State of California
AIR RESOURCES BOARD

STAFF REPORT: INITIAL STATEMENT OF REASONS

PROPOSED ALTERNATIVE CERTIFICATION REQUIREMENTS AND TEST PROCEDURES FOR HEAVY-DUTY ELECTRIC AND FUEL-CELL VEHICLES AND PROPOSED STANDARDS AND TEST PROCEDURES FOR ZERO-EMISSION POWERTRAINS
(ZERO-EMISSION POWERTRAIN CERTIFICATION REGULATION)

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List of Acronyms and Abbreviations

ACT	Advanced Clean Truck
APCF	Air Pollution Control Fund
APS	Air Pollution Specialist
AQIP	Air Quality Improvement Program
ARE	Air Resources Engineer
ART	Air Resources Technician
CAPP	Community Air Protection Program
CARB	California Air Resources Board
CEQA	California Environmental Quality Act
CVRP	Clean Vehicle Rebate Project
EO	Executive Officer
FARMER	Funding Agricultural Replacement Measures for Emission Reductions
FEL	family emission limit
GEM	GHG Emission Model
GHG	greenhouse gas
GVWR	gross vehicle weight rating
HDEV	heavy-duty electric vehicle
HDFCV	heavy-duty fuel-cell vehicle
HVIP	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project
ICT	Innovative Clean Transit
LEV	Low Emission Vehicle
MIL	Malfunction Indicator Light
MVA	Motor Vehicle Account
MY	model year
NHTSA	National Highway Traffic Safety Administration
NOx	oxide-of-nitrogen
OBD	on-board diagnostic
PM2.5	fine particulate matter
SAE	Society of Automotive Engineers
TRL	technology readiness level
U.S. EPA	United States Environmental Protection Agency
ZEPCert	Zero-Emission Powertrain Certification
ZEV	Zero-Emission Vehicle

EXECUTIVE SUMMARY

California Air Resources Board (CARB or Board) staff is proposing to amend California's Heavy-Duty Phase 2 Greenhouse Gas Regulation (Phase 2)[1] to include a new, optional certification pathway for heavy-duty electric and fuel-cell vehicles and the zero-emission powertrains they use. The proposed Zero-Emission Powertrain Certification (ZEPCert) Regulation is part of a suite of near-term strategies intended to accelerate the transition of California's heavy-duty and off-road fleets to zero-emission technology. It would establish a process that could be used to provide additional transparency, consistency, and stability in heavy-duty zero-emission market segments targeted by CARB's technology-forcing regulatory measures or incentives geared to deploying more-commercialized zero-emission vehicles. In addition, the proposed pathway could be used by manufacturers to "prove" heavy-duty electric vehicles, fuel-cell vehicles, and zero-emission powertrains as a business strategy to provide greater confidence to fleet purchasers.

The certification pathway is being proposed as optional, but it would serve as a defined process developed with public input that, once adopted, could be made mandatory by other zero-emission measures (such as, the proposed Zero-Emission Airport Shuttle Regulation). The provisions are based largely on expected best practices of market leaders. The resulting certification framework would strike a good balance between providing a process that addresses the needs of more-mature heavy-duty zero-emission applications while still promoting technology innovation by allowing more-cutting-edge applications to continue to certify through the less-stringent certification pathway that exists today.

Background

While California has made dramatic progress to improve its air quality, the State must continue its transition to significantly cleaner transportation and freight-movement technologies to achieve its long-term climate and public health goals, which include:

- Reducing greenhouse gas (GHG) emissions to 40 percent below 1990 levels by 2030, as directed in Senate Bill (SB) 32, the California Global Warming Solutions Act[2];
- Achieving carbon neutrality as soon as possible, and no later than 2045 and maintaining net negative emissions thereafter, as directed in Governor Brown's Executive Order B-55-18[3];
- Reducing GHG emissions from the transportation sector to 80 percent below 1990 levels by 2050, as directed in Governor Brown's Executive Order B-16-2012[4];

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[1] CARB, Phase 2 and Tractor-Trailer Amendments Regulation, https://www.arb.ca.gov/regact/2018/phase2/phase2.htm, accessed on September 25, 2018.
[2] Chap. 249, Stats. 2016 (Pavley) California HSC § 38566.
[3] Governor Brown's Executive Order B-55-18: https://www.gov.ca.gov/wp-content/uploads/2018/09/9.10.18-Executive-Order.pdf, September 2018.
[4] Governor Brown's Executive Order B-16-2012: http://www.gov.ca.gov/news.php?id=17472, March 2012.

- Deploying 1.5 million zero-emission vehicles by 2025, as directed in Governor Brown's Executive Order B-16-2012;
- Deploying 5 million zero-emission vehicles by 2030, as directed in Governor Brown's Executive Order B-48-18[5]; and
- Deploying 100,000 freight vehicles and equipment capable of zero-emission operation by 2030, as set forth in the California Sustainable Freight Action Plan[6].

Consistent with these goals are the priorities set forth in CARB's 2017 adoption of the *Revised Proposed 2016 State Strategy for the State Implementation Plan*[7], which calls for zero-emission technologies to help achieve necessary emission reductions. Furthermore, CARB's *2016 ZEV Action Plan*[8] sets forth as a priority, increasing consumer awareness and education about zero-emission technology, which will further support the commercial viability of heavy-duty electric and fuel-cell vehicles. In addition, CARB's *Mobile Source Strategy*[9] sets forth near-term measures that enable California to simultaneously meet air quality standards, achieve GHG emission reduction targets, decrease health risk from transportation emissions, and reduce petroleum consumption. To complement these actions, California's long-term perspective in Executive Order B-32-15[10] directs the development and implementation of the *California Sustainable Freight Action Plan*, which established clear targets to improve freight efficiency, transition to zero-emission technologies, and increase competitiveness of California's freight system.

The *Mobile Source Strategy* and *Sustainable Freight Action Plan* include several zero-emission measures that target vehicles staff believes operate in applications that are well-suited, technically and economically, for the first launch of zero-emission technologies in the heavy-duty sector. Accordingly, several near-term regulatory measures are currently being developed to drive both production and demand of heavy-duty zero-emission technology. In addition, hundreds of millions of dollars are appropriated each year for projects that fund commercial deployment of zero-emission technology in the mobile source sector.

Market challenges still exist because the heavy-duty zero-emission industry is an emerging industry that is primarily served by smaller manufacturers. While the

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[5] Governor Brown Takes Action to Increase Zero-Emission Vehicles, Fund New Climate Investments: https://www.gov.ca.gov/2018/01/26/governor-brown-takes-action-to-increase-zero-emission-vehicles-fund-new-climate-investments/, accessed on September 12, 2018.
[6] CARB et.al.; Sustainable Freight Action Plan: http://www.dot.ca.gov/casustainablefreight/documents/CSFAP_Main%20Document_FINAL_07272016.pdf, July 2016.
[7] CARB; Proposed 2016 State Strategy for the State Implementation Plan; https://www.arb.ca.gov/planning/sip/2016sip/rev2016statesip.pdf May 17, 2016.
[8] CARB; ZEV Action Plan; https://www.gov.ca.gov/wp-content/uploads/2017/09/2016_ZEV_Action_Plan.pdf, October 2016.
[9] CARB; 2016 Mobile Source Strategy, May 2016; http://www.arb.ca.gov/planning/sip/2016sip/2016mobsrc.htm.
[10] Governor Brown's Executive Order B-32-15: https://www.gov.ca.gov/2015/07/17/news19046/, accessed on December 18, 2018.

technology has been deemed ready for various applications, the market, itself, still lacks the transparency, consistency, and stability needed to ensure a smooth transition. Furthermore, some purchasers lack confidence that the manufacturers in the industry today will be able to support their vehicles long term. Therefore, staff is proposing this item to address some of these issues in order to help California achieve its heavy-duty zero-emission goals.

Regulatory Proposal

Staff is proposing an optional certification pathway that would help reduce variability in the quality and reliability of heavy-duty zero-emission technology, ensure information regarding heavy-duty electric and fuel-cell vehicles (and their powertrains) are effectively and consistently communicated to purchasers, and accelerate progress towards greater vehicle repairability. By building upon existing certification requirements set forth in California's Phase 2 regulation, the proposal would establish a more-robust, alternative certification pathway that manufacturers could use, at their own discretion, to certify their heavy-duty electric and fuel-cell vehicles. That said, if approved, the proposed alternative certification pathway could be incorporated into future technology-forcing zero-emission regulatory measures as a requirement. In that way, more-commercialized products that CARB targets through its transformational efforts could be required to certify to the ZEPCert procedures, while less-commercialized products and products from smaller manufacturers could continue to be certified using the current process.

The ZEPCert process is simple and straightforward and is based upon the expected best practices by market leaders. Specifically, for 2021 and subsequent model heavy-duty electric and fuel-cell vehicles, the proposed alternate certification pathway would require a manufacturer to:

- Use a simple, defined test procedure developed by the automotive industry to determine battery-capacity;
- Provide a modest 3-year, 50,000-mile warranty on powertrain components that covers workmanship and defects, and be subject to recall provisions;
- Make certain diagnostic information readable through a generic automotive scan tool;
- Make diagnostic and repair manuals and proprietary service tools available to third-party repair facilities at a reasonable cost; and
- Make available to the consumer specific information about its zero-emission technology so that the consumer can make an informed choice when selecting a vehicle for purchase.

