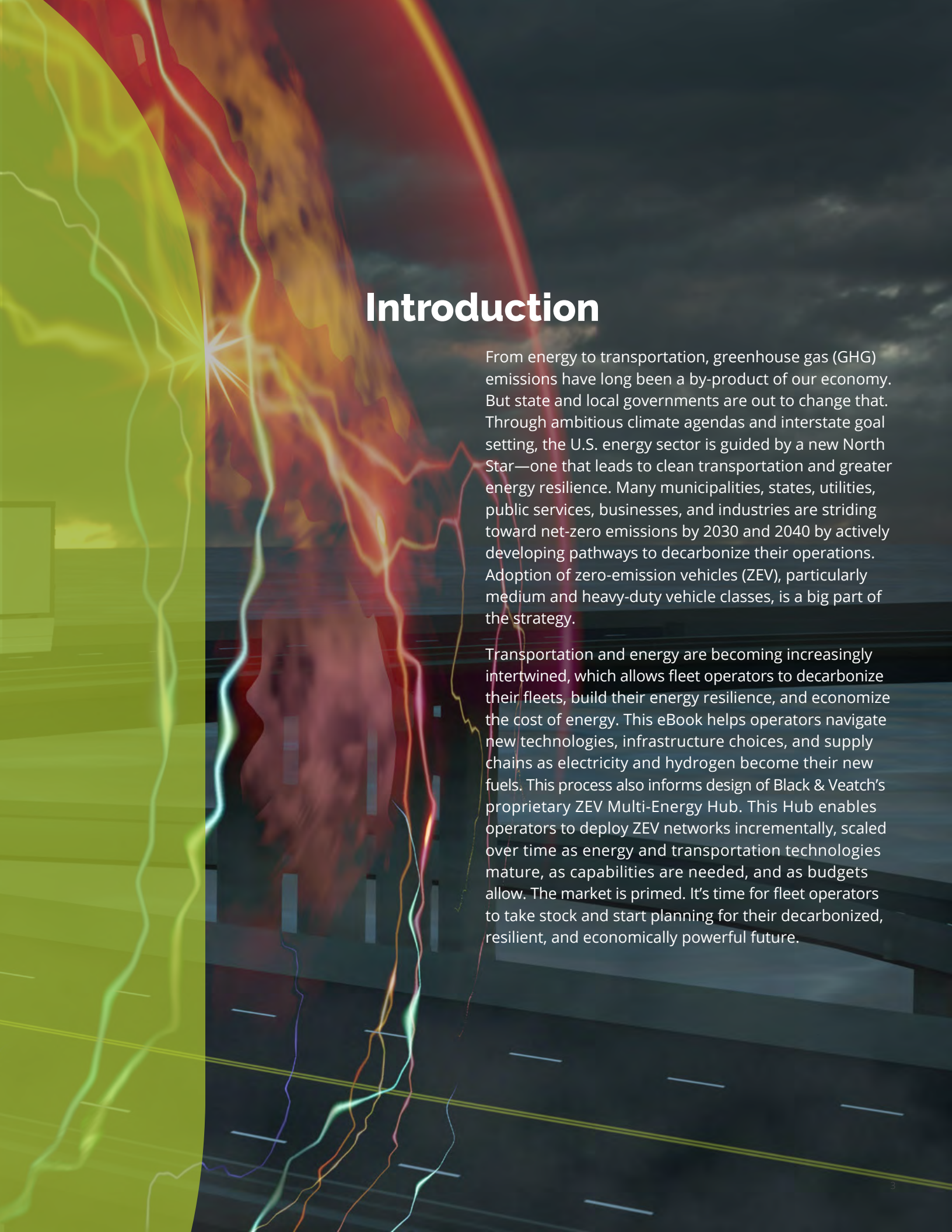
# Fleet Decarbonization

A Guide to Cost-Efficient Zero-Emission Vehicle Transition



# Introduction

From energy to transportation, greenhouse gas (GHG) emissions have long been a by-product of our economy. But state and local governments are out to change that. Through ambitious climate agendas and interstate goal setting, the U.S. energy sector is guided by a new North Star—one that leads to clean transportation and greater energy resilience. Many municipalities, states, utilities, public services, businesses, and industries are striding toward net-zero emissions by 2030 and 2040 by actively developing pathways to decarbonize their operations. Adoption of zero-emission vehicles (ZEV), particularly medium and heavy-duty vehicle classes, is a big part of the strategy.

