The energy weighted carbon intensity of all natural gas consumed in California for all of 2021 was -33.36 gCO2e/MJ, down from the -27.17 through the first three quarters of 2021.

This trend is expected to continue in 2022 and beyond. Growth in the volume of swine and dairy gas being reported into the state’s LCFS program is the main factor driving the CI value of natural gas transportation fuel lower. For fleets working to reduce GHG emissions, using carbon negative RNG can provide significant sustainability benefits, while simultaneously allowing fleets to achieve substantial fuel cost savings.

In May 2021, Chevron and Clean Energy Fuels launched their Adopt-a-Port initiative with $28 million in funding to provide carbon-negative RNG to large trucking fleets and owner-operators serving the San Pedro Bay Ports. After ordering hundreds of NGVs in Q1 of 2021, Amazon signed a deal with Clean Energy Fuels for both low- and negative-carbon RNG at 27 existing fueling stations and an additional 19 non-exclusive new or upgraded stations, which Clean Energy planned to construct in 2021 and 2022.

RNG is favored by fleets for its environmental and economic sustainability benefits, as the cost of this very low-carbon — and sometimes carbon-negative — fuel is typically at or below the cost of traditional natural gas, as is the case in California due to the LCFS market. In the State of Sustainable Fleets annual survey, around 60% of CNG users confirmed that they are currently using RNG, showing both its success in the market and the growth opportunity that remains.

CNG Maintains Cost Advantage Over Diesel During Volatile Year

Throughout 2021, CNG maintained a clear cost advantage and relative price stability when compared to a volatile year for diesel. The clean fuel continued to prove its value, with the price of CNG increasing approximately 3% on average at public fueling stations compared to 2020. Diesel prices increased nearly 19% nationwide and were, on average, 25% higher than the price of CNG on a DGE basis.

Fuel cost is a primary benefit of CNG users in the annual fleet survey with 79% reporting it as an advantage of the technology. For fleets with private, on-site fueling infrastructure, prices increased 12% in 2021, compared to about 3% the previous year.

The use of CNG and RNG has greatly reduced our emissions and increased driver satisfaction.”

**Footnotes:**


86 Ibid.


that are likely driving this number. Transit bus deliveries increased 22% with 1,033 vehicles registered in 2021 versus 848 in 2020.\textsuperscript{93}

Transit, Straight Truck, and Tractors Continue to Dominate Sales, Sustain Growth

NGV registrations increased 3% in 2021, to 6,477, a slightly higher growth than in 2020, when delivery growth was around 2%. Tractor trucks were the strongest growth segment, with a 94% increase to 3,013 in 2021 versus 1,550 in 2020. Both Amazon and UPS have made large, multi-year purchases of tractor trucks.\textsuperscript{92}

Straight trucks were the second-largest segment of NGVs, with 2,166 units delivered in 2021. According to DMV registration data provided by IHSMarkit, many of these vehicles — 1,295 identified vehicles — were for refuse applications. The number is likely low due to registration and delivery data lagging on several large orders, including purchases of around 1,000 CNG vehicles by WM, which operates the largest HD natural gas truck fleet of its kind in North America, with more than 10,300 CNG trucks in operation and more than 170 natural gas fueling stations.\textsuperscript{95}

The school bus segment has seen a steady decline in new CNG buses since 2017, with a sharp drop of 64% in 2021 — only 69 new CNG buses were registered, compared to an average decline of 20-30% year-over-year since 2017. This is likely due to the continued competitive TCO of propane school buses, a general reduction in school bus activity due to the COVID-19 pandemic, and an increase in the level of attention and funding being directed to battery-electric school buses. Cargo and passenger van purchases also declined significantly — 96% for cargo vans and 89% for passenger vans, primarily due to the COVID-19 pandemic.

Natural Gas Fueling Station Count Remains Steady While Fuel Consumption Increases

The ongoing trend of natural gas fueling station closures continued in 2021, with a 6% closure of public and private stations as reported by the Alternative Fuel Data Center.\textsuperscript{90} However, 13 public stations designed to support HD vehicles across the West and South were in the planning stage as of February 2022. While natural gas fueling infrastructure numbers have declined, DGE pump price remained competitive at $2.32 per DGE for private fuelers versus $2.57 per DGE at public fueling stations.\textsuperscript{89}

Natural Gas Fueling Infrastructure Numbers Have Declined

The Alternative Fuels Data Center reported a 7% decline in natural gas fueling station count in 2021, with 3,075 stations in operation as of December 31, 2021. This decline continues the ongoing trend of closures in the public and private sectors. However, there were 13 planned public stations designed to support HD vehicles across the West and South as of February 2022. While natural gas fueling infrastructure numbers have declined slightly, CNG fuel sales increased 8% nationally, recovering from a 4% decline between 2019 and 2020. Total consumption in this segment has grown 25% since 2015, suggesting a concentration of fuel use among fewer stations.

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This is likely a result of the growth of the HD CNG market and a waning of the LD CNG vehicle market since the mid-2010 period. As the U.S. Energy Information Administration's survey methodology will begin tracking RNG and CNG separately starting in 2022, better data on the national use of RNG is expected to result end enable validation of year-over-year growth.\textsuperscript{91}

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67% for passenger vans. This was triggered by GM’s removal of most of its vehicle offerings in this segment at the start of 2021.

Refuse and transit bus models are the most common, with more than 10 models available from manufacturers in each category. GNA’s review of publicly available data from three transit bus manufacturers show that the capital cost of HD CNG transit buses declined approximately 10% in 2021, making them even more competitive with diesel buses.

In the yard truck segment, two models are available for purchase, while the MD segment, which includes chassis cabs and pickups, has the largest numbers of offerings, all from upfitters. Overall, MD models declined 40%, with GM’s exit causing the biggest drops in cab-over, cutaway, passenger shuttle, and pickup models.

### THE NATURAL GAS VEHICLE MARKET

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<tr>
<th>Body Type</th>
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<td>Autocar Truck, TICO</td>
</tr>
</tbody>
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NGV: Fleet Adoption & Insights

Among early adopters of the four drivetrains that the State of Sustainable Fleets report assesses, just under half (45%) have operated CNG vehicles in the past two years. However, CNG is also the alternative drivetrain with the greatest overall uptake by vehicle count. Among all clean technology vehicles operated by early adopters surveyed in 2021 (diesel engines using BD, RD, or any clean drivetrain), 20% are CNG vehicles, speaking to the technology’s use at scale by a significant number of individual fleets and fleet types that see sustained cost and performance benefits.

Looking closer at the breakdown of CNG early adopters surveyed, just over one-third of state, county, and municipal fleets (32%), as well as nearly one-third of transit fleets (28%), have operated CNG vehicles in the past two years. Also, close to one-quarter of refuse fleets (24%) surveyed have operated CNG vehicles in the past two years. Across all CNG vehicles operated by fleets in the annual survey, two fleet types account for nearly half of all vehicles, with refuse and Class 8 tractors operating in the mail and package delivery sector representing 40% of all vehicles. These figures suggest the technology has found a strong foothold with these fleet types and opportunity for growth to similar fleet types.

As reported above, many of the nation’s largest fleets have made major investments in NGVs, a "CNG buses have been a successful implementation in technology and provide a significant fueling cost benefit."

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PERFORMANCE AND ADOPTION RESULTS REPORTED BY CNG USERS

3HUFHQWRI&1* XVHVUXUYH\HGZKRFLWHDQLOHWLUDDVHTXDOEHWWHRUDQGRSRQLQFDQDOOHQJH

Equal or Better Performance

Adoption Challenges

<table>
<thead>
<tr>
<th>Equal or Better Performance</th>
<th>Adoption Challenges</th>
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<tbody>
<tr>
<td>TCO</td>
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<tr>
<td>Fuel Supply</td>
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<td>Reduced Emissions</td>
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<td>Range</td>
<td>46%</td>
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<tr>
<td>Vehicle Availability</td>
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Source: Percent of surveyed early adopter fleets that have either piloted or purchased MD or HD CNG vehicles who cite a criteria as either equal/better or a challenge from the State of Sustainable Fleets 2022 survey.
Plan recently proposed by EPA. The additional benefits of refueling with RNG allow natural gas fleets to achieve carbon-negative emissions today.