Potential Policy Intersections

The proposed ZEPCert regulation would support potential future regulatory measures that target heavy-duty on-road vehicles, including the following:

- Zero-Emission Airport Shuttle Regulation;
- Advanced Clean Truck Regulation;
- Heavy-Duty Low Oxides of Nitrogen Standards;
- Zero-Emission Drayage Truck Regulation; and

- Indirect Source Rule.

In addition, the ZEPCert pathway could also serve as the starting point in the development of a similar process that supports CARB's potential future off-road measures, such as:

- Zero-Emission Airport Ground Support Equipment Regulation;
- Zero-Emission Off-Road Forklift Regulation;
- Zero-Emission Transport Refrigeration Unit Regulation; and
- Zero-Emission Cargo Handling Equipment Regulation.

The proposed ZEPCert regulation would also support CARB's various incentive strategies such as the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP), Carl Moyer Program, Zero-Emission Warehouse Program, and other incentive/funding programs.

Benefits Analysis

The potential benefits of a transition to zero-emission technology in the heavy-duty sector will be significant, especially in disadvantaged communities, where many petroleum-fueled heavy-duty vehicles operate. However, the emission benefits directly attributable to staff's proposal have not been quantified. It is more appropriate that these benefits be quantified as part of individual measures/programs (because such benefits would likely differ greatly for specific regulatory measures and programs).

Cost Analysis

Staff believes the anticipated cost savings would outweigh the projected costs of this proposal. Although not quantifiable, the proposal is expected to result in real-world cost savings due to better-informed purchase decisions, more-seamless integration of zero-emission technology into fleets, and reduced vehicle downtime due to a more-efficient repair network. Staff estimates the proposed ZEPCert regulation would add less than 1% to the cost of a heavy-duty electric or fuel-cell vehicle while the potential real-world cost savings will support market growth.

Public Process

Staff conducted four public workshops and three workgroup meetings between November 29, 2017, and July 25, 2018. Participating stakeholders included vehicle manufacturers, engine manufacturers, zero-emission technology manufacturers, industry associations, fleets, and government agencies.

Staff also participated in numerous individual meetings with many of those same stakeholders. In addition, staff also met with test laboratories, scan tool manufacturers, and environmental groups.

Staff Recommendation

Staff believes this proposal is a critical component of CARB's holistic approach towards transitioning California's heavy-duty fleet to cleaner, more-efficient vehicles. This proposal would establish the foundation upon which many future heavy-duty

zero-emission measures and programs, such as those outlined in the *Mobile Source Strategy*, will be built. Additionally, because further deployment of zero-emission technology will be a key strategy in helping California achieve necessary emission reductions, the proposed provisions are consistent with the priorities set forth in the *Revised Proposed 2016 State Strategy for the State Implementation Plan*[5]. Furthermore, CARB's *2016 ZEV Action Plan* includes increasing consumer awareness and education about zero-emission technology as a priority to help make heavy-duty electric and fuel-cell vehicles more commercially viable, which staff's proposal would help achieve. In conclusion, the proposed ZEPCert regulation would foster accelerated growth of the zero-emission market while supporting continued innovation.

I. INTRODUCTION AND BACKGROUND

California Air Resources Board (CARB or Board) staff is proposing to amend the certification requirements and test procedures for electric and fuel-cell vehicles set forth in California's Heavy-Duty Phase 2 Greenhouse Gas Regulation (Phase 2)[1] and to adopt new standards, test procedures, and certification requirements for zero-emission powertrains used in such vehicles. The proposed Zero-Emission Powertrain Certification (ZEPCert) Regulation, which is part of a suite of near-term strategies intended to accelerate the transition of California's heavy-duty and off-road fleets to zero-emission technology, would support existing and future zero-emission regulations and programs by establishing new certification provisions that provide more transparency, consistency, and stability to a dynamic and evolving zero-emission industry with the ultimate objective of helping ensure heavy-duty electric and fuel-cell vehicles (HDEV and HDFCV, respectively) operating in their intended applications are as effective and reliable as their internal combustion counterparts.

Specifically, the proposed ZEPCert regulation would establish an alternative certification pathway for HDEVs and HDFCVs that would help reduce the variability in the quality and reliability of such vehicles, ensure information regarding such vehicles and their powertrains are effectively and consistently communicated to purchasers, and accelerate progress towards greater vehicle repairability. While the proposed certification pathway would be optional to manufacturers (meaning manufacturers could still choose to certify HDEVs and HDFCVs using the existing certification pathway), this proposal would codify a more-comprehensive certification process that could be incorporated into other zero-emission measures (e.g., the proposed Zero-Emission Airport Shuttle Regulation) as a requirement.

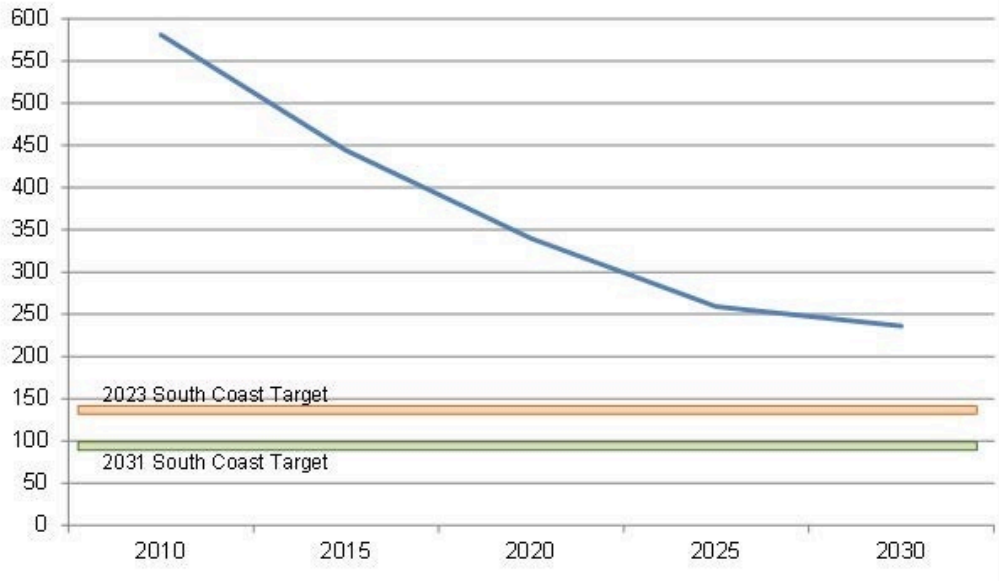
A. California's Air Quality and Climate Challenges

California has employed a number of strategies to significantly reduce mobile source emissions over the years, including: progressively lower new engine and vehicle emission standards; certification, on-board diagnostics, Smog Check and other requirements to ensure emissions remain low in-use; fleet rules and financial incentives to clean up the existing legacy fleet; zero-emission requirements for passenger vehicles; and, most recently, incentive funding to accelerate demonstration and deployment of the next generation of advanced heavy-duty vehicle and equipment technologies. However, while its air quality has greatly improved over the years, California still faces significant challenges in the years to come.

Both the South Coast Air Basin and the San Joaquin Valley, home to over half of California's residents, are classified by the United States Environmental Protection Agency (U.S. EPA) as extreme nonattainment areas for the 2008 eight-hour federal ozone standard[2]. Mobile sources – cars, trucks, and off-road equipment – and the fuels that power them are still responsible for about 80 percent of oxide of nitrogen (NOx) emissions, a major smog-forming pollutant, in California. Figure I-1, below, illustrates

the scope of NOx emission reductions still needed, beyond what is expected to be achieved by existing control strategies, to attain federal ozone standards in the South Coast Air Basin.[3]

Figure I-1: South Coast NOx Emission Trends



In addition, climate change is one of the most serious environmental threats facing the world today. Increased atmospheric GHG levels continue to cause changes to the earth's climate that are already being experienced in California and throughout the world. California is now forced to adapt to increases in the frequency and intensity of wildfires, severity of droughts, rising sea levels, and extreme weather patterns. Research also suggests that higher temperatures, longer and more frequent heat waves, a longer ozone season, and other impacts of climate change will result in more frequent, multi-day high-ozone episodes.

Therefore, there is still much more work to do, and California must continue its transition to significantly cleaner transportation and freight-movement technologies to meet its upcoming air quality and climate goals, which include:

- Reducing greenhouse gas (GHG) emissions to 40 percent below 1990 levels by 2030, as directed in Senate Bill (SB) 32, the California Global Warming Solutions Act[4];
- Achieving carbon neutrality as soon as possible, and no later than 2045 and maintaining net negative emissions thereafter, as directed in Governor Brown's Executive Order B-55-18[5];
- Reducing GHG emissions from the transportation sector to 80 percent below 1990 levels by 2050, as directed in Governor Brown's Executive Order B-16-2012[6];

- Deploying 1.5 million zero-emission vehicles (ZEV) by 2025, as directed in Governor Brown's Executive Order B-16-2012;
- Deploying 5 million ZEVs by 2030, as directed in Governor Brown's Executive Order B-48-18[7];
- Deploying 100,000 freight vehicles and equipment capable of zero-emission operation by 2030, as set forth in the California Sustainable Freight Action Plan[8] (developed as directed by Governor Brown's Executive Order B-32-15[9]); and
- Meeting federal health-based eight-hour ozone standards as required by 2023 and 2031 in the South Coast Air Basin, which will require a NOx reduction of approximately 70 percent by 2023 and 80 percent by 2031 from today's levels.[2]

B. Pathway to Zero-Emission

CARB's 2016 ZEV Action Plan[10], a roadmap toward 1.5 million ZEVs on California roadways by 2025, directs staff to consider incentive and regulatory strategies that will increase the number of heavy-duty ZEVs on the road. How each strategy will be applied will depend upon where technologies reside on the commercialization arc, indicated by their technology readiness level* (TRL). In general, incentive strategies target pre-commercial and early-commercial technologies and are designed to help accelerate technology advancement and encourage early adoption (TRLs 1-9). Regulatory strategies drive broad market deployment of technologies once they have demonstrated their commercial viability (TRL 9).