Transportation and energy are becoming increasingly intertwined, which allows fleet operators to decarbonize their fleets, build their energy resilience, and economize the cost of energy. This eBook helps operators navigate new technologies, infrastructure choices, and supply chains as electricity and hydrogen become their new fuels. This process also informs design of Black & Veatch's proprietary ZEV Multi-Energy Hub. This Hub enables operators to deploy ZEV networks incrementally, scaled over time as energy and transportation technologies mature, as capabilities are needed, and as budgets allow. The market is primed. It's time for fleet operators to take stock and start planning for their decarbonized, resilient, and economically powerful future.

# Decarbonizing Medium and Heavy-Duty Vehicles

GHG emissions have long been a by-product of the U.S. economy. The transportation sector has been the greatest contributor to U.S. CO2 emissions since 2017.[1] Medium to heavy-duty trucks such as Class 8 trucks, transit buses, shuttles, garbage trucks, and delivery trucks, make up only 5% of vehicles on the road, but they account for about 20% of U.S. transportation emissions.[2] This group also logs vastly more miles than any other class of vehicle.[3] For these reasons—high emissions and vehicle miles traveled (VMT)—federal, state, and local governments are working to accelerate the medium and heavy-duty ZEV market through policy, investment, and incentives.

Like our counterparts in Europe and Asia, a ZEV soon may be required to deliver packages or groceries in U.S. neighborhoods, as cities, like Santa Monica, California, start to designate areas that require low or zero emissions. Decarbonization is becoming tightly tied to our economy and to customer expectations for clean transportation. As a result, transit agencies, cities, airports, school districts, delivery companies, federal fleets, and corporate giants are taking advantage of the evolving electric vehicle (EV) and fuel cell electric vehicle (FCEV) technologies and incentives. Recently, Black & Veatch and GreenBiz surveyed 420 Fortune 1000 companies. About 89% say GHG reduction is a sustainability goal, and 53% say electrifying their fleet is a primary strategy.[4]

## Clean Fleets in the U.S.

**Amazon:** Pledges to be net-zero carbon by 2040.

**Anheuser-Busch:** Long-haul fleet will transition to ZEV by 2025.

**Denver International Airport:** Has 300 alternative-fuel buses, sweepers and light-duty vehicles.

**Walmart:** Will transition 6,500 semi-trucks and 4,000 passenger vehicles to ZEV by 2040.

**City of Seattle:** Will use only fossil-fuel-free vehicles by 2030.

**FedEx:** Company-wide fleet of pickup and delivery trucks will be electric and carbon-neutral by 2040.

**U.S. Postal Service:** At least 50% of medium/heavy-duty vehicle purchases will be electric or zero-emission through 2029 and 100% zero-emission after January 2040.

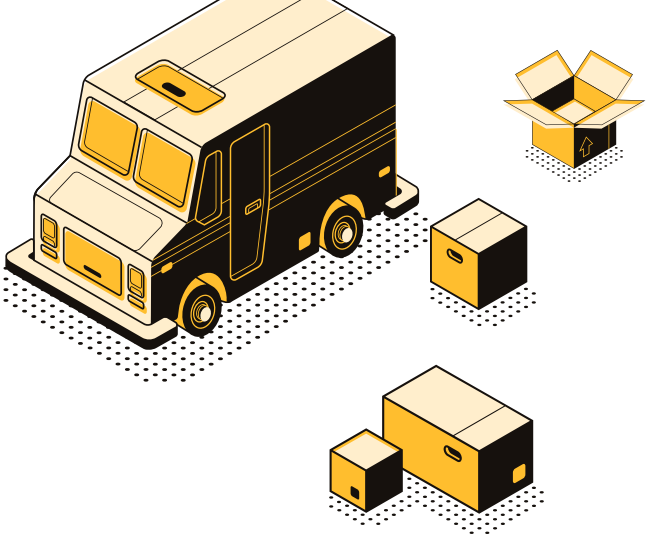
**Rochester-Genesee RTA:** Deployed 10 eBus charging stations with futureproofing up to 60 buses.

**Daimler Trucks:** Installed 4.5 MW utility capacity and charging for 9+ vehicles. Plans on-site energy storage, solar power generation, and a product and technology showcase building.

# Policy, Investment, and Incentives Ignite the ZEV Market

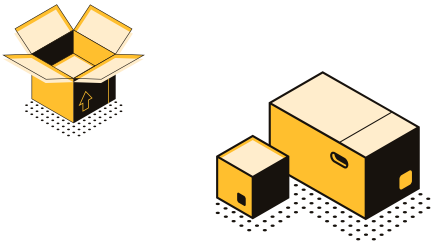
Federal, state, and local policy, rebates, programs, and incentives attract early adopters and advance first-success applications. These applications, like EV and FCEV buses and forklifts, are commercially available, encourage technological evolution, and transfer to other use cases and transportation sectors.[5] With continued evolution, components like power electronics and fuel cell stacks mature, their performance increases, vehicle quantities grow, and costs decrease; ultimately, technologies become self-sustaining and viable across sectors such as transportation and energy.