In 2021, 64% of all natural gas used in on-road transportation nationally was RNG, up from 53% in 2020.

The average carbon intensity of bio-CNG sold in California continues to get better, dropping to -62.31 gCO2e/MJ in Q4 2021.

Based on the mix of fuel sold nationally, the average carbon intensity of all RNG is approximately 12.65 gCO2e/MJ.

RNG availability continues to grow. There are 250 production facilities in operation and more than 235 in the planning stages or under construction, and more states are looking to join California, Oregon, and Washington in adopting clean fuel standard programs.

Since RNG is interchangeable with any NGV in either compressed or liquefied form, RNG is the one low-carbon and carbon-negative fuel that does not require the build-out of infrastructure, since it is dispensed from existing fueling stations.

Natural gas fleets of every size benefit from low, stable natural gas prices, allowing for a quick return on investment. Available government and local incentives can further reduce total cost of ownership. And expected multi-year extension of the federal $0.50/gallon AFTC and proposed $1/gallon Renewable Natural Gas motor fuel tax credit further encourage natural gas fleet adoption.

Industry Perspective: Natural Gas Vehicles America (NGVA)

With environmental sustainability at the top of the global agenda and companies around the world focusing on decarbonizing operations, natural gas and RNG vehicles deliver a clean fuel transportation solution that is cost effective. And since RNG is interchangeable with any NGV in either compressed or liquefied form, RNG is the one low-carbon and carbon-negative fuel that does not require the build-out of infrastructure, since it is dispensed from existing fueling stations.

Vehicle options are designed to meet the daily performance and range needs of fleets while delivering significantly low emissions. Our Start Now. RNG is How! report released in April, available at https://ngvamerica.org/rng-is-how, details just how fleets can achieve sustainability goals and save money all while transitioning to natural gas vehicles fueled by RNG.

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Vehicle options are designed to meet the daily performance and range needs of fleets while delivering significantly low emissions. Our Start Now. RNG is How! report released in April, available at https://ngvamerica.org/rng-is-how, details just how fleets can achieve sustainability goals and save money all while transitioning to natural gas vehicles fueled by RNG.

Cummins natural gas engines continue to be DYLDLOEOH DGQ DOO DUH FHUUWLH & WR D QHDU|HUR HPLTVLRQ JEXSKU VWDQGDUQ FOHDQHU WKDQ WKH 86 [35] FXUQHWW 12 |VWDQGDUQ $QG WKH VXWUDORZ12 |WHFKQRORJLH DYLDLOEOHQRZ meet the more stringent upcoming Clean Trucks

Larger scale heavy-duty BEV projects are emerging and many of these fleets will go from a handful of units in 2021 to dozens and even hundreds in 2022 and 2023.

Most startup BEV OEMs in the LD and MD BEV segment have experienced production delays, while large traditional OEMs are beginning to deliver BEV products to customers in very small numbers, with significant orders to be fulfilled in 2022 and beyond.

Global OEMs continue to deliver on, and even accelerate, their investment commitments to BEVs with top OEMs vying for early leads and market share in the MD market.

Vehicles, batteries, and infrastructure costs have not fallen as fast as expected. Ongoing LDV cost decreases for batteries, a critical driver of vehicle cost, are not yet translating to MD and HD batteries.

New national commitments by a coalition of utilities and other private sector investors will lay the groundwork for national charging networks. However, most early adoption by fleets to date has relied on private charging, which is expected to dominate in the near-term.

### THE FLEET TYPES LEADING BEV ADOPTION

- Municipal
- Shuttle
- Transit
- Delivery
- Utility
- School
- Cargo
- Drayage

**MARKET SNAPSHOT**

Tractor and Yard Truck Fleets Begin Operating HD BEVs at Larger Scale

State of Sustainable Fleets 2022 Market and Trends Brief
Several demonstration projects planned for 2022 will feature commercially certified trucks to help prove that fleets can successfully manage 10, 50, and even 100 BEVs and their charging requirements.

NFI and Schneider successfully applied for funding to purchase a total of 100 Class 8 battery electric trucks: DQ9 (R0Y R915) and DQ9 (R0Y R915) V6L and DQ9 (R0Y R915) V6L, respectively. The trucks will be used for testing in California’s Zero Emission Drayage Truck and Infrastructure Pilot Project, with at least 50 Class 8 BEVs from each of the following OEMs being used in drayage service: Freightliner (80), Lion Electric (50), Navistar (53), Tesla (50), and Volvo Trucks North America (VTNA) (70). This will be a significant test of vehicle charging infrastructure, including that of utilities to deliver sufficient and cost-effective power. These orders come just two years after Daimler Truck North America (DTNA) was the first major manufacturer to deliver an HD BEV to Penske Truck Leasing and NFI to demonstrate the real-world applications of the technology.

Aside from the tractor and yard trucks segments, after successfully piloting a refuse truck from Mack in 2020, the New York City Department of Sanitation, the world’s largest municipal sanitation department, ordered an additional seven battery-electric Mack refuse trucks, a substantial BEV order for the refuse sector. Additional announcements for battery-electric refuse truck sales are anticipated in 2022.

Two MD Players Vie for Market Share

Competition for the MD fleet BEV market is increasing, with global OEMs Ford and GM both expanding their support services to fleets. NFI and Schneider successfully applied for funding to purchase a total of 100 Class 8 battery electric trucks: DQ9 (R0Y R915) V6L and DQ9 (R0Y R915) V6L, respectively. The trucks will be used for testing in California’s Zero Emission Drayage Truck and Infrastructure Pilot Project, with at least 50 Class 8 BEVs from each of the following OEMs being used in drayage service: Freightliner (80), Lion Electric (50), Navistar (53), Tesla (50), and Volvo Trucks North America (VTNA) (70). This will be a significant test of vehicle charging infrastructure, including that of utilities to deliver sufficient and cost-effective power. These orders come just two years after Daimler Truck North America (DTNA) was the first major manufacturer to deliver an HD BEV to Penske Truck Leasing and NFI to demonstrate the real-world applications of the technology.

Several demonstration projects planned for 2022 will feature commercially certified trucks to help prove that fleets can successfully manage 10, 50, and even 100 BEVs and their charging requirements.
8SRQ DQQRXQFLQ| VSXHV IRU WKH )LJWKQOLQJ \RUGUHYDOHGRUGWKH FWUDWLQJ RI ODLQDWLRQ DQG OHZU RZUN RI (9FHULWHG GHDOHV KLSV DOQLQJ 644 commercial vehicle centers. It now RIHVU LRQ 3URD\VWIRLWV NLQGV HUYLELFW PRQJ 2[8 ZKLFW OQGODVH VDFURPSKDQW YHXLWRI ODLQDWLRQ F KDUJLQDO DGQ DOHQHUV KLSV XVSRRWV RQ |HHWRSUDWRRUVRWVHDPHOHVVLQLQWHJUDW (9V LQWHGULQDQWLQGQHUVLVW

Reservations for Ford's F-150 Lightning exceeded 120,000, prompting the company to invest another $250 million to double its 2024 production target to 80,000 units and double it again in 2025.

0HDQZKLOH *OW %ULJKW'URS RSHQHG LWV JVVV dealerships last year and announced the launch R180WLX&KDUJHDVHUYLHFRQOHFWLQJ|HHWV to EVSEs. GM aims to incorporate more than SXEOLF KDJULQJ |DIFLQLWLV LQWR LWV VWULYFWH WKURXJK SDUWQHUV KLSV ZLWK H7UDQVQHUJ \XNH (QHUJ)9 RI,1KDUJH(QHUJ)DQG6FKQHGLU Electric.