Figure I-2 below shows the evolution of technology along the commercialization arc.

Figure I-2: Commercialization Arc of New Technology

CARB's zero-emission strategy for the heavy-duty sector (and the off-road sector) will build upon zero-emission efforts in the light-duty sector by taking advantage of the knowledge and technological innovation, economies of scale, and efficiency improvements gained by producing generations of lighter application technologies. As zero-emission technologies achieve progressively greater penetration in the heavy-duty and off-road sectors, further technology advancement and the concomitant decrease in costs will likely enable even broader deployment of zero-emission technology into heavier on- and off-road applications.

* Scale developed by the National Aeronautics and Space Administration used to estimate technology maturity: https://www.nasa.gov/topics/aeronautics/features/trl_demystified.html

1. Role of Incentives

California invests public funds across the entire evolution of technology along its commercialization arc. This approach is critical because it provides the opportunity to invest not only in the commercial technologies that help meet important near-term goals, but also ensures continual development, demonstration, and deployment of technologies that are necessary to meet the State's long-term goals. It also signals the importance California places on the development and deployment of advanced technologies, attracting innovators and green businesses to the state.

Investments in GHG emission reductions and zero-emission technology, in particular, have grown significantly over the past decade. For example, over the last 5 budget cycles, the Legislature has appropriated nearly $1.2 billion to CARB for Low Carbon Transportation investments to reduce GHG emissions. These investments are being used to provide consumer rebates for zero-emission and plug-in hybrid passenger vehicles through the Clean Vehicle Rebate Project (CVRP) and vouchers for fleets to purchase clean trucks and buses through the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP). Investments also include zero-emission truck and bus pilot deployment projects and advanced technology demonstration projects for the freight sector, among others.

Other CARB incentive programs include the:

- Air Quality Improvement Program (AQIP)[11];
- Carl Moyer Program[12];
- Proposition 1B Goods Movement Emission Reduction Program[13];
- Zero-Emission Warehouse Program[14];
- School Bus Retrofit Program[15];
- Volkswagen Zero-Emission Vehicle Investment Commitment[16];
- Volkswagen Mitigation Trust[17];
- Funding Agricultural Replacement Measures for Emission Reductions (FARMER) Program[18]; and
- Community Air Protection Program (CAPP)[19].

With respect to the CARB incentive programs that fund zero-emission technology in the heavy-duty and off-road sectors, staff envisions that the proposed ZEPCert regulation, if approved, would be integrated into such programs.

2. Regulatory Strategies

CARB's 2016 Mobile Source Strategy sets forth near-term measures that enable California to simultaneously meet air quality standards, achieve greenhouse gas emission reduction targets, decrease health risk from transportation emissions, and reduce petroleum consumption. Several key heavy-duty and off-road zero-emission measures included in the Mobile Source Strategy, as well as a number of new policy priorities that have emerged since the development of the Mobile Source Strategy, are described herein.

In September 2018, the Board approved for adoption the California Heavy-Duty Phase 2 Greenhouse Gas Standards. CARB staff worked jointly with U.S. EPA and the National Highway Traffic Safety Administration (NHTSA) on this new phase of GHG emission standards for heavy-duty vehicles. These Phase 2 standards were built on the improvements in engine and vehicle efficiency required by the Heavy-Duty Phase 1 GHG emission standards, adopted in 2014, and represent a significant opportunity to achieve further GHG reductions for 2018 and later model year heavy-duty vehicles. Both the Phase 1 and Phase 2 programs provide aggressive credit multipliers for electric and fuel-cell vehicles up until the 2027 model year (MY).

In Febuary 2019, the Board will consider the adoption of the Innovative Clean Transit (ICT) regulation, which focuses on the long-term goal of transforming the public transit sector to zero-emission. Historically, transit agencies have played an important leadership role in deploying cleaner, more-efficient technologies in the heavy-duty vehicle sector (e.g., deploying low-NOx compressed natural gas engines, and particulate filter-equipped diesel engines). Looking forward, it is envisioned that they will also play a leadership role in transforming the heavy-duty sector to zero-emission technologies. The ICT regulation would require that 100 percent of new buses purchased starting January 1, 2029, be zero-emission.

Beyond transit buses, airport shuttles have also been identified as another heavy-duty application well-suited for commercially available zero-emission technologies, as airport shuttles using zero-emission technology currently exist. Therefore, staff is currently developing a proposal for the Zero-Emission Airport Shuttle Regulation, which is scheduled for Board consideration in Febuary 2019. The Zero-Emission Airport Shuttle regulation aims to turn over California's airport shuttle fleet to zero-emission by 2035, and is expected to displace approximately 1,400 petroleum-fueled vehicles, ranging from Class 2b vehicles (8,501-10,000 pounds gross vehicle weight rating) to full-size transit buses. The Zero-Emission Airport Shuttle regulatory proposal is expected to be the first to include the proposed ZEPCert process as a requirement.

Another potential heavy-duty zero-emission measure identified in the Mobile Source Strategy is the Advanced Clean Truck (ACT) Regulation, formerly known as Last Mile Delivery. The proposal for this measure, which is tentatively scheduled for Board consideration in 2019, is currently being developed and could ultimately include both manufacturer requirements to develop and sell electric and fuel-cell vehicles (i.e., similar to the light-duty ZEV mandate) as well as fleet requirements to purchase such vehicles. The ACT regulatory proposal is expected to include the incorporation of the proposed ZEPCert pathway as a requirement.

The Mobile Source Strategy also includes measures that advance clean combustion technologies. One key measure would establish heavy-duty low-NOx engine emission standards and accompanying real world in-use measures resulting in a 90-percent reduction in NOx emissions compared to the emissions of today's diesel engines. This measure will be critical for attaining federal health-based air quality standards for ozone in 2023 and 2031 in the South Coast and San Joaquin Valley air basins, and fine

particulate matter (PM2.5) in the next decade. Under the current concept for the low-NOx measure, staff is considering offering NOx compliance credit for zero-emission powertrains certified via the proposed ZEPCert process.

There are also a number of zero-emission measures for the off-road equipment sector identified in the Mobile Source Strategy, including the potential Zero-Emission Off-Road Forklift Regulation, the potential Zero-Emission Airport Ground Support Regulation, and the potential Zero-Emission Transport Refrigeration Unit Regulation. Because the development efforts for these measures either have yet to begin or are in their early stages, details (such as regulatory scope) of the proposals are not yet available. That said, while the current ZEPCert regulatory proposal would only be applicable to on-road vehicles, staff would likely consider potential future changes to the proposed ZEPCert regulation that would incorporate off-road powertrains and equipment.

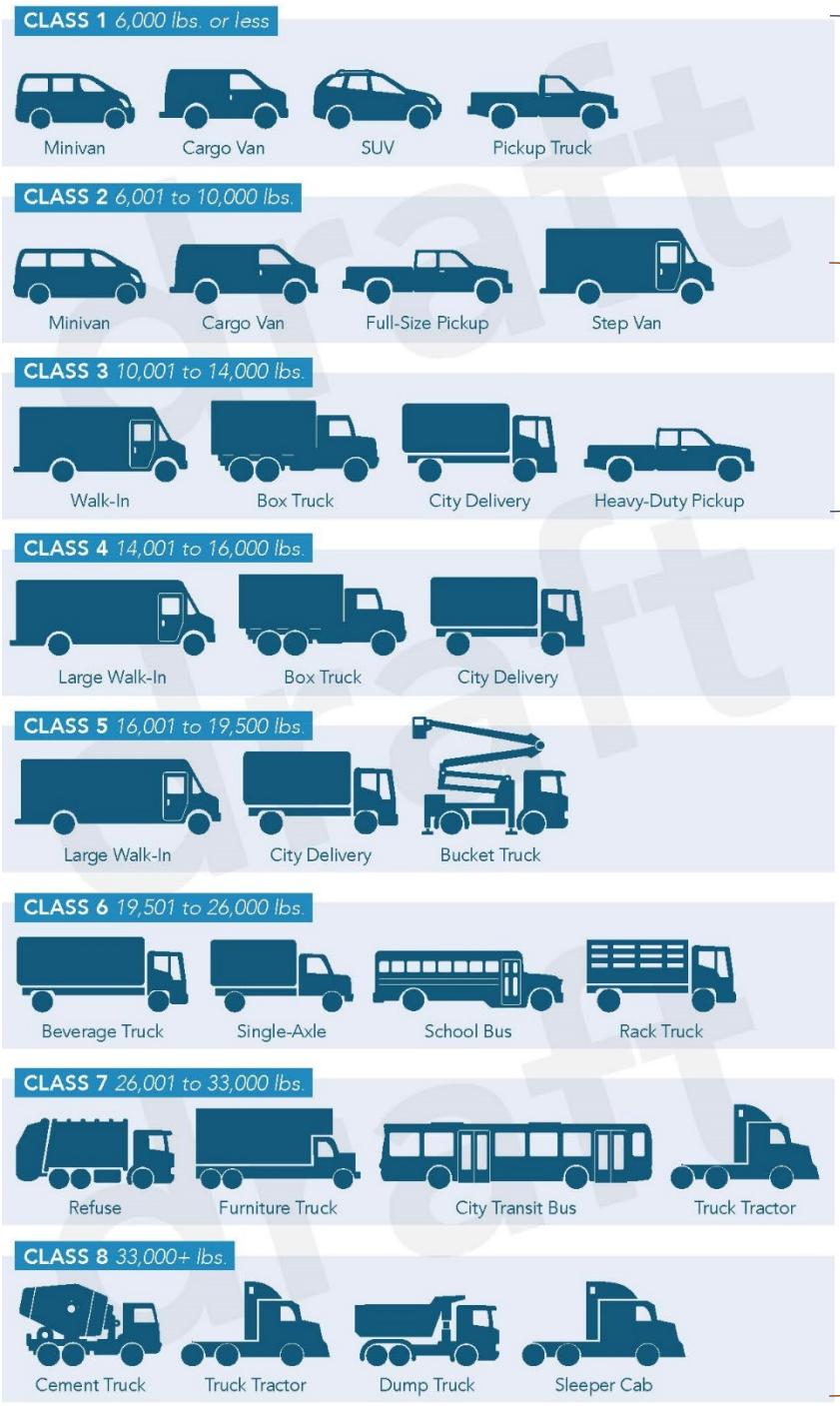
Furthermore, development continues on a potential Indirect Source Rule that would target vehicles, equipment, and the facilities in which they operate. New zero-emission concepts for cargo handling equipment and drayage trucks are also being considered by staff. The proposed ZEPCert regulation could be considered for those measures as well.