Government fiscal incentives and policies are critical to transportation's emerging markets because they help raise both supply and demand. They also create a strong policy environment that fortifies technology confidence, which is especially important post-COVID as depressed markets recover.



Federal and state programs, such as those highlighted below, demonstrate the commitment to decarbonization and ZEV adoption, which will ignite the ZEV market:

- **The Multi-State Medium and Heavy-Duty Zero Emission Vehicle agreement:** So far, CA, CT, CO, HI, ME, MD, MA, NJ, NY, NC, OR, PA, RI, VT, WA, and Washington, D.C., made this groundbreaking commitment to decarbonize their trucking industries with ZEV sales targets of 30% of new medium and heavy-duty vehicle sales by 2030, and 100% by 2050.
- **The Zero-Emission Vehicles Act:** Presented to congress in October 2020, this act would unite the U.S. by setting a federal ZEV standard that by 2025, 50% of sales for new passenger vehicles are ZEV, and ramp up 5% each year to 100% by 2035.
- **Federal Aviation Administration's Airport ZEV Program:** FAA issues Airport Improvement Program (AIP) grants to eligible, public-use airports to purchase on-road, airport-owned ZEV, like buses, and required infrastructure.



- **California Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project:** This program offers point-of-sale discounts to increase commercial technology transformation.
- **California Air Resources Board:** Adopted a first-in-the-world rule that truck manufacturers transition from diesel trucks and vans to electric zero-emission trucks beginning in 2024. By 2045, every new truck sold will be zero-emission.
- **ZEV and Infrastructure Support:** To date, 45 states and the District of Columbia incentivize deployment of ZEV and related infrastructure.[6] Examples include Michigan's Medium and Heavy-Duty Grant Program and New York's Heavy-Duty Alternative Fuel and Advanced Vehicle Purchase Vouchers.

## State Zero-Emission Vehicle Policies and Incentives in the US[8]

### Vehicle sales mandate or target

**1 state** — Internal combustion engine vehicle ban from 2035

**12 states** — Zero-emission vehicle mandate

**16 states** — Medium and heavy-duty vehicle sales target

### Infrastructure development and vehicle-to-grid integration

**14 states** — State incentives for charging equipment/ infrastructure

**25 states** — Grants and loan programs for charging equipment/ infrastructure

**38 states** — Utility vehicle-to-grid incentives/charging rate discounts

### Vehicle purchase and fleet procurement incentives

**14 states** — Tax incentives for consumers and fleet owners

**25 states** — Rebates for consumers and fleet owners

**36 states** — Grant and loan programs for fleet procurement/ conversion

# Market Trends Help ZEV Fleets Take Shape

ZEV medium and heavy-duty vehicle classes are growing as technology is transferred from first-success applications and use cases expand. In the U.S., medium and heavy-duty electric trucks are expected to soar from 2,000 on the road in 2019 to a predicted 54,000 by 2025.[9] There are 2,790 ZEV buses on order or deployed—2,703 are electric and 87 are hydrogen fuel cell.[10] By 2030, Bloomberg forecasts U.S. sales of over 1,000 FCEV buses, and over 800 medium and heavy-duty commercial FCEV,[11] which aligns with Toyota, Nikola, Hyundai, and Daimler plans to expand FCEV big-rigs in North America.[12] As an off-road first-success application, there are more than 30,000 fuel cell forklifts[13] operating in the U.S., and of the 260,180 forklift trucks sold in North America in 2018, electric products accounted for roughly 64%.[14]

Both the EV and FCEV commercial markets are off to a good start. At the same time, several ongoing trends are merging to increase market momentum. These trends will also form positive cross-sector synergies. As transportation and energy intertwine and influence each other, modernizing one sector requires innovation in the other. The combined effect of these synergies will advance commercialization of EV and FCEV medium and heavy-duty vehicles and make decarbonization more cost-effective and impactful across sectors:

- **Battery Prices:** A core technology for transportation and energy storage, battery costs have plummeted 77% in the last six years. Bloomberg predicts a lithium-ion battery pack price average of $93/kWh by 2024 and $61/kWh by 2030.[15]
- **Electrolyzer Prices:** Electrolyzers enable Green Hydrogen, which is hydrogen made from 100% renewable energy with no carbon emissions. They are used widely to meet a variety of the smaller quantity needs for hydrogen. Electrolysis technology is expected to be the fastest-growing market from 2020 to 2025, and by 2030, electrolyzer technology improvements will contribute to a 60% reduction in the cost of Green Hydrogen production.[16]
- **Green and Blue Hydrogen Pilots:** Green Hydrogen is preferred for decarbonization, but Blue Hydrogen (hydrogen made from fossil sources using emission carbon-capture) is a necessary bridge-fuel until green varieties scale. There are 320 green hydrogen production pilots globally, totaling 200 MW of electrolyzer capacity.[17] In the U.S., renewable hydrogen projects are underway in California, Utah, and Washington State,[18] including a pilot that produces blue hydrogen with 30% lower cost and carbon emissions than with traditional methods.[19]
- **Renewable Energy Growth:** Electricity supply is the largest cost factor of green hydrogen[20] and a critical resource for EV charging. To support EV and FCEV adoption, the U.S. will need 2-8 times the electricity generated today[21] and adequate distribution infrastructure to move electricity to the "right" places. Renewable power is increasingly cheaper than fossil fuels, which will help scale renewable hydrogen production, slashing production costs 30%[22]-60%[23] by 2030.
- **Record-Breaking Infrastructure Deployment:** Depot, on-route and corridor networks are expanding. Investors are backing FirstElement Fuel to quadruple their retail capacity.[24] On the charging side, regulators in 24 states approved $2.6 billion for utility investment in transportation electrification.[25]

# Fleet Operators Help Establish a Net-Zero Economy

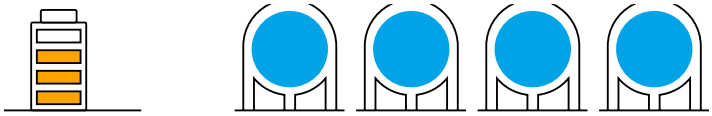
As they decarbonize their mobility, fleet operators put into motion a ripple effect that resonates across the entire ZEV market. While fleets account for only 3% of all registered vehicles,[26] their economies of scale catalyze ZEV adoption across the entire transportation sector. When President Joe Biden committed to replace the U.S. Government's fleet of 650,000 vehicles—412,000 of which are trucks—with ZEV, the renewable power and ZEV advocates roared approval of the plan and of the "immense purchasing power" that would back their nascent industries.[27] Market vigor helps establish a net-zero economy by building the foundation needed to:

- Improve ZEV supply chains, business practices, deployment models, and technologies.
- Create momentum for automakers, domestic regional supply/maintenance markets, and charging and hydrogen filling infrastructure providers.
- Generate confidence in ZEV performance and use cases, encouraging other fleets to decarbonize.
- Help decarbonize the power industry by emphasizing clean energy generation for ZEV.

# Which Zero-Emission Vehicles are Best for Fleet Decarbonization?

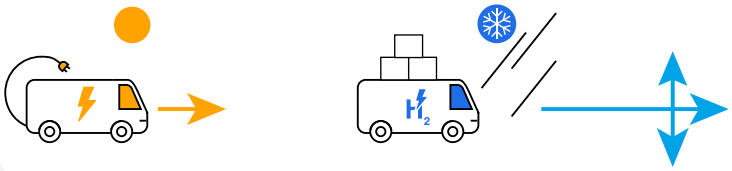
Fleet operators are making the switch from diesel to ZEV and assessing EV and FCEV as decarbonization options. Each technology is viable, so the best decarbonization plan may be the one that provides flexibility for both EV and FCEV, optimized for different duty cycles, uses, and locations. As battery technology advances, some use cases may be serviceable by both EV and FCEV.

**Range:** FCEV excel on long-distance routes or routes with frequent stops and heavy payload, which gives fleet operators greater route and payload flexibility. EV excel on shorter routes with fewer stops.



**Power:** EV need power infrastructure and utility interconnection with adequate capacity. FCEV require less power than EV, unless on-site hydrogen production is planned, which requires significant capacity akin to EV power demand.

**Terrain:** Both EV and FCEV traverse variable terrains depending on fleet profile, road conditions, and route length. FCEV climb hilly terrain and steep grades. EV perform best on flat roads.



**Predictability:** FCEV may be the best choice for variable routes, payload, and harsh weather. EV perform best with predictable duty cycles.

**Climate:** Warm to moderate temperatures are ideal for EV because batteries drain more quickly in cold climates. FCEV can handle all types of weather, hot or cold.