Ford and GM are accelerating production timelines to meet high demand. Reservations IRU |RUGUHYDOHGRUGWKH FWUDWLQJ RI ODLQDWLRQ DQG OHZU RZUN RI (9FHULWHG GHDOHV KLSV DOQLQJ 644 commercial vehicle centers. It now RIHVU LRQ 3URD\VWIRLWV NLQGV HUYLELFW PRQJ 2[8 ZKLFW OQGODVH VDFURPSKDQW YHXLWRI ODLQDWLRQ F KDUJLQDO DGQ DOHQHUV KLSV XVSRRWV RQ |HHWRSUDWRRUVRWVHDPHOHVVLQLQWHJUDW (9V LQWHGULQDQWLQGQHUVLVW

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electric school buses in October 2021. Regulatory and funding developments are expected to continue to create demand for battery-electric school buses. The State of New York passed a budget with a rule that will require the estimated 50,000 school buses in the state to transition to zero-emission by 2035, with purchases beginning as early as 2027. The IIJA sets aside half of the $1 billion annually for the next five years for zero-emission school bus technologies. Some early adopters of electric school buses are already seeing improvements in TCO. Twin Rivers School District in Northern California currently runs 40 battery-electric school buses and has reported an 80% reduction in fuel costs, with further revenue generation being realized via LCFS credits. Maintenance costs have dropped 70%, and the district reports practically zero cost for inventory, as well as extended brake and tire life. With much of the costs covered by the more than $29 million the district has received in grants. It is also planning to install 22 new chargers to be V2G compatible. V2G could provide additional financial benefit to the district through payment from the utility for access to the battery during vehicle down times.

School Bus Market Sees Early Performance Results, Increased Orders

The battery-electric school bus market experienced a substantial rebound in 2021 with a total of 612 units purchased, up from just 20 purchased in 2020. To date, more than 350 fleets have ordered or deployed approximately 1,800 electric school buses in the U.S., with the majority of these being Type C and D models from Thomas Built, Blue Bird, and Lion Electric.

Although the geographic focus of the State of Sustainable Fleets report is the U.S., it is notable that Canadian division of U.S.-based Student Transportation of America placed a conditional order for 1,000 zero-emission school buses. This follows the partnerships announced by Amazon with startup Rivian for a commitment of 100,000 delivery vans and UPS with startup Arrival for 10,000 vehicles that were reported in previous editions of State of Sustainable Fleets.

"Purchasing and utilizing EVs has greatly surpassed our expectations as it relates to the speed, performance, charging, and maintenance costs. The vehicles are fun to drive, and our user departments are satisfied."

To date, more than 350 fleets have ordered or deployed approximately 1,800 electric school buses in the U.S.
a shorter timeline to get electric buses on the road (which can be weeks versus months), lower costs for the electric bus (by approximately 50%), and a more favorable opportunity for a positive TCO. SEA Electric and Midwest Transit Equipment also announced an agreement to repower 10,000 school buses to battery electric during the next five years.

Commitments to Expand National Charging Infrastructure Grows

A majority of MD and HD BEV charging now takes place on-site within a fleet yard, which is consistent with the data and trends for other more mature fuels like propane and natural gas. Given the incremental level of investment in the BEV market by the public and private sectors, and the increased regulatory focus on forcing BEV sales and deployments, public charging infrastructure will likely be more important in the years ahead.

With the anticipated growth of the commercial BEV market in the next five years and beyond, there is growing focus on the development of public access charging infrastructure, networks, and corridors.

Of all the segments covered, the school bus market appears to be furthest along in terms of offering V2G compatible BEVs. However, few projects have yet to demonstrate the technology due to the significant number of regulatory, technical, and other hurdles that have yet to be addressed within the market and electric utility systems. V2G capable school buses are being offered by Blue Bird, Lion Electric, and Thomas Built Buses.

Given the need for school districts to take advantage of funding programs to procure EDWWHU\HOHF\ULF\EXVehicles, district administrators are looking into new federal programs that could provide an important stimulus to the forward growth of this market in the years to come.

An interesting trend observed in the last year is a movement to repower existing school buses with battery-electric drivetrains, with the goals being...
not all are ready for delivery (Figure 7). During the past year, more than 170 BEV models have been advertised by OEMs and aftermarket providers, with only 70% available for customer order. While many of the aftermarket and startup BEV manufacturers were quick to market with announcements and prototypes, getting to commercial production and scale has been a challenge.

Compared to the prior year, model availability grew in the HD tractor segment by 60% from five models to eight, HD straight truck by 25% from three models to five and refuse by 200% from two models to six. Unfortunately, fleets have found that the MD and HD BEV markets have been affected by delivery delays, with Tesla’s Semi tractor being the most notable example where delivery of the first units has been delayed.

The goal of the coalition is to develop fast charging along major U.S. travel corridors to fill infrastructure gaps by 2023, though the details have not yet emerged around how tailored or accessible these will be for the needs of fleet operators.

BlackRock Renewable Power, NextEra Energy Resources and DTNA, signed an MOU in 2022 to develop, install, and operate a nationwide, high-performance charging network for MD and HD battery-electric and hydrogen FCEVs in the U.S.

Fleets looking to deploy BEVs have more advertised choices today than ever before, but...
have only filled low volume orders, if any at all. Global supply chain issues and the challenges of building new manufacturing plants and new vehicle platforms from the ground up — while in the middle of a global pandemic — have only contributed to these delays.

Forward scaling of MD BEV deliveries is expected in the years to come, especially from traditional OEMs, but also from the new BEV manufacturers once their supply chain and production issues are resolved.

Meanwhile, established manufacturers such as Ford, GM, DTNA, VTNA, Peterbilt, International, and others have been working to develop their production capabilities and ramp up marketing and sales efforts.

For example, Rivian, Lightning eMotors, and Nikola are among the manufacturers that have cut 2022 investments and production targets due to expected ongoing supplier delays.

Despite some delays, there has also been considerable progress. Currently, 14 battery-electric tractor models are either being produced or are in development. The cargo van segment has seen especially strong growth in the last two years, with 18 models either available or advertised from at least 14 manufacturers.

"We will replace vehicles that have and/or approaching the end of their useful life with equivalent battery-electric vehicles as they become available."

"The greatest challenge we face in transitioning to EVs is finding suitable models that meet specialized operations of our fleet. The second barrier is investing in charging infrastructure that is dependable on an inconsistent powergrid."

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### THE BATTERY-ELECTRIC VEHICLE MARKET

**0'DQG+%'DWWHU\(OHFWULF9HKLQFHV/LPLWHGWR)XOO3URGXFWRQ**

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Battery and Charging Infrastructure Costs Remain Stubbornly High

131 new EV battery production plants in the U.S. are expected to be operational by 2025, only two currently plan to produce batteries for the commercial vehicle market. The combined lower volume market of the MD and HD segment compared to passenger cars, the larger battery pack requirements for HD vehicles, and other scaling considerations suggest that the cost/kWh curve for the commercial sector may follow a different trajectory than the LD sector. Looking beyond current low volume market pricing, most predict that battery and delivered BEV costs will decrease in the coming decade.

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Battery and Charging Infrastructure Costs Remain Stubbornly High

With many BEVs still in limited production, there have been no major price decreases observed for any one vehicle type. Prices for batteries, a critical driver of end-vehicle cost, remain stubbornly high. While LD vehicle battery pack prices dropped to approximately $140/kWh in 2021, HD vehicle battery pack costs are still at least double the price of their LD counterparts due to currently low production volumes. Market analysts suggest that prices could even rise in the short term from 2021 due to mineral shortages and supply chain disruptions. While 131 new EV battery production plants in the U.S. are expected to be operational by 2025, only two currently plan to produce batteries for the commercial vehicle market. The combined lower volume market of the MD and HD segment compared to passenger cars, the larger battery pack requirements for HD vehicles, and other scaling considerations suggest that the cost/kWh curve for the commercial sector may follow a different trajectory than the LD sector. Looking beyond current low volume market pricing, most predict that battery and delivered BEV costs will decrease in the coming decade.

**References**


OEMs Expand Beyond Manufacturing to Support Fleets

A noticeable trend in the last year has been Wkh 15dqvlrq ri wkh wudglwlqjdo uroh ri 2( as vehicle manufacturers into a much more comprehensive customer engagement and management role. This shift has been driven by the increasing complexity of BEV development projects and the need for closer collaboration with end-use customers. OEMs are increasingly helping customers assess how BEVs will perform in their operations and duty cycles, while also identifying potential constraints and the best routes for the technology. In terms of fleet planning, OEMs are engaging with customers early on, discussing how BEVs will perform in a fleet's existing conditions and constraints. Last spring, DTNA launched Detroit eConsulting, which provides customers with a team of e-mobility experts to help fleets navigate electric truck conversion projects. Lightning eMotors offers grant and incentive assistance for fleets, as well as driver and maintenance training.