C. Existing New Vehicle and Engine Certification Requirements

California law requires new motor vehicles and engines to be certified by CARB for compliance with emission standards before they are legal for sale, use, or registration in California.[20] Whereas new light- and medium-duty vehicles are typically certified compliant with criteria pollutant and GHG emission standards as complete vehicles on a chassis dynamometer, heavy-duty vehicles are typically certified by way of a two-step process—first, the engine is certified to criteria pollutant and GHG emission standards on an engine dynamometer, then the completed vehicle is subsequently certified compliant to GHG emission standards using a simulation model, known as the GHG Emission Model (GEM). This two-step process ensures vehicle emissions are adequately controlled while also accounting for the multi-stage manufacturing process of the heavy-duty vehicle industry.

A heavy-duty vehicle is defined as one with a gross vehicle weight rating (GVWR) over 8,500 pounds. Vehicles over 14,000 pounds and their engines certify to California's heavy-duty vehicle and engine emission standards, such as Phase 2. However, vehicles from 8,501 to 14,000 pounds GVWR are required to be certified under California's Low Emission Vehicle Program (or LEV program)[21], except for "incomplete vehicles," which can be certified to either LEV program standards or heavy-duty engine and vehicle standards. Incomplete vehicles do not have the primary load carrying device or container installed on the vehicle . Figure I-3 provides examples of vehicles in each class and their respective typical emissions certification pathway.

Figure I-3: Vehicle Classes and Typical Criteria Pollutant Certification Approach



Light- and Medium-Duty Vehicles (≤14,000 pounds) Passenger cars, pickup trucks, vans and other light- and medium-duty vehicles are typically chassis certified to meet emission standards, meaning the complete vehicle must demonstrate emission compliance on a chassis dynamometer.

Heavy-Duty Engines and Vehicles (>8,500 pounds) Engines typically demonstrate compliance with emission standards on an engine dynamometer, meaning only the engine is emission tested. Vehicle then demonstrates compliance with GHG emission standards using engine test data, vehicle test data, and simulation modeling.

Certification requirements for a new vehicle family and an engine family include, but are not limited to, the following:

- Demonstration that the new vehicle/engine family complies with applicable emission standards, both when new and over its useful life, when tested in conformity with specified test procedures;

- Demonstration of durability for the useful life of the vehicle or engine family;
- Meeting applicable labeling requirements;
- Providing emissions warranty to the engine or vehicle purchaser; and
- Demonstrating compliance with on-board diagnostic (OBD) requirements.

1. Heavy-Duty Engine Certification

Similar heavy-duty engines are certified as part of an "engine family." Engines within an engine family share common characteristics, such as manufacturer, engine MY, fuel type, and emission control strategy. CARB certification requirements mandate that for each MY, a heavy-duty engine manufacturer must demonstrate its engine families will comply with the applicable emission standards over its full useful life. Heavy-duty engines are currently subject to both criteria pollutant and Phase 2 GHG emission standards.

There are currently no standards or a certification process for heavy-duty zero-emission "engines" (i.e., powertrains). All requirements for zero-emission technology in the heavy-duty sector are applied directly to the vehicle. These vehicle requirements are described below.

2. Heavy-Duty Vehicle Certification

Heavy-duty vehicles are certified to heavy-duty Phase 2 GHG emission standards, as part of a vehicle family, which is based on vehicle weight, vocation, and features that impact GHG emissions. In order to determine GHG emissions from a vehicle, the process takes into account engine test data, vehicle test data, and vehicle specifications, which are run through the GEM simulation model.

GEM was developed by U.S. EPA for the heavy-duty Phase 1 GHG Program[22] and is now used to certify to both California's and federal heavy-duty Phase 2 GHG emission standards. While most of the simulation parameters in Phase 2 GEM are predefined, manufacturers are required to input certain parameters, such as coefficient of aerodynamic drag, tire rolling resistance (steer/drive), and engine data, as well as to identify the presence of technologies that limit vehicle speed, reduce vehicle weight reduction, or reduce extended idling.

Under Phase 2, HDEVs and HDFCVs may generate GHG credits and through the 2027 MY, credits derived for such vehicles are multiplied by 4.5 and 5.5, respectively, when determining GHG fleet averages. HDEVs are considered to have no tailpipe emissions, and are to use 0 grams/ton-mile as its family emission limit (FEL). While the Phase 2 regulatory language does not explicitly set forth the procedure for determining the FEL for a hydrogen-fueled HDFCV, staff proposes (to be consistent with U.S. EPA practice) that hydrogen-fueled HDFCVs would also be assigned an FEL of 0 grams/ton-mile.

Unless certified through the LEV Program, no exhaust emission standards for *criteria* pollutants currently apply to heavy-duty vehicles.

3. On-Board Diagnostics

Internal combustion engines and vehicles so equipped must also certify to OBD requirements. The OBD program is an important emission control program that is critical to California's achievement of its air quality goals. Currently, OBD requirements only exist for criteria pollutants. OBD consists mostly of added software in the relevant powertrain control modules that monitor virtually every component that can cause an emission increase, including, but not limited to, all emission controls and all electronic components (such as sensors and actuators) that can potentially affect emissions or are used to monitor other emission controls. A robust OBD system is critical for identifying and addressing engine and aftertreatment system malfunctions that can lead to excess in-use emissions. OBD monitors an engine and vehicle's emission related components, identifies emission threshold exceedances, and provides owners with an early warning of malfunctions by way of a dashboard "Check Engine" light (also known as a Malfunction Indicator Light, or MIL). By providing this early warning, OBD not only ensures reductions of emissions through improvements of emission control system durability and performance, but also protects consumers by helping them identify minor problems before they require major repairs.

OBD does not currently apply to electric and fuel-cell (without an on-board reformer) vehicles.

D. Disadvantaged Communities

Disadvantaged communities are expected to benefit from the transition of the heavy-duty and off-road sectors to zero-emission technologies. Most, if not all, of CARB's planned heavy-duty and off-road zero-emission measures are expected to have the greatest emission impact in disadvantaged communities because these communities are disproportionately impacted by heavy-duty truck traffic and off-road equipment usage. While emission reductions would not be directly quantifiable, staff's proposal would help reduce variability in the quality and reliability of HDEVs and HDFCVs, ensure information regarding HDEVs and HDFCVs and their powertrains are effectively and consistently communicated to purchasers, and accelerate progress towards greater vehicle repairability. By accomplishing these goals, ZEPCert is expected to benefit disadvantaged communities in that it would help ensure the success of CARB's other zero-emission efforts.

II. PROBLEM THAT THE PROPOSAL IS INTENDED TO ADDRESS

CARB staff is developing a suite of near-term strategies intended to accelerate the transition of California's heavy-duty fleets to zero-emission technology. The potential benefits of this transition will be significant, especially in disadvantaged communities, where many petroleum-fueled heavy-duty vehicles operate. While there are several heavy-duty vehicle applications that are already well-suited for broad deployment of zero-emission technology, staff believes CARB's strategies intended to drive greater deployment in those applications will need the support of more-robust certification requirements, which the proposed ZEPCert regulation would establish.

The heavy-duty zero-emission market is predominantly occupied by relatively small manufacturers, who started off in the industry as innovators, not vehicle manufacturers. In addition, while the industry has experienced significant progress, consumers are still relatively unfamiliar with zero-emission technology, the vehicles that use it, and their operational impacts. While some manufacturers may have already positioned themselves well to be able to produce and support commercial volumes of HDEVs or HDFCVs, the industry is still relatively new, especially in the context of heavy-duty vehicle manufacturing. Therefore, staff's proposal is intended to bring about greater transparency, consistency, and stability to the market by addressing some of the key concerns associated with the dynamic and evolving nature of the heavy-duty zero-emission industry. Specifically, staff's proposal would help reduce variability in the quality and reliability of HDEVs and HDFCVs, ensure information regarding HDEVs and HDFCVs and their powertrains are effectively and consistently communicated to purchasers, and accelerate progress towards greater vehicle repairability. Adding market transparency, consistency, and stability will be a critical step towards broad market adoption of zero-emission technology in the heavy-duty sector.