**Operational Efficiency:** FCEV fleets refill fast, which increases operation uptime. EV cost-efficiency increases in uses when charging times and duty cycles are repetitive and predictable.

# Flexible and Proactive Fleet Planning

Operators who plan now will be in the best position to capitalize on funding opportunities as medium and heavy-duty vehicles become readily available. They will also stay ahead of stringent emission regulations and get a jump on real estate acquisition and electric utility capacity, which is incredibly competitive in some states.

Many fleet operators question which technology to choose, but Black & Veatch sees successful investments in both the EV and FCEV spaces. In fact, the best decarbonization plan may be one that is flexible enough to include both technologies, today or in the future, optimized for different duty cycles, uses, and locations.

The same applies to business models—Black & Veatch advises fleets to stay flexible. In our experience, fleets have numerous choices to navigate across geographies and segments, so it makes sense to explore all the options. Black & Veatch most commonly sees fleet operators plan their transition under these models:

- **In-House Networks:** Fleet operators build their own networks. Ideal for fleet operators with long terms left on their lease and can develop their own charging infrastructure with their own capital.
- **Fueling Company Networks:** Operators partner with fueling companies who build the infrastructure and maintain a private fueling station for fleet use.
- **Power Utility Networks:** Operators participate in utility Make-Ready Programs and earn incentives to offset costs associated with preparing charging sites and infrastructure installation.
- **Automakers and Commercial Real Estate Networks:** Working with third-party charging companies, automakers and commercial companies deploy charging to expand networks and capitalize on the dwell time, which could be profitable at retail locations. Operators can take advantage of charging and fueling stations built by automakers and commercial real estate companies as a benefit to purchasing vehicles or leasing commercial space.
- **New Energy Provider Networks:** Power marketers control 21%[28] of the U.S. electricity market. They build charging networks and purchase renewable energy networks to sell clean electricity to businesses towards sustainability goals. Oil companies and international energy companies have entered the ZEV space, and their expertise could advance green hydrogen networks[29] and make them available for fleet use.

# 8 Landmarks on the Journey to ZEV

To decarbonize transportation, the U.S. needs more charging and hydrogen filling stations, as well as hydrogen supplies and adequate electrical power in the "right" locations. Utilities, power marketers, and fueling companies are motivated to expand networks, and 2021 could see a blitz of new programs as funding surges. Now is the ideal time for fleet operators to take stock and start planning.

If life is a highway, then ZEV planning is an exploratory road trip where fleet operators encounter new technologies, infrastructure choices, and supply chains as electricity and hydrogen become their new fuels. The transition to ZEV fleets is different for each organization. Some operators swap major portions of their fleets, while others begin with a smaller trial project to help with ZEV proof-of-concept. Regardless of the undertaking, these 8 Landmarks map the process, inform scheduling, and help operators cost-effectively plan optimal facilities.


## Electric Fleet Planning

## Hydrogen Fleet Planning

# Milepost 1:

**Define Fleet Characteristics and Use**

Define duty/drive cycles, fleet route length and conditions, lifetime cycles, payload, dwell time, and maintenance & operational considerations. This information helps determine the total cost of operation (TCO), optimize technologies, and translate route data into cost savings.

**EV:** Options include depot charging, on-route, shared, and destination/endpoint charging, either alone or in combination, to meet capacity and resilience requirements.

**Hydrogen:** Options include hydrogen filling at a hub, on-route, and/or end-destination to meet capacity, reliability, and resilience requirements.

# Milepost 2:

**Review & Select Technology Options**

Consider types of vehicles, and charging/fueling technologies, and software/networking capabilities. These selections help managers build an optimal system and integrate on-site facilities and distributed energy resources. A networked system is especially valuable as the size of fleets and capacities grow exponentially.

# Milepost 3:

**Understand Demand for On-Site Electric Power/ Hydrogen**

ZEV sites need power, which may require equipment upgrades to grid elements and building facilities to support on-site charging and hydrogen production. Building retrofits require electrical and utility interface planning, cooling design, and space for equipment.

**EV:** A fleet of 56 buses would roughly require around 11 MWh; a fleet of 542 could demand around 109 MWh.[30]

**Hydrogen:** One FCEV bus uses roughly 30-40 kg of hydrogen per day. Current electrolyzer efficiencies are between 60-80% depending on the technology. At this efficiency range, 50-58 kWh of electricity and 9-19 liters of water are needed to produce 1 kilogram of hydrogen through electrolysis.[31]

# Milepost 4:

**Site Selection and Planning**

Careful consideration of zoning, permitting, physical space, and power supply is critical. If new sites are needed, then thoughtful and informed site selection will minimize project cost and time. Sites need to support a functional facility layout that is ideally located and built with the community in mind.