Beyond a focus on the vehicles and fleet operations, OEMs are even branching out into the development of BEV charging infrastructure. GM, VTNA, Ford, DTNA, and Nikola have all either launched partnerships with EVSE providers or are developing their own branded EVSE and software services to grow charging networks for LD, MD, and HD BEVs. Taking this even one step further, some OEMs also offer assistance with power procurement, including cleaner-than-grid options. Navistar offers clean power procurement through the purchase of renewable energy credits.

Costs within the charging infrastructure market may be in a similar holding pattern. According to recent grant-funded projects and purchase experiences by several fleets from the past year, no significant cost reductions were observed in the EVSE market in 2021. Just as in the automotive industry, inflation and supply chain constraints impacted the market. Fleets also reported that soft costs related to current demonstrations and ODU of VEHFDOLQ LWDO DQRQ RI 96( FRQWLQXH WR EH PDMRU FRPSRQHQWV RI WKH WRWDO SURMHFW FRWV /DERRUIRLQW DWDWLDLRQRIDYL& &FDQEHVDPXFKDVKWHTXLSPHQWLVHOIQRWDO WRIWV GHVLJQSHUPLWWLQJ FRPPPLVLRRLQJ ZHDWKHULJL networking and cable management — can add XSWRDVXPXFDVRIWKHWRWDO SURMHFWFRWV


Ibid.

GNA assessment of quotes in grant funded MD and HD BEV projects as well as market intelligence from leading fleets.


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"Drivers liked the BEVs we piloted in 2021, but infrastructure is a larger hurdle than most people realize."

"We are working to pilot Class 8 EVs and have realized this transition requires close collaboration with multiple parties to overcome challenges like lead-times, availability, and required infrastructure."
While end-of-life battery treatment faces several challenges, solutions exist, and companies are starting to prove-out their concepts. The Volvo LIGHTS project studied the possibility of using second-life batteries to improve grid and facility resiliency as well as to provide load management. In the transit and motorcoach segment, Canadian bus manufacturer NFI Group now offers customers access to battery recycling through Li-Cycle, under a formal program announced late in 2021 that followed a year-long proof of concept.

Li-Cycle’s process recovers resources from lithium-ion batteries at the end of their useful life for use of those materials in other products. GM’s Ultium Cells LLC, a battery production joint venture with LG Energy Solutions, also partnered with Li-Cycle on recycling scrap metal from Ultium’s battery manufacturing processes, reducing landfill waste and the demand for raw materials.

Ford has partnered with battery recycling startup Redwood Materials to incorporate battery recycling into the OEM’s domestic battery strategy. The partnership aims to improve the reliability of domestically sourced battery materials for Ford’s BEV production targets.

As projects are further developed, OEMs are supporting fleets by connecting them with innovative new financing options. For example, Daimler Truck Financial Services offers tailor-made solutions for ZEV trucks and buses that include finance offerings that support acquisition of chargers and VTNA’s Electric Vehicle Financial Services offers similar financing tailored to BEVs and infrastructure. Lion Electric also launched LionCapital Solutions, a new division within the company that offers financing solutions specifically tailored to the MD and HD BEV market.

These early market development efforts by YHKLFOH 20V DUH QRWHERUWK\DV WKH\DUH D departure from the traditional model where 20V PDQIDFWXUH\YHKLFOHV DQG VDQH\VHUYLFH and support functions are handled by a dealer OHZWUR\YVW K%\PDUNHW PDWXUHV\DQG\JURZV WKH DELOLW\IRU FQHWDVODL\HG20W WRVXSSRUWZLGH customer engagement will become increasingly OPLWHG,QVHYHUDOWIRUHODUHJ\DV\UEHDQJ to train select dealerships on their BEV products VRWKVHV GDHDHV DQG WUDGLW\RQDQ\VDQH\VXSSRUWGDVQHUHYLFHUROHVZLWKWKHFKWVXWPHU of their useful life for use of those materials in RWKHUSURGWXFWV*0\80WLP\HOOV\\DDEWWHU\SURGWXFWLRQMRLQWHYHOWXUHDLKW\HQHJ\6ROXLRQ\VSDUWQDUHHLJZLWK\LFOHRQHUHFOLQ\VFUDS metal from Ultium’s battery manufacturing SURFHVVH UHGXFLOQ ODQG\DQW DIWHU WHQ demand for raw materials. Ford has partnered with battery recycling startup Redwood Materials for all the known environmental benefits of BEVs’ ability to eliminate tailpipe emissions, there is growing concern about the environmental impacts that result from the disposal of the battery at the end of its useful life. Typical warranties for EDWVWHULHV DQG\W1RP YOU WH \HDUV DQG DUN designed to cover batteries until their capacity degrades more than 20%. When the battery is RXWRI\ZDUUDQ\WKHUKLVQRFXUH\HQWVVDQGDUG\RU handling or disposal.

operated BEVs say they have installed on-site renewable electricity. Several of the large, grant-funded projects with large fleet deployments of Class 8 BEVs above included on-site renewable electricity, in addition to others like one funded by the California Energy Commission for Sysco Corporation to test on-site solar and storage to support 40 battery-electric tractors at its Riverside, California, location.

Fleets choose to use RECs or on-site renewable electricity for different project types and goals. Projects without on-site electricity generation in California benefit from a financial gain for purchasing RECs. Fleets aiming to maximize their TCO and reduce overall costs may be the ones using this strategy and avoid the additional capital cost of installing on-site solar.

Standardization Moves to Address Several Critical Needs

Electric vehicle stakeholders are collectively addressing the need for a charging standard to support 1 MW or higher charge rates for Class 6-8 vehicles. As HD BEV demonstrations advance, fleets are more clearly defining the battery capacity that they require to complete their routes, as well as the timeframe that they consider reasonable to charge vehicles between shifts.

Renewable Electricity Advances Nationally

In 2021, the IEA forecasted that U.S. renewable capacity on the grid would expand by 65% by 2026, adding 200 GW by solar (75%) with the remainder mostly wind. The sector faces similar policy, cost, and infrastructure barriers as the EV infrastructure and vehicle sectors, with a need for increased and robust transmission and distribution infrastructure to deliver the expected renewable power to the places it is required. Programs such as California's LCFS program require fuel producers and encourage transportation stakeholders to reduce the carbon content of their fuel consumption. In 2021, fleet consumption of lower-than-grid-average CI in California more than doubled, comprising the majority of electricity consumption by on-road MD and HD vehicles. Total electricity consumption increased 24% in Wkh 1vv Wk uhh TxD u Wolverine RI Frpdshuh WR Wkh previous year. Total electricity consumption increased 24% in Wkh 1vv Wk uhh TxD u Wolverine RI Frpdshuh WR Wkh previous year.

In many cases, low-CI electricity on California's LCFS was achieved through the purchase of renewable energy credits (RECs) rather than the direct consumption of renewable power.

As larger HD BEV projects are now in the development stage, fleets have increasingly been looking to leverage on-site solar power generation paired with battery storage systems to both increase the use of renewable energy as a truck fuel and address resiliency concerns. In the annual fleet survey, 38% of fleets that have operated BEVs say they have installed on-site renewable electricity.

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The MCS went through iterative testing and validation with the National Renewable Energy Laboratory in 2021. The system is being designed to support bi-directional power flow. Several HD BEV demonstrations are currently incorporating charging rates at this level. Commercial truck manufacturer Kenworth was awarded funding to demonstrate a 1 MW system on its T680 BEV on a route between Seattle and Portland. The system is being designed to be compatible with existing Combined Charging System (CCS) infrastructure, while supporting bi-directional power flow. Several HD BEV demonstrations are currently incorporating charging rates at this level. Commercial truck manufacturer Kenworth was awarded funding to demonstrate a 1 MW system on its T680 BEV on a route between Seattle and Portland. The timeline is unclear as to when an industry ready MCS standard will be commercially available.

The timeline is unclear as to when an industry-ready MCS standard will be commercially available. It is expected that the MCS standard will be approved sometime in 2022, at which point commercial hardware can begin to be developed, installed, and tested. Commercialization of the MCS will be an important industry topic to monitor in the years ahead, as it will enable longer routes and new applications to the HD BEV market.