Given time, staff expects that the market forces would eventually lead to a ZEV industry that is self-sustaining. However, considering California's aggressive zero-emission goals, staff believes the market will need additional policy support to accelerate this process.

BARRIERS TO ZERO-EMISSION DEPLOYMENT

The emission benefits associated with zero-emission technology are dependent upon the successful deployment of vehicles equipped with such technology in applications traditionally served by internal combustion technology. California's current certification paradigm for internal combustion engines and vehicles is not well-suited for the certification of HDEVs and HDFCVs. Consequently, to better account for this relatively new industry, staff is proposing to take a different approach.

Staff's proposal includes requirements that would help reduce some of the key barriers staff believes are hindering the growth of the zero-emission industry today. These requirements are summarized below.

III. STAFF'S PROPOSAL

Staff's proposal would amend Phase 2 to establish an alternative certification pathway for HDEVs and HDFCVs, and as previously stated, certification using this proposed pathway would be optional. However, in order to certify an HDEV or HDFCV using the proposed ZEPCert pathway, a certified zero-emission powertrain would also be required. While one does not exist today, staff's proposal would also establish a new certification process applicable to zero-emission powertrains that would be installed in HDEVs and HDFCVs certified to the proposed ZEPCert vehicle requirements. Use of uncertified zero-emission powertrains would still be allowed in HDEVs and HDFCVs for which the manufacturer has elected to certify in accordance with existing Phase 2 requirements. The proposed ZEPCert requirements for HDEVs, HDFCVS, and zero-emission powertrains are further described in this section.

VEHICLE CERTIFICATION PROCEDURES

Applicability

The proposed ZEPCert regulation would apply to model year 2021 and later HDEVs and HDFCVs greater than 14,000 pounds GVWR and medium-duty vehicles (from 8,501 through 14,000 pounds GVWR) that certify as incomplete vehicles. For the purpose of this proposal, "HDEVs" and "HDFCVs" shall be interpreted to also include incomplete medium-duty electric vehicles and incomplete medium-duty fuel-cell vehicles, respectively, that would be certified in accordance with the proposed alternative certification procedures.

Alternative Pathway

Staff's proposal would establish an optional alternative certification pathway for HDEVs and HDFCVs that builds upon existing heavy-duty Phase 2 requirements. While the pathway would include more-robust certification requirements, staff's proposal would not dictate which certification pathway a manufacturer would be required to use. That is, absent other policy/regulatory drivers, a manufacturer, at its own discretion, could certify an HDEV or HDFCV to either the existing Phase 2 requirements or the proposed alternative pathway requirements.

The intent of the proposed ZEPCert regulation is not to establish a mandatory certification process, but to create a framework that would support both new, "cutting-edge" technologies (i.e., technologies earlier along the commercialization arc) as well as technologies that have demonstrated commercial viability. If warranted, future zero-emission measures could incorporate the alternative certification pathway as required, especially for technologies with greater TRLs. Furthermore, some manufacturers may choose to certify to the alternative pathway requirements in order to gain a market advantage.

Required Use of a Certified Zero-Emission Powertrain

In order to certify a vehicle family to the proposed alternative pathway requirements, the vehicles of said family would be required to use a zero-emission powertrain that is certified in accordance with the proposed ZEPCert powertrain requirements, which are further described below. While existing heavy-duty Phase 2 requirements do not include a mechanism to certify a zero-emission powertrain, staff is proposing a separate zero-emission powertrain standard and certification process as part of the proposed ZEPCert regulation to better accommodate the multi-stage manufacturing process of heavy-duty vehicles today. This approach is consistent with the engine-vehicle certification paradigm currently in place for internal combustion technology.

Zero-Emission Powertrain Integration

As part of the certification application, manufacturers would be required to attest that the the vehicle integration components are designed and developed to accommodate the expected output of the zero-emission powertrain to be used. Today, battery-electric are fuel-cell vehicles are often built through a “conversion” process. That is, such vehicles are built by integrating an electrified powertrain into an existing vehicle driveline. These modifications may lead to issues, such as a zero-emission powertrain delivering more power than existing driveline components are designed for. This provision would help ensure that manufacturers design a reliable product and prevent potential “poisoning” of the market.

Labeling

The proposed ZEPCert provisions would require vehicle manufacturers to include a compliance statement on their Phase 2 vehicle labels indicating if the proposed certification pathway was used.

The proposed labeling requirements would allow consumers to identify vehicles certified to the proposed alternative pathway requirements. In addition, the proposed labeling requirements would also enable these vehicles to be identified in the field, either for compliance or research purposes.

Purchase Guidance Statement

Manufacturers would be required to provide purchasers with a prescribed guidance statement identifying considerations that should be made when choosing a HDEV and HDFCV. The list of considerations would include range, top speed, maximum grade, and impacts of vehicle load and battery degradation on performance.

The manufacturer would also be required to provide a detailed description to the purchaser of its diagnosis and repair process, and the implications of said process on repair timeframes and vehicle transportation costs.

While providing a battery-capacity warranty would not be required, manufacturers would be required to ensure that whatever coverage is provided, even if no coverage, it is explicitly disclosed to the purchaser at the time of sale.

Given that zero-emission technologies are still unfamiliar to many of the fleets who will be considering such technologies in the near-term, these proposed provisions would help ensure consumers consider the appropriate parameters when selecting a particular HDEV or HDFCV model. The intent of these provisions is to increase the likelihood that an HDEV or HDFCV is effective once deployed in its intended application and is capable of fulfilling the expectations of the purchaser, thereby increasing consumer confidence in zero-emission technology.

Repairability Provisions

Vehicle manufacturers would be required to make available its diagnostic and repair manual as well as any service tools necessary to perform repairs to third-party repair facilities at reasonable cost.

On-Board Vehicle Information

Staff's proposal would require that certain vehicle information be accessible on-board to the fleet owner, such as *kilowatts used per trip* and *remaining usable battery-capacity*. These parameters would help fleet owners determine the efficiency of a particular vehicle or driver as well as provide the ability to assess the condition of a powertrain, which would be useful during a resale transaction, for example.

Fuel-Fired Heaters

Specific emission and operational requirements would be established for fuel-fired heaters used on HDEVs and HDFCVs. Specifically, fuel-fired heaters would be required to meet LEV II Ultra Low Emission Vehicle standards[23] and demonstrate zero-evaporative emissions under any and all possible operational modes and conditions. The proposal would align fuel-fired heater requirements with those set forth in the LEV II program and add clarity to the existing Phase 2 certification procedures.

POWERTRAIN CERTIFICATION STANDARDS AND REQUIREMENTS

Applicability

Staff's proposal would establish new emission standards and certification requirements for 2021 MY and later zero-emission powertrains installed in electric and fuel-cell vehicles certified in accordance with the proposed alternative certification pathway. These zero-emission powertrain standards and requirements would be voluntary for zero-emission powertrains installed in vehicles not certified in accordance with the proposed certification pathway.

The “powertrain” in the context of this regulation refers to the components, such as the energy storage system, the electric motor, and on-board charger, which are responsible for storage, delivery, and conversion of energy within the vehicle to mechanical power.

Zero-Emission Standards

The proposal would establish zero-emission powertrain standards for all criteria pollutants and greenhouse gases.

Standardized Battery Test for Battery-Based Powertrains

Currently, there is no one procedure all manufacturers use to determine the usable capacity of their batteries. Therefore, while battery-capacity information is widely cited (e.g., in vehicle marketing materials), the information cannot be reliably used to compare product offerings.

Staff is proposing to establish a standardized battery-capacity test for certification under the alternative certification pathway. Specifically, the proposed ZEPCert regulation would require the use of the constant current battery depletion test set forth in the Society of Automotive Engineers (SAE) Standard J1798, *Recommended Practice for Performance Rating of Electric Vehicle Battery Module*[24], or another test procedure that is substantially similar subject to Executive Officer review and approval. While this test would not provide information on how long a battery would last in a particular application, it would provide a useful reference point by which different battery-based powertrains could be compared.

Fuel-cell powertrains, without plug-in capabilities, would not be subject to this requirement.

Powertrain Monitoring and Diagnostic Strategy Information

Staff’s proposal would require powertrain manufacturers to describe the monitoring and diagnostic strategies they use. The proposal would not however, dictate *how* a manufacturer monitors a powertrain or diagnoses powertrain problems. The information provided under these provisions would help CARB staff understand potential causes of, and solutions to, problems experienced by HDEVs and HDFCVs, which would help inform the development of future zero-emission measures. CARB staff could also use this information to validate the effectiveness of zero-emission powertrain diagnostics systems should in-use problems arise.

Repairability Provisions

The powertrain manufacturer would be required to make available its internal diagnostic and repair manual as well as any required service tools or parts to third-party repair facilities at reasonable cost. The manufacturer could require special training in order to gain access to the diagnostic and repair manual manual and tools. This requirement

would establish a framework that facilitates the expansion of the repair network for HDEVs and HDFCVs.

Standardized Connector and Communications Compatibility with Scan Tools

The proposal would establish the requirement to use a diagnostic connector that meets the requirements set forth in California's OBD regulations. The proposal would also require that malfunction codes and certain powertrain parameters to be readable by a generic automotive scan tool.

These provisions would help move the industry towards greater repairability.