**EV:** Several factors can dramatically affect schedule and cost, like distance from the site to a substation, and whether additional upgrades are needed along the distribution circuit resulting from competing site developments and charging load.

**Hydrogen:** Evaluate sites for constructability of fueling components and structures. Urban sites are sometimes too small to accommodate the filling equipment and 18-wheeler trucks. Rural sites may be located close to sensitive environments like wetlands.

# Milepost 5:

**Conduct Utility Coordination, Engineering & Design**

Start local and regional utility engagement early to develop power delivery roadmap that leverages utility programs and charging rates. Calculated savings based on future charging or production loads will be incorporated into the planning process.

To future-proof design, consider growth over 5-10 years (and longer) to anticipate power capacity for a facility. Charging, filling, and hydrogen production technology will continue to advance, but it may be most cost-effective to install existing and anticipated on-site infrastructure at the same time.[32]

# Milepost 6:

**Apply for Permits & Approvals**

Zoning, land use, permitting, and right-of-way requirements are complex with larger-scale developments, increased power levels, and hydrogen equipment deployment. This is driven by space requirements and the many real property agreements needed for the utility to cross parcels for power delivery. Required entitlements may include state environmental impact filings and interagency agreements and approvals.

**EV:** Other related paperwork that may be required includes applicable terms and conditions of equipment, vehicles and infrastructure, leaseholder or property owner agreements, and deployment services.

**Hydrogen:** Local municipal zoning and permitting processes to approve hydrogen equipment installations are lengthy and subject to more internal reviews and public opposition than EV infrastructure.

# Milepost 7:

**Grid/Electrical Services Upgrades**

New charging loads and on-site hydrogen production may require upgraded or new utility feeders, substation modernization, and even new substations. Engineering, design, and construction scopes become more substantial with increasingly complex upgrades, affecting deployment cost and schedule.

**EV:** A power delivery schedule without grid upgrades is about 8 months. A schedule with grid upgrades can run 48 months or longer depending on the upgrade's complexity.

**Hydrogen:** Without on-site generation, sites may need additional electrical services (8 months). With green hydrogen on-site generation, ≥2MW of power will be needed with utility betterment taking 12-18 months or more.

# Milepost 8:

**Obtain/integrate Equipment, Construct, & Commission**

Construction can start when the fleet operator or EPC firm obtains all permits and approvals:

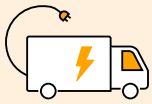
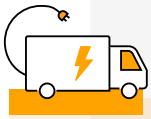
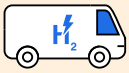
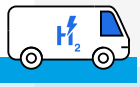
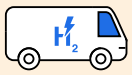
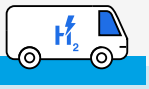
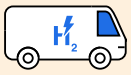
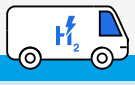
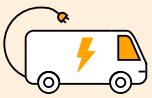
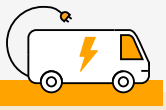
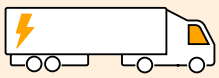
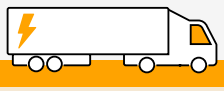
- Signed Lease (for EV)
- Signed and Sealed Drawing Set
- Utility Design Package
- Easement (if required)
- Permits
- OEM Equipment Available
- Preconstruction Meeting

Construction usually involves:

- Exterior building work (e.g., boring, trenching, paving, and landscaping)
- Internal building work (e.g., drywall, painting, and ceiling repair).
- Traffic control
- Site safety plans
- Additional commissioning and testing are typically conducted once full power has been delivered to the site.

# Grid Connection Lead Times

ZEV sites need power, which may require equipment upgrades to grid elements and building facilities. Plan ahead to account for potential grid and electrical service upgrades.

| Sample hydrogen & electric fleets | Capacity required | Grid upgrade | Example timeline required |
|---|---|---|---|
|  20 overnight charging medium-duty delivery trucks | **1MW charging site** | **Service transformer** |  **3 months** |
|  10 hydrogen buses without on-site generation | **250-500 kg/ day and 250-500 kW** | **Minor electrical service upgrade** |  **8 months** |
|  50 hydrogen buses without on-site generation | **1500-1875 kg/ day and 1.1MW** | **Electrical service upgrade** |  **12 months** |
|  30 hydrogen buses with on-site generation via electrolyzer | **900-1125 kg/ day and 2MW or more** | **Grid and electrical services upgrades** |  **18 months** |
|  200 overnight charging light-duty delivery vans | **5MW charging site** | **Feeder upgrade** |  **12 months** |
|  200 daytime fast charging heavy-duty trucks | **20MW charging site** | **Substation upgrade** |  **24 months or more** |