Fleet Adoption and Insights: BEVs

While it remains an emerging or early commercial technology among fleets that took the annual survey, more than half (52%) have either piloted or purchased at least one Class 2-8 BEV in the past two years. Public sector/government fleets lead adoption with 56% of government fleets in the annual survey, having piloted or purchased a MD or HD BEV since 2020, followed by 44% of private sector fleets.

In the next 12 months, nearly all fleets (89%) that have already piloted or purchased BEVs expect to continue to invest in BEVs.

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Performance and Adoption Results by BEV Users

Equal or Better Performance

<table>
<thead>
<tr>
<th>Maintenance Cost</th>
<th>Fuel Cost</th>
<th>Torque</th>
<th>Odor</th>
<th>Noise</th>
<th>Reduced Emissions</th>
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</thead>
<tbody>
<tr>
<td>78%</td>
<td>80%</td>
<td>93%</td>
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Adoption Challenges

<table>
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<tr>
<th>Vehicle Cost</th>
<th>Range</th>
<th>Vehicle Availability</th>
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<tr>
<td>78%</td>
<td>76%</td>
<td>64%</td>
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</table>

PERFORMANCE AND ADOPTION RESULTS REPORTED BY BEV USERS

In the next 12 months, nearly all fleets (89%) that have already piloted or purchased BEVs expect to continue to invest in BEVs.

\[
\text{DG WHYWHHG} \& \text{RPPHUF}L \text{DO}L \text{J} \text{DWRQRI} \text{WKH} \text{0} \& \text{6 ZLOO}
\]

be an important industry topic to monitor in the

\[
\text{HVUV DHGDVLWZLQOHQDEOHQRQJUHURXWHV} \text{DQG QHZDSSOLFDWLRQVWRWKH} +\%\text{9PDUNHW}
\]

FIGURE 8: PERFORMANCE AND ADOPTION RESULTS REPORTED BY BEV USERS

Source: Percent of surveyed early adopter fleets that have either piloted or purchased MD or HD BEVs who cite a criteria as either equal/better or a challenge from the State of Sustainable Fleets 2022 survey.

78% 76% 64%

Comparison to diesel and gasoline.

3HUFHQWR1\%(9XVHUVVXUYH)HGZKRFLWHDFULWHULDDVHTXDOEHWWHURUDQGRS沃尔QFKDOOHQJH

\[LJXUH3HUIRUPDQFHDQGDGRS沃尔QHVRXOWVUHSRWHGE}(9XVHUVLQWKHDQXDOJHHWWUXUYH)\]
Private charging is becoming standard practice among fleets that are piloting or purchasing MD or HD BEVs, with 97% purchasing their own chargers. Many of these same fleets are pairing this with on-site energy storage (31%). Some are also integrating diesel or natural gas generators (18%) into their on-site energy generation.

In the next 12 months, many fleets in this year's survey plan to pilot or purchase MD or HD BEVs (67%), with nearly all fleets (89%) that have already piloted or purchased BEVs expecting to continue to invest in BEVs. These same fleets intend to purchase private charging (98%) in the next 12 months, and 35% of those fleets also intend to procure renewable electricity.

Nearly all fleets that have either piloted or purchased BEVs report equal or better performance on emissions (97%), noise (97%), and odor (96%) (Figure 8). Additional operational strengths include torque (93%) and driver safety (88%), which fleets viewed as equal or better than their diesel counterparts. Not surprisingly, given that well-managed BEVs are expected to offer these benefits, fleets that have piloted or purchased BEVs in the annual survey report that fuel (70%) and maintenance costs (63%) stand out as benefits when compared to gasoline or diesel vehicles. Mirroring the biggest challenges to adoption cited by last year's fleet survey, early BEV adopters again cite vehicle cost (78%), range (76%), and availability (64%) as the top challenges of BEVs in this year's survey.

Industry Perspective: Edison Electric Institute (EEI)

Fleet electrification is a growing priority for policymakers and for commercial and public fleet operators, and it represents an important step toward meeting sustainability goals. In 2021, 40% of the nation's electricity came from clean, carbon-free sources like nuclear, hydropower, wind, and solar energy. Electric power sector carbon emissions have been declining for the last decade and are now 14% below transportation sector emissions. As the nation's energy grid becomes cleaner, the carbon and emissions reductions benefits of BEVs continue to increase.

In short, electric companies are preparing for a growing wave of fleet electrification and are eager to partner with both corporate and public fleet customers to ensure a seamless transition.

On the policy front, the enactment of the IIJA in November 2021 was a watershed moment for the EV ecosystem, making more than $21 billion of federal funding available for electric transit buses, electric school buses, public EV charging infrastructure, and other areas over the next several years. In addition, new proposed standards for MD and HD vehicles from the U.S. EPA, as well as the growing number of states enacting or considering the ACT rule that requires manufacturers to sell an increasing share of zero-emission vehicle technology, will make electrification an increasingly attractive path for truck manufacturers and for fleet operators.

Electric companies are well-positioned to support corporate and public fleet customers. EEI member companies are investing more than $3.4 billion in customer programs to support charging infrastructure and other actions to accelerate electric transportation. Nearly half of this investment is available for charging needs other than passenger vehicles, including fleet applications like school buses, transit buses, and others.

These programs typically help to reduce the customer cost of installing charging infrastructure by providing rebates, providing “make-ready” infrastructure for customers, and/or providing end-to-end charging solutions. Fleet customers can find more information on these programs in EEI's EV Program Database, available at [https://www.eei.org/issues-and-policy/electric-transportation/EVPrograms](https://www.eei.org/issues-and-policy/electric-transportation/EVPrograms).

The National Electric Highway Coalition is comprised of more than 60 electric companies that are committed to supporting the deployment of EV fast charging along major travel corridors across their service territories. While initially focused on providing confidence for individual EV drivers, LD commercial fleets also stand to benefit from increased availability of public EV fast charging infrastructure. Collaborations such as the West Coast Clean Transit Corridor Initiative and private partnerships like that between DTNA and NextEra Energy Resources are laying the groundwork for dedicated MD and HD EV charging infrastructure.

In short, electric companies are preparing for a growing wave of fleet electrification and are eager to partner with both corporate and public fleet customers to ensure a seamless transition.
MARKET SNAPSHOT

After a COVID-19 Pause, Hydrogen Development Resumes

Estimated Medium- and Heavy-Duty Vehicles in Operation

THE FLEET TYPES LEADING FCEV ADOPTION

MARKET SNAPSHOT

After a COVID-19 Pause, Hydrogen Development Resumes

- While COVID-19 delays impacted hydrogen station development in 2020, this past year signaled a rebound in hydrogen infrastructure planning, although many projects are still in their early stages of development.

- Transit continues to lead FCEV adoption by vehicle count, but dozens of tractors were awarded grant-funding and are expected to be on order soon.

- California transit agencies that are required to transition to ZEVs are planning for FCEVs in higher numbers than predicted.

- No public hydrogen stations were opened outside of California in 2021, but private investments are expected to launch infrastructure along key transportation corridors.

- At least 110 stations for LD and MD vehicles and 16 stations for HD vehicles are planned to be developed in California, Ohio, New York, Rhode Island, Connecticut, and Massachusetts in the coming years.

- While no commercial FCEVs were delivered to fleet customers in 2021, vehicle orders quadrupled across the transit and HD tractor segments, and the largest demonstrations and orders for Class 8 FCEV trucks in the U.S. to date were initiated.

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- At least 110 stations for LD and MD vehicles and 16 stations for HD vehicles are planned to be developed in California, Ohio, New York, Rhode Island, Connecticut, and Massachusetts in the coming years.
A recent analysis of large transit agency rollout plans developed in compliance with the regulation indicates that 18% of the state’s large agency fleet may be powered by hydrogen, a big jump from the 1% assumed by CARB when the ICT rule was passed.

Purchases of HD FCEVs increased four-fold in 2021, to 143 transit buses, all for New Flyer’s commercial HD bus, and several tractors.

Transit Leads Adoption, Indicates FCEVs May Fit Sector Better Than BEVs
of large transit agency rollouts plans developed in compliance with the regulation indicates that 18% of the state's large agency fleet are planning to utilize hydrogen fuel cell buses for their compliance strategy, which is a significant increase from the 1% fuel cell bus adoption assumed by CARB when the ICT rule was passed.\footnote{131} This could signal both greater confidence in the anticipated performance of fuel cell electric buses, as well as concerns in battery-electric bus range, weight, fueling, and increased cost and fueling complexity.