Warranty and Recall Requirements

Each powertrain family certified in accordance with the proposed alternative pathway would be required to be covered, at a minimum, by a 3-year, 50,000 mile warranty against workmanship and defects applicable to the powertrain system and its components. In addition, other provisions associated with the warranty of emission control components, such as recall provisions, would apply.

These provisions would help ensure that manufacturers support the zero-emission powertrains they sell and that defective zero-emission powertrains are adequately repaired, or removed from commerce; this would prevent potential "poisoning" of the market.

Labeling

The proposed ZEPCert provisions would require powertrain manufacturers to affix a label on each powertrain that includes the following information:

- Manufacturer Name;
- Compliance Statement, indicating that the zero-emission powertrain has been certified to the proposed requirements;
- Certification Family Name;
- Model Code, identifying the specific configuration; and
- Build Date.

The model code is a manufacturer-defined number that can be used in place of serialization to identify unique powertrain configurations. The proposed labeling requirements would allow consumers to identify powertrains certified to the proposed alternative pathway requirements. In addition, the proposed labeling requirements would also enable these powertrains to be identified in the field, either for compliance or research purposes.

ADDING CLARITY TO THE PHASE 2 CERTIFICATION PROCEDURES FOR HDEVS AND HDFCVS

While Phase 2 provides aggressive GHG emission credit multipliers for HDEVs and HDFCVs, the program was developed under the assumption that few, if any, such vehicles would actually be manufactured. That is, none of the emission standards in Phase 2 account for HDEVs and HDFCVs. As such, Phase 2's certification process for such vehicles is not well defined. Staff's proposal is intended to clarify the certification process.

IV. TECHNICAL FEASIBILITY OF THE REGULATION

A. Feasibility of Certification Procedures

1. Powertrain Battery Testing

Staff's proposal would establish energy-capacity testing requirements for batteries used in zero-emission powertrains being certified. The energy capacity of a battery pack is analogous to the volumetric capacity (e.g., gallons) of a fuel tank. While all manufacturers of HDEVs currently determine energy capacity of the batteries they utilize in their vehicles, no one consistent methodology is used. Because energy-capacity values can vary significantly depending on *how* a battery is tested (e.g., discharge rate, test temperature, etc.), such values cannot be reliably used today to compare different products. In order to provide consistency in the manner energy capacity is determined, the proposed regulatory action would require manufacturers to use a standardized, automotive-industry-developed test method described in SAE J1798, or a substantially similar test.

The proposed regulatory action would require one of the tests described in SAE J1798 (the constant rate discharge test) as a condition of certification. This constant rate discharge test requires discharging the battery from its fully charged state to measure how much energy it is capable of storing. While the test would not provide information on actual range (because range also depends on vehicle characteristics and duty cycle), it provides a reference point to compare different batteries and the efficiency of different vehicles, similar to how one measures miles-per-gallon in an internal combustion engine vehicle.

In terms of cost, staff consulted with the Idaho National Laboratory, experienced in performing the tests described in SAE J1798. The information they provided indicates that the test would cost approximately $7,500 to perform. However, because manufacturers already test their batteries for energy capacity, the net cost to a manufacturer is not expected to be the full $7,500 (because the SAE J1798 test would presumably be performed in place of the test they currently perform today).

In addition, according to the Idaho National Laboratory, there are dozens of laboratories nationwide capable of performing the SAE J1798 test. The test could also be performed in-house with test equipment that manufacturers who develop zero-emission technologies are already expected to have.

For the aforementioned reasons, staff believes the proposed battery-testing requirements are technically feasible, and can be performed at reasonable cost.

2. Scan Tool Compatibility of the Vehicle Diagnostic System

Staff's proposal could require some manufacturers to update the communications protocol used by zero-emission powertrain components over the vehicle's controller area network (CAN bus). The CAN bus is a communication system that allows devices (on a vehicle) to communicate with each other without the need of a host computer. The CAN bus acts in a manner similar to *telephone lines* and the communications protocol is the *language* that is used to communicate over those telephone lines.

Almost every internal combustion engine commercial vehicle in the United States uses a standardized CAN bus and communications protocol. This allows for more-seamless integration of components from different manufacturers because the components are able to *talk* to each other without additional modifications. In addition, it allows for the ability for a person to read and interact with the vehicle using a generic automotive scan tool, which facilitates the diagnosis and repair of vehicle problems.

According to feedback from manufacturers, while most current HDEVs and HDFCVs use a standardized CAN bus, some do not use a standardized communications protocol. Customized communications protocols prevent third-party repair facilities and fleets themselves from being able to diagnose vehicle and powertrain problems because available scan tools do not *understand* the signals sent over the CAN bus. This often results in extended downtime for HDEVs and HDFCVs needing repairs because fleets must go through the manufacturer for such repairs and most manufacturers in the segment today handle repairs entirely with in-house resources. That is, except for vehicles that are operated near the vehicle manufacturer's facility, it typically takes significant time and effort to resolve vehicle problems because fleets neither have the option to repair the vehicles themselves nor the option to transport their vehicles to a local facility for repair. Furthermore, should a manufacturer go out-of-business, locating a person with the ability to diagnose and repair vehicles produced by such manufacturer would be extremely difficult. While many manufacturers are likely to prefer maintaining full control over who is provided with the ability to diagnose problems associated with their respective powertrains or vehicles, by following the model set in the light-duty vehicle industry (that is, ensuring manufacturers

use a standardized CAN bus and communications protocol), the proposed ZEPCert would result in a more-efficient repair network and process for those who own and operate HDEVs and HDFCVs certified through the program.

While staff's proposal would not require full compliance with a standardized communications protocol, it would require that certain data (such as malfunction codes and other key parameters for vehicle diagnosis) are readable through a generic scan tool. The scope of work would primarily involve overlaying a *translator,* so that CAN bus signals could be interpreted. Based on staff's discussions with manufacturers, the work necessary to facilitate this functionality (further discussed in Section IX. Economics Impact Assessment) would be minor. In addition, the incorporation of a standardized communications connector could also be required, but the cost of such a connector would be minimal. Therefore, staff believes the proposed scan tool compatibility requirements are technically feasible, and could be met at minimal cost.

3. On-Board Efficiency and Battery Information

Staff's proposal would require that information on vehicle efficiency and remaining battery energy capacity (if applicable) be accessible to vehicle owners. The information could be made available via the dashboard display or through a generic scan tool. Based on discussions with manufacturers, the parameters necessary to derive this information are already being monitored on modern HDEVs and HDFCVs. Manufacturers would simply be required to *unlock* the information, so that vehicle owners could access it. Therefore, staff believes the aforementioned requirements are technically feasible.

4. Other Certification Requirements

All other actions required by the proposal would be administrative in nature and would include tasks, such as preparing the certification application, amending language in owner's manuals, and producing a compliance label. The estimated costs associated with such requirements are discussed further in Section IX. Economics Impact Assessment.

B. Feasibility of Heavy-Duty Electric and Fuel-Cell Vehicles

1. Battery-Electric and Fuel-Cell Heavy-Duty Vehicle Deployments

While the proposed ZEPCert regulation would not directly drive the deployment of zero-emission technology, staff developed this feasibility analysis to highlight the

progress that has been made in the heavy-duty zero-emission industry thus far. The information presented here demonstrates that HDEVs and HDFCVs are technically feasible in a number of applications today.

In 2015, CARB released the "Draft Technology Assessment: Medium- and Heavy-Duty Battery Electric Trucks and Buses," that overall found battery-electric vehicles were beginning to penetrate the medium- and heavy-duty vehicle markets. Consistent with that finding, battery-electric transit buses, school buses, shuttles, and other medium-duty vocational vehicles are increasingly available from a variety of manufacturers. In addition, the Draft Technology Assessment also cited continuing progress in the development of fuel-cell technology for transit buses, shuttles, delivery vehicles, refuse trucks, and drayage trucks. Furthermore, fuel-cells have also successfully penetrated the forklift category, and the lessons learned there should be transferrable to the on-road market.[25]

CARB, other agencies, and private companies continue to invest in battery-electric and fuel-cell technology in the heavy-duty and off-road sectors in order to help accelerate the market transition. The following is a list of some of the zero-emission heavy-duty vehicle projects funded by CARB incentives, and the vehicles and infrastructure that have been deployed from these programs.

a. The Hybrid & Zero-Emission Truck & Bus Voucher Incentive Project (HVIP)

HVIP is a statewide program that provides vouchers for California purchasers of Class 2b to Class 8 vehicles of up to $175,000 for a zero-emission bus and up to $325,000 for a fuel-cell bus or Class 7 or 8 truck (greater than 26,000 pounds gross vehicle weight rating). In addition, monies are also available for hybrid and low-NOx trucks. The program offsets the higher costs of clean vehicles, and additional incentives are available for providing disadvantaged community benefits. As of March 31, 2018, there were 16 manufacturers that offer an HVIP-eligible electric or fuel-cell vehicle and as of August 2018, the program has helped deploy:

- 573 zero-emission trucks and buses
- 2,351 hybrid trucks
- 408 low-NOx trucks
- 136 trucks outfitted with electric power take-off systems

The total zero-emission vehicles sales by weight class as part of HVIP are shown in Table 1.