# ZEV Multi-Energy Hub

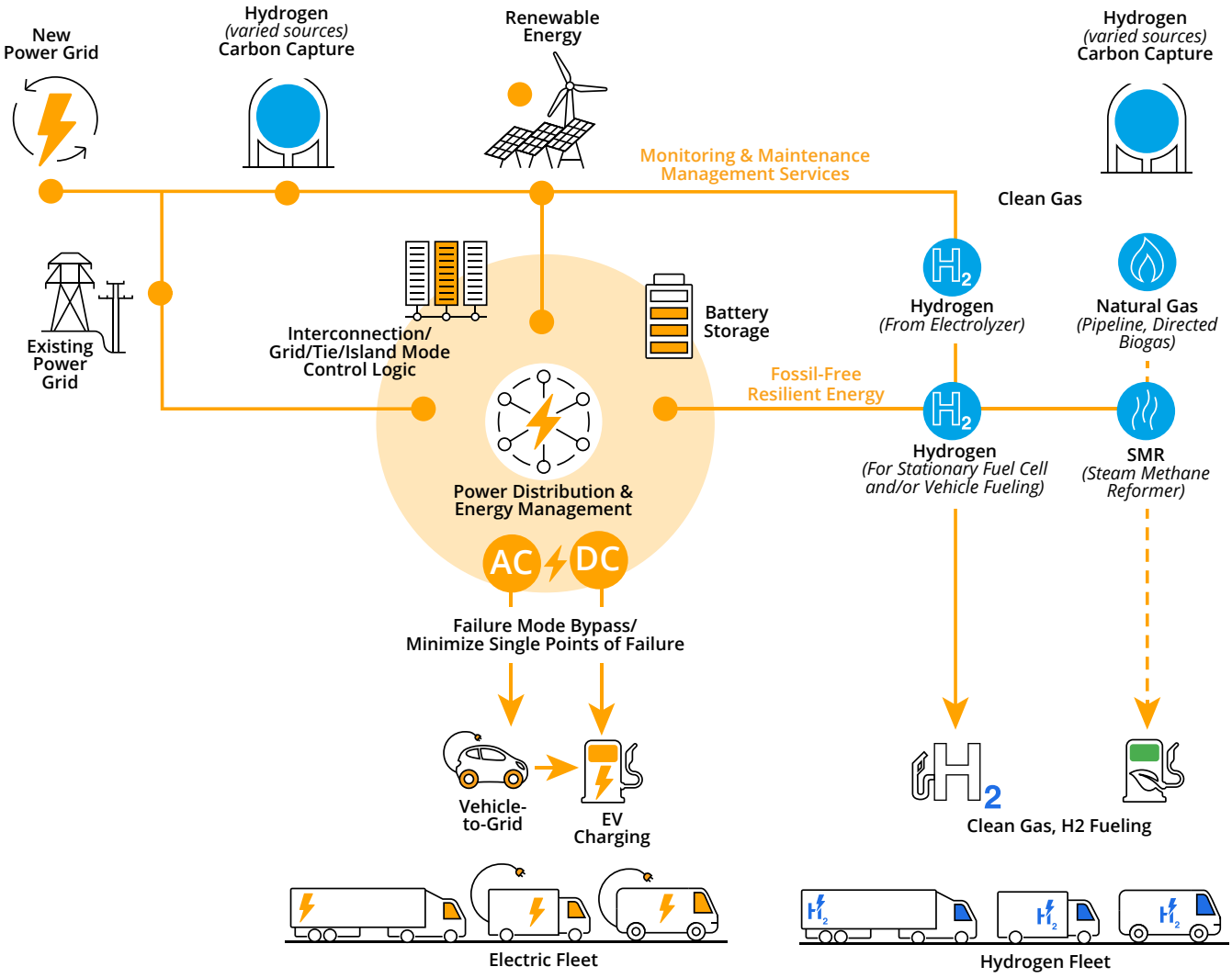
Decarbonization requires a fundamental shift in fleet operations. This shift is an opportunity to benefit from a holistic view of mobility—one that includes energy generation and sourcing. Site planning needs to embody this principle because today's ZEV design decisions impact tomorrow's longevity, scalability for future growth, and bottom-line cost-efficiency.