**First Pre-Commercial Tractor Products Arriving at Fleets This Year**

The past year saw the largest Class 8 FCEV tractor deployments and purchases in the U.S. to date. At least 10 of Kenworth's proof-of-concept T680 fuel cell tractors began drayage operations between the Port of Los Angeles and the Inland Empire with fleets TTSI, UPS, and Toyota Logistics. These trucks feature fuel cell stacks from Toyota and are supported by two purpose-built hydrogen fueling stations developed by Shell in Wilmington, California. Toyota has separately developed a private fueling facility at its terminal at the Port of Long Beach to support deployment of its trucks and passenger cars.

The Class 8 tractor segment also saw 80 grant-funded purchases of FCEVs in 2021 in the U.S., 50 of which were from new market entrant Hyzon. The manufacturer, founded in 2020, reportedly delivered nearly 90 hydrogen fuel cell MD/HD vehicles to customers in Asia over the course of 2021, but delivery of Hyzon's first demonstration vehicle for Southern California-based drayage fleet TTSI was delayed until sometime in 2022.\footnote{132}

Hyundai also received funding for two pilots of its FCEV Class 8 tractor truck in the U.S. The pilot called "We have seen great stride in the advancement of hydrogen fuel cell vehicles over the past eight years, but more advancements are needed to make the vehicle at or near parity of diesel vehicles." —Tony Williamson, Director, Compliance & Sustainability, TTSI, California.
The number of FCEVs advertised as commercially available from OEMs has doubled since 2020, driven primarily by Hyzon (Figure 9). The number of MD FCEVs now available dwindled from five advertised models to one available model, signaling the MD market segment is not likely a good fit for FCEVs.

Trucks with capacity to meet 30 kg of fuel demand per day. The first two of Nikola's Tre FCEVs traveled from Arizona to California in early 2022, where they supported an Anheuser-Busch delivery to Super Bowl LVI in Los Angeles. A unit was also delivered in early 2022 to Biagi Bros., and an additional two units are planned for drayage service with TTSI alongside two of the company's BEV Tre models.

### Station Costs Dropping, Utilization Increasing with Government Support

The average retail price of hydrogen at passenger vehicle fueling stations declined approximately 3% on average between Q3 2020 and Q2 2021, remaining above $16/kg. This remains twice the state's target cost for gasoline parity of $8/kg.

### The Hydrogen Fuel Cell Electric Vehicle Market

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<tr>
<th>Body Type</th>
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<th>Number of Models</th>
<th>Vehicle Manufacturers</th>
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<td>1</td>
<td>Hyzon</td>
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<table>
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<th>Timeframe</th>
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<th>Vehicle Manufacturers</th>
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<td>Capacity, Toyota</td>
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Fueling Stations Expand with Growth Outside of California on the Horizon

While available hydrogen fueling capacity grew from 2020 and is expected to double again in 2022, nearly all public hydrogen fueling stations are still located in California. Most of the 48 stations existing prior to June 2021 were designed to serve the passenger car market, while most of the 128 new stations projected are designed to serve LD and MD vehicles, with some also serving HD vehicles.

California’s 2021 hydrogen station development did not quite meet CARB’s original goal for the year, but investments from the CEC and private parties point to continued growth through 2027. California’s hydrogen fueling station count increased to 52, with 48 new stations open throughout the state as of June 2021. This number is short of the 62 stations that CARB projected in 2020. Funding awards from the CEC announced in late December 2020 will add up to 94 new hydrogen stations and upgrade four existing stations.

Continued growth within his sector will help drive down station capital costs in the coming years. The CEC’s latest funding round fundamentally changed the outlook for hydrogen fueling network deployments in California, according to CARB. By requiring proposals to demonstrate multi-year, multi-station plans, the CEC’s intentions are clear — a robust fueling infrastructure plan to drive increased station utilization is also essential to building the market. In 2018, utilization of California’s network was approaching 40%, and although this dipped in 2020, several station operators reported in 2021 that utilization had rebounded and was even approaching 100%.

The state calculates average utilization by dividing total annual demand by the capacity of stations across the state with consideration for funded and future stations. Continued growth within his sector will help drive down station capital costs in the coming years. The CEC’s latest funding round fundamentally changed the outlook for hydrogen fueling network deployments in California, according to CARB. By requiring proposals to demonstrate multi-year, multi-station plans, the CEC’s intentions are clear — a robust fueling infrastructure plan to drive increased station utilization is also essential to building the market. In 2018, utilization of California’s network was approaching 40%, and although this dipped in 2020, several station operators reported in 2021 that utilization had rebounded and was even approaching 100%.

The average retail price of hydrogen at passenger vehicle fueling stations declined approximately 3% on average between Q3 2020 and Q2 2021, remaining above $16/kg.

“...the infrastructure of producing and, when necessary, transporting, clean hydrogen stands out.”

— Guy Welton, Director of Operations, Werner, Nebraska.
Several are being planned nationally, including in Ohio, New York, Rhode Island, Connecticut, Massachusetts, and California. California continues to lead in terms of public investment, private capital, and partnerships aimed at developing hydrogen fueling infrastructure throughout the state with an increasing level of activity happening in 2021.

While available hydrogen fueling capacity doubled from 2020 and is expected to double again in 2022, nearly all public hydrogen fueling stations are still located in California. Beyond California, new private investment commitments towards hydrogen infrastructure continued in 2021 with an MOU signed by BlackRock Renewable Power, NextEra Energy Resources, and DTNA as detailed previously. The joint funding of $650 million will build a national, high-performance charging and fueling network for both MD and HD BEVs and FCEVs in the U.S. While no other public hydrogen stations were reported opening elsewhere in the U.S. as of February 2022, an additional 57 were reported.

While available hydrogen fueling capacity doubled from 2020 and is expected to double again in 2022, nearly all public hydrogen fueling stations are still located in California.
An innovative partnership between Nikola and TravelCenters of America will install HD truck fueling stations at two Southern California locations, slated to start operating in Q1 2023.

Iwatani and Chevron agreed to co-develop and construct 30 hydrogen fueling sites in California by 2026 at Chevron-branded retail locations. While initially intended to service the LD market, station design will reportedly be flexible to eventually support HD FCEV needs.

Synergies between renewable fuel markets for LNG, RD, and hydrogen continue to solidify. RNG is now the primary feedstock for hydrogen production in California, where 98% of CNG vehicle fuel used in the state is renewable.

Growing investment in and production of RNG creates more potential feedstock for hydrogen, although hydrogen producers will have to compete with other RNG end users for this feedstock. In 2021, RD production expanded significantly, a trend which has the potential to drive demand for lower carbon, renewable hydrogen as a feedstock for RD. Decarbonized hydrogen enables RD producers to achieve a lower CI for RD, increasing their dollar per gallon in LCFS revenue in California and states with similar programs.

With several proposed large-scale fuel supply projects recently announced across the U.S., renewable hydrogen production is on a growth trajectory, supporting sectors beyond transportation. One such project is Hy Stor Energy's plan to build the country's largest renewable hydrogen hub in Mississippi, aiming to produce 110,000 metric tons annually. The facility will use underground salt caverns to store another 70,000 metric tons in its first year of operations, 2025. If approved, the project's production and storage capacity would be more than 10 times the size of the joint Intermountain Power and Advanced Clean Energy Storage projects — the previously largest planned U.S. project, which is expected to come online in 2025 to supply hydrogen for power generation in Los Angeles.

Hydrogen Production Commitments Proliferate, Renewables Dominate Early Production

Commitments to produce hydrogen fuel have proliferated in 2022, mostly for the LDV market, with renewable hydrogen leading in California to date. Overall fuel capacity projection in California by CARB for 2022 was 34,000 kg/day, more than double the prior year's forecast of 14,500 kg/day.

Two of the leading producers in that market, FirstElement and Shell, advertised that they achieved 100% zero CI hydrogen in California in 2021. According to the state's LCFS program, as much as 92% of the hydrogen dispensed from California fueling stations reporting to the program was also renewable.
Hydrogen Industry Aligning to Streamline and Stimulate Growth

A new coalition of 11 companies, including Shell, Toyota, and Cummins, formed Hydrogen Forward to promote the benefits of hydrogen.