Table 1: Sales of Heavy-Duty Vehicles with Zero-Emission Powertrains in HVIP[26]

Vehicle Class	Gross Vehicle Weight Rating (in pounds)	Zero-Emission Vehicle Sales
2b	8,501 – 10,000	0[a]
3	10,001 – 14,000	91
4	14,001 – 16,000	6
5	16,001 – 19,500	110
6	19,501 – 26,000	229
7	26,001 – 33,000	16
8	33,001 and over	70

[a] A battery-electric or fuel-cell Class 2b vehicle is not represented in the HVIP program currently because HVIP limits eligibility to commercial applications, and Class 2b vehicles are not typically used in commercial applications. However, Class 2b vehicles typically share similar powertrains with class 3 vehicles, and staff expects the same zero-emission powertrains to be used in both vehicle classes.

b. Zero- and Near Zero-Emission Freight Facilities Project

CARB is currently administering the $150-million Zero- and Near Zero-Emission Freight Facilities Project[9], which will be used to fund zero-emission on-road trucks amongst other equipment types and supporting infrastructure used in the freight sector.

c. Zero-Emission Urban Transit Bus Projects

Battery-electric and fuel-cell buses better serve communities' transit needs by reducing GHG and criteria pollutant emissions, and providing economic benefits. The following is a list of projects that funded such buses:

<u>San Joaquin Valley Transit Electrification Project</u>
- 15 electric buses
- 11 depot charging stations
- Four fast chargers

<u>City of Porterville Transit Electrification Project</u>
- 10 40-foot electric buses
- Depot charging station

<u>SunLine Transit Agency Fuel-Cell Bus Deployment</u>
- Five fuel-cell buses
- Upgraded hydrogen refueling station with onsite renewable generation

<u>Center for Transportation and the Environment Fuel-Cell Bus Project</u>
- 20 fuel-cell electric buses

d. Zero-Emission School Bus Project

The Sacramento Regional Zero-Emission School Bus Deployment Project

- Eight battery-electric school buses in service through 2017
- 21 additional state-of-the-art battery-electric school buses deployed by fall 2018
- 29 charging ports

e. Zero-Emission Delivery Truck Projects

Green On-Road Linen Delivery Project
- 20 all-electric walk-in-van delivery vehicles

Los Angeles County Repowering Electric Delivery
- 21 repowered battery-electric United Parcel Service (UPS) delivery trucks
- Four depot charging stations

Goodwill Industries Electric Delivery Vehicle Project
- 11 battery-electric delivery trucks

United States Postal Service (USPS) Zero-Emission Delivery Truck Pilot Commercial Deployment Project
- 15 battery-electric step vans
- Recharging infrastructure at two USPS facilities

f. Drayage Truck Project

California Collaborative Advanced Technology Drayage Truck Demonstration Project

- 43 battery-electric and plug-in hybrid drayage trucks

Many fleets have made commitments to reducing GHG emissions by utilizing zero-emission technology. The International Council on Clean Transportation white paper, "Transitioning to Zero-Emission Heavy-Duty Freight Vehicles," lists dozens of companies and organizations worldwide with demonstration deployments of medium- and heavy-duty electric vehicles and the infrastructure necessary to support such vehicles (including in-ground and catenary charging strategies)[27]. For example, in 2013, the United Parcel Service deployed 100 fully electric commercial delivery vehicles throughout California[28]. More recently, Anheuser-Busch has set goals to have its vehicles produce zero carbon emissions by 2025, indicating the intent to choose a combination of hydrogen-powered trucks and electric trucks[29]. In addition, at the Ports

of Los Angeles and Long Beach, 20 heavy-duty electric trucks will be developed by Daimler to support the goal of having all drayage trucks servicing the ports transition to zero-emission technology by 2035.[30]

C. Feasibility of Zero-Emission Powertrain Technology

1. Anatomy of a Zero-Emission Powertrain

Staff's proposal would establish optional zero-emission standards and certification procedures for electric and hydrogen fuel-cell powertrains used in heavy-duty trucks and buses. An electric powertrain is one that is driven by an electric motor drawing power from an energy storage device. The components of a typical electric powertrain can be grouped into the following categories:

- energy storage systems (such as batteries);
- motors (or generators);
- powertrain/vehicle management systems;
- thermal controls;
- charging components;
- inverters and converters; and
- power electronics, wiring, and connectors.

A fuel-cell powertrain is an electric powertrain, in which the energy is supplied by an electrochemical cell that produces electricity by way of a noncombustion reaction using a consumable fuel, such as hydrogen. A typical fuel-cell powertrain contains many of the same components of an electric powertrain, including a battery that may be used as a smaller-capacity energy storage buffer. However, such powertrains also contain a fuel-cell stack (i.e., an assembly of electrochemical cells), a storage tank for the consumable fuel, and fueling components.

In an electric vehicle, a typical energy storage system consists of one or more battery packs, which are composed of individual battery cells. These cells are often organized into modules, which are groupings of cells that are connected in series and/or parallel. Modules, packaged together, form battery packs, which also include sensors (e.g., for voltage and temperature), a battery management system, and a thermal management system[31]. Energy storage systems supply electrical energy, but are also used to recapture the energy produced through processes, such as regenerative braking. Battery management systems monitor, control, and balance battery modules because electrical imbalances can lead to substantial decreases in performance[32]. In addition, a thermal management system helps maintain optimal temperature conditions for the energy storage system in order to minimize temperature effects on performance, lifespan, and safety[33]. Both passive (e.g., air flow cooling) and active thermal management strategies are currently used.

Traction motors receive electrical energy from a battery pack or fuel-cell stack and convert it to mechanical energy. The motors are typically connected to the driveline and provide the necessary torque to propel the vehicle. In addition, motors can be used to supply mechanical power to integrated power take-off devices or recapture braking energy.

Electric and fuel-cell vehicles also contain a number of other electric and electronic components (such as inverters, switches, controllers, etc.) as well as onboard control systems that manage the flow of electricity throughout the powertrain and vehicle to ensure its safe and effective operation. Furthermore, battery-electric vehicles (and some fuel-cell vehicles with plug-in capabilities) are also equipped or supplied with the equipment necessary for charging the energy storage system.

2. Availability of Zero-Emission Powertrains

Currently, almost all HDEV and HDFCV manufacturers also manufacture the powertrains such vehicles use. Manufacturing a zero-emission powertrain involves designing the powertrain, assembling the hardware components that make up the powertrain, and developing and implementing the software and electronic controls and other hardware components necessary to integrate such powertrains into vehicles.

Generally, powertrain manufacturers in the market today focus on a limited number of vehicle applications. For example, there are several manufacturers that have focused their efforts solely on transit buses because such buses are considered ideal for early-deployment of zero-emission technology due to their fixed routes and often times lower operating weight compared to other heavy-duty applications, such as long-haul trucks that may often operate fully loaded and travel longer distances. However, the market is still an emerging one, and staff expects that as the market matures, the focus will shift towards more-flexible powertrain platforms that can be adapted to work across a variety of heavy-duty applications, including Class 8 trucks.

Some manufacturers, such as Motiv Power Systems and Transpower, already offer powertrain products designed to be adaptable to different vehicles classes. Motiv Power System's "Electric Powered Intelligent Chassis" (EPIC®) is a chassis integrated with electric driveline components ready to be installed with a vehicle body. In addition, Transpower's Electruck™ system consists of the battery energy storage system, motor, power controllers, inverters, and other powertrain accessories and is designed to be integrated into large vehicles, including Class 8 trucks. Furthermore, many other manufacturers, including OrangeEV[34] and Lightning Systems[35] are also designing powertrains that can be flexibly integrated into other vehicles. Each of these companies has plans to continue to expand to meet the demands of the growing zero-emission powertrain industry.

There are currently hundreds of manufacturers that supply components (such as a battery cell, fuel-cell stack, motor, etc.) for zero-emission powertrains and their integration into heavy-duty vehicles[36]. These manufacturers include suppliers to the

automotive, aviation, and energy industries (and others), and for many, the heavy-duty zero-emission industry represents just one component of their total market.
There are a number of companies supplying batteries for use in heavy-duty vehicle applications today. Battery cell providers include, but are not limited to, A123 Systems[37] (whose batteries are used in New Flyer vehicles), Altairnano[38] (whose batteries are used in Phoenix and Proterra vehicles), and Winston[39] (whose batteries are used in Transpower vehicles). Some companies, such as BYD[40], produce the battery packs as well as the powertrains and vehicles in which they are installed. In general, battery suppliers focus on large-scale battery production, and the heavy-duty zero-emission market represents just one possible application for them. Most automotive batteries used today are based on lithium-ion chemistries. Table 2 shows a variety of lithium-ion chemistries with their associated specific energy densities, expected life spans, and existing applications.

Table 2: Lithium-Ion Battery Chemistry Characteristics and Applications[41]

Battery Chemistries	Specific Energy Capacity (Watt-hours/kg)	Life Span (cycles)[a]	Applications
Lithium Nickel Cobalt Aluminum (NCA)	160	2,000+	Used in cars (e.g., Toyota Prius plug-in hybrid, Tesla)
Lithium Nickel Manganese Cobalt Oxide (NMC)	150	2,000+	Used in consumer goods, cars, and buses (e.g., Nissan Leaf, Chevrolet Bolt, Proterra, New Flyer)
Lithium Manganese Oxide (LMO)	150	1,500+	Used in cars; most LMO blends with NMC to improve the specific energy and prolong the life span (e.g., Nissan Leaf)
Lithium Titanate (LTO)	90	5,000+	Used in cars and buses (e.g., Honda Fit, Proterra)
Lithium Iron Phosphate (LFP)	140	5,000+	Used in cars, buses, and trucks (e.g., BYD, Transpower, Siemens, Nova Bus, Volvo) and stationary energy storage systems

[a] A full discharge and recharge of a battery is one cycle. A cycle may also refer to smaller charge and discharge amounts that cumulatively add up to one full discharge and recharge.