Transportation and energy technologies keep evolving, so site planning can occur in stages, with incremental deployment of ZEV Hub technologies as innovation and budgets align. A fleet operator may start with a feasibility study and site scouting. When reasonable, they deploy baseline charging and hydrogen filling infrastructure for a small fleet and add capabilities as demand increases and technologies mature. Though the planning horizon may extend months and even years, Black & Veatch ensures that each planning decision made supports the future state. The fleet operator will avoid repetitive and redundant investments, gain efficiencies of scale, and achieve an optimal configuration of vehicles, charging/filling infrastructure, and energy options.

Black & Veatch's proprietary ZEV Multi-Energy Hub[33] concept is the culmination of the 8 Landmarks on the Journey to ZEV—it illustrates a scaled future state, with monetized low-cost energy, balanced supply and demand, predictable performance, and built-in resilience scaled for fleet autonomy. The Hub uses existing energy pathways as part of the transition to a decarbonized, energy-efficient fleet.

# ZEV Multi-Energy Hub

## Black & Veatch proprietary concept




### The ZEV Hub Builds Energy Resilience...

- Diversifies energy sources to match route conditions, weather, or range.
- Provides battery energy storage and hydrogen storage to balance energy fluctuations, mitigate intermittency from renewables, and provide continuous energy.
- Ensures high availability for critical loads with data center power distribution design.
- Gives fleet operator more energy autonomy to respond to supply and demand and charging/filling autonomy.

### ...and the Flexible Design Evolves Over Time...

- Retrofits to support new apps and energy, charging, or hydrogen filling technologies as they mature.
- Supports foundational telecommunications now and evolves to support 5G with simple radio equipment additions.
- Scales to accommodate larger, more diverse fleets over time.

### ...to Provide a Cost-Effective Way to Decarbonize Fleets.

- Shares infrastructure across ZEV and hydrogen applications.
- Creates low-cost energy, which makes cost-predictions more transparent, speeds ROI, and reduces the TCO.
- Monetizes energy sources to control fleet expenditures.

## End Notes


1 U.S. Environmental Protection Agency. 2021. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2019. Table 3-6.

2 Center for Climate and Energy Solutions. 2021. Federal Vehicle Standards.

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# Conclusion

Massive industry investment, government incentives, and advances in EV and FCEV technologies generate market confidence and motivate fleet operators to begin their transition to ZEV. But energy and transportation resilience and autonomy starts with well-designed EV charging and hydrogen filling facilities.

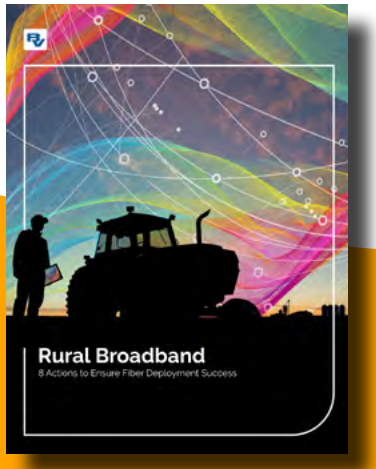
As long-term investments, charging and filling facilities are intended to be enduring energy and telecommunications networks that support unique transportation and resilience missions even as technology evolves over time. As a qualified, experienced power and telecommunication service company, Black & Veatch provides valuable strategy, analysis, and design services for data-centric, high-power charging facilities and hydrogen filling facilities. With our insight, fleet operators build facilities for today and tomorrow, with better outcomes in design, costs, and timeframes.

Black & Veatch is a clean energy planning and transportation infrastructure leader, with expertise in communication networks, charging infrastructure, hydrogen generation, grid modernization, renewable energy, and emerging technologies. We are proud to be a part of the ecosystem collaborating to accelerate clean, sustainable, and cost-efficient energy and transportation in our communities. Together, we will deliver a decarbonized future. For more information, visit bv.com/industries/transportation.

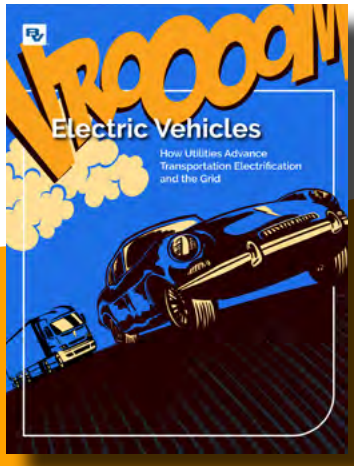
*Accelerate*

At Black & Veatch, we've made it our mission to help companies and organizations identify, evaluate, and deploy the most advanced carbon-reduction technologies available.

Digital technology deployment is accelerating. **Our eBook series fast-tracks** industry transformation.





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