Chevron entered separate agreements with Toyota and Cummins to advance hydrogen for the commercial transportation segment. In Wkhvuhfphqw Dqg Ewklqj, Shell, Toyota, and Cummins are actively developing standardized fueling equipment and collaborating to build the market. 7Zr Fqrovrulxvp Odxqfh Surmhfwwr Vr Ghyhorsqj and test standards for fuel cell modules and hydrogen fueling equipment. The European Fuel Cells & Hydrogen Joint Undertaking launched these relationships, the parties are integrating and aligning efforts for technology development and growth of market demand for FCEV solutions.

Also in 2021, a new coalition of 11 companies (including Shell, Toyota, Cummins, and Shell) signed agreements to promote the benefits of hydrogen. This early alignment of fuel producers and component and vehicle manufacturers is critical to ensuring integration of technology as the industry matures.

Fuel Cell Partnership working to build the foundation of the industry in the state. This early alignment of fuel producers and component and vehicle manufacturers is critical to ensuring integration of technology as the industry matures.

Testing was due to begin in late 2021. These are expected to reduce both time and cost for project deployment as a result of streamlined permitting, commissioning, and growth of market demand for FCEV solutions.

Several other fuel production projects that have been announced or in development will bring a mix of renewable and fossil-based hydrogen to manufacture. Testing was due to begin in late 2021. These are expected to reduce both time and cost for project deployment as a result of streamlined permitting, commissioning, and growth of market demand for FCEV solutions.

A new coalition of 11 companies, including Shell, Toyota, and Cummins, formed Hydrogen Forward to promote the benefits of hydrogen.
Fleet Insights: FCEVs

With the technology still in the early stages of commercialization, only 12 fleets reported using MD or HD FCEVs in the 2022 annual fleet survey. These 12 fleets unanimously report emission and noise reduction benefits, while most also report odor reduction (92%), torque improvement (83%), and driver satisfaction (83%).

Predictably, top challenges among surveyed fleets include vehicle cost (92%), as well as fuel cost and supply (75%). Among the dozen fleets that have demonstrated FCEVs, nearly all (92%) intend to continue to pilot or purchase FCEVs in the next year.

Private infrastructure is a critical aspect of early demonstrations given the minimal public hydrogen infrastructure available for MD and HD fleets. Less than half (42%) of fleets surveyed intend to pilot or purchase hydrogen fueling infrastructure. Given the very early state of the market, preferred fueling options by fleets are still to be determined. About 30% of fleets that have piloted FCEVs say they will install on-site non-renewable hydrogen production, while a quarter intend to produce hydrogen on-site from renewable sources in the next 12 months. The remaining fleets will use off-site fueling infrastructure.

While these data points provide a glimpse of end-user experiences, more fleets operating FCEVs are needed to offer greater insight into the direction of adoption by commercial MD and HD vehicle operators.
Dispensed hydrogen must reach around $5-6/kg to compete with today's diesel prices, given the efficiency of fuel cell drivetrains, even with the uptick in oil prices. These price levels can be achieved through hydrogen consumption at scale, especially with California’s LCFS program incentivizing the use of low- and negative-carbon hydrogen for transportation. New federal funding dedicates $1B for the Clean Hydrogen Electrolysis Program to reduce hydrogen production costs to $2/kg by 2026.

A fleet of 20 fuel cell tractors will consume around 1,000kg/day. Companies looking to produce hydrogen are considering capacities up to 30,000kg/day across California and around the rest of the country. While no public hydrogen stations were opened outside of California in 2021, private investments are expected to launch infrastructure along transportation corridors around the country, especially as the U.S. DOE launches the Hydrogen Hub program with $8 billion in funding, as well as $500 million for Clean Hydrogen Manufacturing and Recycling. Currently, 100 public stations are expected to be operational in California by 2023, and 200 stations between 2025 and 2026. Additional stations, primarily for LDVs, are planned for Ohio, New York, Rhode Island, Connecticut, and Massachusetts. Overall fleets can expect costs for FCEVs and hydrogen to decline in 12-24 months while station counts rise, especially as demand grows from adoption and increased production of vehicles. Combined with funding programs that support significant market development, like California’s HVIP that can provide up to $270,000 for a Class 8 drayage, hydrogen is an opportunity for fleets to meet their ZE and operational goals as early as 2023.

Industry Perspective: California Hydrogen Business Council (CHBC)

The hydrogen fuel cell transportation market is continuing to accelerate rapidly. In the last 12 months, Class 8 tractors manufactured by Toyota/Kenworth, Nikola, Hyundai, Cummins, and Hyzon were under demonstration in California and 169 fuel cell transit buses are either on order or in operation nationally, up from 87 in 2020. Overall vehicle orders quadrupled across the transit and HD tractor segments, with the largest demonstrations and orders for Class 8 fuel cell trucks in the U.S. to date underway.

70% of early adopter fleets that have either piloted or purchased MD or HD FCEVs who cite a criteria as either equal/better or a challenge from the State of Sustainable Fleets 2022 survey.

<table>
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<tr>
<th>Driver Safety</th>
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<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>92%</td>
<td>75%</td>
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Source: Percent of surveyed early adopter fleets that have either piloted or purchased MD or HD FCEVs who cite a criteria as either equal/better or a challenge from the State of Sustainable Fleets 2022 survey.
This low-carbon, drop-in fuel enables fleets to quickly achieve significant GHG emission reductions using their existing fueling and vehicle assets. Subsequently, growth in demand has been significant, and forward production, supply, and the likely use of RD is expected to see strong uptake.

While RD's growth trajectory is a positive sign and offers fleets a near-term option, criteria emissions from diesel vehicles are becoming increasingly regulated. These regulations will make the technology more expensive, more complicated to operate and maintain, and less efficient, resulting in higher GHG emissions. Coupled with very high diesel prices, the increased costs of operating diesel technology soften the incremental costs of near-zero and zero-emission vehicles, making them more attractive to end users. Furthermore, moves by California and 11 other states and the District of Columbia to adopt regulations that will force the transition to ZEVs in the next two decades will add even greater incentive for fleets to implement technologies other than diesel. Even with the immediate GHG benefits provided by RD, these regulations and aggressive commitments to science-based or net-zero targets will drive a transition away from petroleum-based technologies.

Bold commitments to environmental sustainability made by some of the world's largest businesses and governments over the last 24 months, with most of these commitments setting their targets for the 2040 to 2050 timeframe — and some moving from goal setting to the development practices that will allow them to meet their targets.

Given the scale of these commitments, and the relatively short time required to meet them, entities must focus on the largest sources of their GHG emissions. In doing so, they are confronting the reality that fleets must reduce GHG emissions by as much as 80-100% by 2050 to reach science-based or net-zero targets, reductions that cannot be achieved via incremental improvements to petroleum-based technologies. To achieve these levels of emission reductions, a combination of clean and efficient vehicles, ultra-low carbon renewable fuels, and zero-emission technologies will be required.

As the industry begins its emissions reduction journey, RD has been an incredibly important and successful tool that can be implemented. Bold commitments to environmental sustainability made by some of the world's largest businesses and governments over the last 24 months, with most of these commitments setting their targets for the 2040 to 2050 timeframe — and some moving from goal setting to the development practices that will allow them to meet their targets.

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As the industry begins its emissions reduction journey, RD has been an incredibly important and successful tool that can be implemented.
infrastructure gap, new partnerships formed in 2021 and 2022 intend to scale charging infrastructure nationally. A coalition of 51 investor-owned utilities committed to develop fast charging along major U.S. travel corridors, while an MOU by Black Rock Renewable Power, NextEra Energy Resources, and DTNA promises to commit $650 million to operate a nationwide, high-performance charging network for MD and HD BEVs.

Enthusiasm for electric vehicles by fleets remains high, though it may be the expanding regulatory landscape for ZEVs that ultimately pushes BEVs and FCEVs into wider fleet operations given the lack of clearly established TCO benefits for these technologies at this early stage. For example, orders quadrupled for HD FCEVs in 2021, totaling 143 vehicles, led by the transit sector which is regulated in California to move to zero emissions. In addition, dozens of grant-funded projects have helped to advance several projects where Class 8 fuel cell tractors will be deployed and tested in real-world operations. All public hydrogen fueling stations are now based solely in California, although among the 100 stations planned for the next few years, around a half dozen will be in other states.

With activity and investment greatly expanding, the foundation for the future sustainable fleet market is firmer than ever before. Clean fuel and commercial vehicle markets will continue to scale each year hereafter. The growth rates for each advanced technology and low-carbon fuel is to be determined by a combination of increased regulatory actions, and the ability to demonstrate sound economic and environmental sustainability benefits. Without question, it is increasingly clear that stakeholders across the commercial transportation sector will be working collectively toward achieving a common goal of steep emission reductions in the next two to three decades.

Among established clean vehicle technologies, NGVs realized modest gains in vehicle sales in 2021, and the market is poised for even more growth in the years ahead. The increasing availability of ultra-low carbon RNG in California and nationally and significant fuel savings compared to diesel, as well as a newly announced 15-liter natural gas Cummins engine that enables a wider spectrum of HD fleets to adopt, will provide a powerful driver for increased fleet adoption. Leading fleets with existing natural gas truck programs report high rates of satisfaction across critical sustainability, economic, and operational factors.

The past year realized historic investment by many of the world’s largest vehicle manufacturers and infrastructure providers to lay the foundation for future scale. Last year’s report covered announcements by Ford and GM for multi-billion-dollar commitments to bring dozens of new battery-electric models to market; since that time, both have accelerated their production timelines. Nearly every major OEM has made a commitment to commercialize BEVs, and many have stated their intention to transition away from internal combustion engines entirely. To bridge the
KEY FINDING: California is the market starter, but clean transportation funding and policy is spreading nationally.

Just a year after California's investor-owned utilities announced $750 million in funding to expand EV infrastructure in support of fleets, New York utilities nearly doubled that amount and similar utility programs are expanding nationally. The $1.2 trillion IIJA has an unprecedented clean technology emphasis, with several multi-billion-dollar...
KEY FINDING: CNG and propane no longer need funding for adoption, though both still benefit from many incentives.

CNG and propane were the original favorites of policymakers and the agencies that administer incentives. Many air districts and local governments tasked with removing 12\[\text{DQGSDUWLF} XODWHU PHDVWHUHVPLVVLQJRIURPDLQG+YHKLQHUVHDQXWVHDFWHFHKQRQRJLHV EDVHGRQFRVWIIHWLQHQHV:\LWKLWVUHODWLHYHO\] ORZHUFDLWDOFRVWVDFRPSDUHD\(WR=9\)

CNG and propane perform very well in these programs.
focus on the benefits of clean technology for children's health by policymakers and funding agencies is expected to expand scale for the school sector, with the State of New York's new rule that passed during the writing of this report as the most recent example. It requires approximately 50,000 school buses in the state to transition fully to ZEVs by 2035, starting as early as 2027.

A few hundred Class 8 BEVs were funded in 2021 and 2022 that designate major manufacturers who will eventually be under contract to fulfill the orders. In the MD sector, both Ford and GM announced accelerated production timelines with Ford expected to produce 160,000 F-150 Lightning units in 2025, not necessarily all for fleets, but both announcing thousands of orders from big customers for their electric delivery vehicles that will largely go to fleets.

Fleet demand for BEVs continues to exceed availability, largely due to significantly limited production thus far, and prices remain stubbornly high. Although 170 BEV models have been advertised by OEMs, only 70% are available for customer order at the time of publication and far fewer are available for delivery. Battery costs, a critical driver of vehicle cost, remain high despite price drops in battery packs for LD vehicles in 2021. Charging costs also show signs of a similar holding pattern.

The segments that drive propane vehicle sales – school, paratransit, delivery – have been harder hit by the pandemic, and therefore sales are down. Nonetheless, the technology is cost-effective with fuel that is sub-$2 per GGE and on-site fueling infrastructure that can be installed very quickly and at little cost. When asked about these benefits in the annual survey, 67% of fleets operating on propane report fuel cost savings as a benefit.

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**KEY FINDING:** Renewable diesel and renewable natural gas experience record growth with support from clean fuel programs.

RD maintained an approximately $1/gal incremental cost over diesel nationwide in 2021. In states with clean fuel programs, such as California, the financial offset...
Available via the LCFS allows for RD to be more competitively priced against diesel, thus driving a growth in end-user consumption. RD use in California increased approximately 50% between 2020 and 2021 to nearly 885 million gallons. The demand growth was also visible via the 84% increase in the volume of RD credits exchanged within the California LCFS program between Q1 2020 and Q4 2021.

Nationally, RNG production capacity increased by 24% from 2020 to 2021, enabling the U.S. to produce enough RNG fuel to displace nearly 574 million gallons of diesel annually. Last year, 64% of all natural gas used in on-road transportation nationally was RNG, up from 53% in 2020. In California, RNG has replaced nearly all natural gas consumption for transportation, comprising 98% of the natural gas reported in the state's LCFS program. California natural gas fuel consumption recovered in 2021 to nearly the same peak levels as in 2019. The emissions associated with RNG used by transportation in California dove further into negative territory: the energy weighted carbon intensity of all natural gas consumed in California for all of 2021 was -33.36 gCO2e/MJ, down from the -27.17 through the first three quarters of 2021. Production will continue to grow given 230 RNG projects that were projected to be in operation across the U.S. as of December 31, 2021 — 46% more than in 2020.

**KEY FINDING:** Hydrogen fuel cell vehicles edge ever closer to reality, with grant-awarded vehicles and planned stations more than doubling.

While no commercial FCEVs were delivered to fleet customers in 2021, vehicle orders quadrupled, largely driven by the transit sector. California transit agencies that are required to transition to ZEVs are planning to utilize FCEVs in higher numbers than predicted when the regulation first passed. At that time, it was assumed that only 1% of vehicles would be hydrogen, but rollout plans submitted by the largest transit agencies show a big jump to 18% of their ZEV deployments. Truck fleets also saw the first batch of grant-funded projects for dozens of fuel cell trucks that are expected to translate into orders. The Class 8 tractor segment saw 80 FCEVs that are expected be deployed near-term in the U.S. with grant-funds awarded in 2021.

No public hydrogen stations were opened outside of California in 2021, but public and private investments are expected to launch infrastructure along key transportation corridors in regions throughout the U.S. By 2026, California anticipates that 176 hydrogen stations will be operating with capacity to serve passenger as well as MD fleet customers. At least an additional 110 hydrogen stations for LD and MD vehicles and 16 stations for HD vehicles are planned to be developed in California, Ohio, New York, Rhode Island, Connecticut, and Massachusetts. Most of the 128 new hydrogen fuel stations projected are designed to serve LD and MD vehicles, with some also serving for HD vehicles. New private partnerships to develop infrastructure have announced that major highways will be a near-term focus for development.
Approach to Data

This study looked at fleets currently operating Class 2-8 vehicles in the U.S. The survey targeted public and private fleets in several sectors: school, shuttle, state/county/municipal, urban delivery, refuse, utility, transit, regional-haul, long-haul, and new in 2022, off-road yard trucks. Renewable fuels considered in this study include renewable hydrogen. Fleets were asked to compare each clean drivetrain technology they had piloted or purchased with their baseline technology of gasoline, diesel, biodiesel drop-in blends, renewable natural gas, renewable propane, renewable electricity, and fuel cell electric, technologies for more sustainable use of baseline fleet vehicle technologies.

Surveys were used to identify trends and operational performance insights from early adopters of the four clean vehicle technologies. Nearly 250 fleet responses were received in January and February 2022. Scope of Study The State of Sustainable Fleets 2022 Market Brief represents a comprehensive, technology-neutral analysis of adoption rates, fleet plans, press releases, and GNA's direct communications with fleets. GNA's vehicle availability data were generated from ongoing policy analysis through its Policy 360 program. The study's geographic scope is the U.S.

GNA's funding's data is generated regularly through its Funding 360 program using information from utilities and critical trends for advanced, clean fuels and technologies. The methodology combines primary data collected from fleets, vehicle technology manufacturers, renewable fuels and electricity for diesel, propane, natural gas, battery-electric, and fuel cell electric, hybrid technologies were not studied in this report. The study's geographic scope is the U.S.

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