Another key component of a zero-emission powertrain is the electric motor. Some examples of motor suppliers include UQM[42] (whose motors have been used in Proterra buses), Siemens[43] (whose motors have been utilized in New Flyer buses), and TM4[44] (whose motors have been utilized in GreenPower buses). Each of these motor manufacturers has an array of motor options for use in applications ranging from light- and heavy-duty vehicles, to marine vessels, aircraft, and industrial machinery.

Companies that supply the same or similar components to the electrical utility industry, at large scale, generally provide other components in zero-emission powertrains, such as inverters and power electronics.

Ultimately, most component suppliers that currently support HDEVs serve a much broader market than the heavy-duty zero-emission industry alone. Therefore, while volumes are modest today, staff believes that component suppliers are well positioned to support any growth in number of HDEVs should it occur.

Relative to battery suppliers, the suppliers of fuel-cell technology for heavy-duty vehicles are more limited. However, Ballard[45] and UTC[46] are two of a number of companies that have developed fuel-cell stacks to power transit buses. Fuel-cell stacks have applications in sectors such as grid storage, light-duty vehicles, heavy-duty vehicles, and others. The heavy-duty sector represents just one market amongst many for fuel-cell suppliers, who are actively looking to scale up production and reach larger deployment volumes. In addition, fuel-cell stacks can easily be scaled for other applications by adding or removing electrochemical cells. As fuel-cell technology continues to develop, there may be more opportunity to utilize fuel-cell stacks in powertrains.

3. Cost of Zero-Emission Technology

Except for fuel-cell powertrains, the energy storage system is typically the most costly component of a zero-emission powertrain. Battery costs have been studied extensively and a summary of their cost per kWh is shown in Table 3. For reference, battery-electric buses have been deployed with battery packs of more than 300 kilowatt-hour. Proterra's battery-electric CATALYST Extended Range™ transit bus uses an NMC battery pack with 330 kWh of onboard energy storage[47], New Flyer's Xcelsior XE40 electric transit bus has a 300 kWh battery pack[48], and BYD has a 40-foot bus with a 324 kWh LFP battery pack.

Table 3: Battery Cost Estimates and Projections from Different Sources[41]

Reference	Chemistry	Application	Cost Estimates and Projection ($/kWh)
CE Delft (2013)	Not Specified	Distribution and long-haul trucks	$600 (2012); $320 (2020); $210 (2030)
CACTUS (2015)	LFP	Not Specified	$350 (2015)
	LTO	Not Specified	$2,000 (2015)
CALSTART (2012)	Not Specified	Trucks	$500-$600 (2015); $450 (2020); $300 (2025)
Rocky Mountain Institute (2015)	Not Specified	Residential and commercial battery storage system	$540 (2015); $405 (2020); $225 (2030); $200 (2040)
Boston Consulting Group (2012)	NCA	Not Specified	$990-$1,220 (2009); $360-$440 (2020)
Navigant Research (2014)	LFP	Not Specified	$400-$1,200 (2014)
	LTO	Not Specified	$800-$2,000 (2014)
	NMC	Not Specified	$700-$900 (2014)
Nykvist and Nisson (2015)	Not Specified	Not Specified	Whole Industry: $410 (2015); Market Leader: $300 (2015)
BYD (2016)	LFP	Buses (depot charging)	$900 (2016); $600 (2025)
Proterra (2016)	LTO	Buses (depot charging)	Upwards of $1,000 (2016); $700 (2022)
New Flyer (2016)	NMC	Buses (depot charging)	$750-$850 (2016)
ACTIA (2016)	LTO	Buses (depot charging)	$1,500-$2,000 (2016)
	Not Specified	Buses (depot charging)	$750-$1,000 (2016)

Staff estimated the costs of zero-emission powertrains by using HVIP voucher amounts for HDEVs, which are primarily based on the incremental cost between a new internal combustion vehicle and a new HDEV. The incremental cost in HVIP is determined by using an aggregation of manufacturer prices for vehicles. While this methodology does not fully represent the range of costs that a vehicle and powertrain manufacturer could actually incur (because cost can vary widely by application, production volume, and component suppliers), staff used this methodology for the purpose of this analysis because there were limited cost data from other sources.

The cost of a baseline internal combustion vehicle plus the HVIP voucher amount provides a reasonable approximation of the total cost of a comparable HDEV. However, because HDEVs do not include an internal combustion engine, the value of the engine installed in an applicable baseline vehicle must be accounted for when determining the cost of a zero-emission powertrain. Specifically, the estimated cost for the zero-emission powertrain for each vehicle class category was determined by adding

the value of the applicable HVIP vouchers to the value of the applicable internal combustion engine, which ranges from $10,000 to $30,000[49]. The values from this analysis were also corroborated with information provided by discussions with manufacturers as well as information from the ICT regulation in order to further capture the range of costs associated with HDEVs and HDEV powertrains. The estimated internal combustion vehicle costs, HVIP voucher amounts, and estimated HDEV and powertrain costs for various vehicle class categories are shown in Table 4.

Table 4: Heavy-Duty Battery-Electric Vehicle and Powertrain Pricing Estimates[50, a]

Vehicle Class	Baseline Internal Combustion Vehicle Cost[51, 52]	HVIP Voucher Amount [b]	HDEV Cost	HDEV Powertrain Cost
Class 2b-3 Vehicle	$80k	$35k-$65k	$115k-$145k	$45k-$95k
Class 4-7	$140k	$110k-$200k	$250k-$340k	$60k-$230k
Class 8 Truck	$135k	$175k	$310k	$80k-$205k
Class 8 Transit Bus	$485k-$525k	$175k	$820k-$860k[53]	$345k-365k

[a] Fuel-cell electric buses are much more costly relative to internal combustion engine buses, with costs ranging from $1.8 million to $2.4 million[54]. It is expected that the fuel-cell powertrain makes up the large majority of this price, at $1.4 million to $2 million.

[b] Voucher amount assumes vehicle is in a disadvantaged community and is one of the first 3 vehicles a fleet purchases

The prevalence of zero-emission component suppliers and zero-emission powertrain manufacturers as well as the volume of recent HDEV and HDFCV sales demonstrate that zero-emission powertrains and the vehicles that use them are technically feasible.

V. BENEFITS ANTICIPATED FROM THE REGULATORY ACTION, INCLUDING THE BENEFITS OR GOALS PROVIDED IN THE AUTHORIZING STATUTE

The proposed ZEPCert regulation would provide numerous benefits that stem from the deployment of more-reliable heavy-duty battery-electric and fuel-cell vehicles. Staff met with several fleets during the development of this proposal, and nearly all of them purchased battery-electric vehicles to displace existing internal combustion vehicles. However, because of extended vehicle downtime and/or performance issues, some fleets ultimately opted to return to using their internal combustion vehicles.

A key factor in the success of battery-electric and fuel-cell vehicles in the heavy-duty marketplace will be consumer acceptance. Only when fleets feel that they are purchasing a reliable, well-supported product will they begin to adopt it in larger volumes. Staff's proposal addresses many of the concerns that fleets have about battery-electric and fuel-cell vehicles by including warranty, repairability, and

information-disclosure requirements. These requiements are expected to result in real-world cost savings due to better-informed purchase decisions, more-seamless integration of zero-emission technology into fleets, and reduced vehicle downtime due to a more-efficient repair network. While not quantifiable, staff's proposal could potentially result in increased adoption of these vehicles because fleets would be more willing to consider these vehicles without additional policy drivers.

VI. AIR QUALITY

The potential benefits of a transition to zero-emission technology in the heavy-duty and off-road sectors are significant, especially in disadvantaged communities, where many petroleum-fueled vehicles and equipment operate. As such, CARB's 2016 Mobile Source Strategy includes a number of near-term measures intended to accelerate the deployment of zero-emission technology in heavy-duty and off-road applications that are already well-suited for the technology today. The impact of these measures will depend upon how successful the vehicles equipped with such technology operate in applications traditionally served by internal combustion technology. While staff's proposal does not contain any provisions that would directly mandate the use of zero-emission technology, it is designed to help increase the likelihood of a successful deployment of HDEVs and HDFCVs in their intended applications. Accordingly, the proposed ZEPCert regulation is expected to benefit California air quality to the extent that it helps ensure the success of CARB's other zero-emission efforts and hastens the development of a self-sustaining zero-emission market. That said, the emission benefits directly attributable to the proposed ZEPCert regulation have not been quantified. Given such benefits would likely differ greatly for specific regulatory measures and programs, it is more appropriate to be quantified as part of those individual measures/programs.

VII. ENVIRONMENTAL ANALYSIS

CARB is the lead agency for the proposed regulation and has prepared an environmental analysis pursuant to its certified regulatory program (Cal. Code Regs., tit. 17, §§ 60000 through 60008) to comply with the requirements of the California Environmental Quality Act (CEQA). CARB's regulatory program, which involves the adoption, approval, amendment, or repeal of standards, rules, regulations, or plans for the protection and enhancement of the State's ambient air quality has been certified by the California Secretary for Natural Resources under Public Resources Code section 21080.5 of CEQA (Cal. Code Regs., tit. 14, § 15251(d)) Public Resources Code section 21080.5 , allows public agencies with certified regulatory programs to prepare a "functionally equivalent" or substitute document in lieu of an environmental impact report or negative declaration, once the program has been certified by the Secretary for the Resources Agency as meeting the requirements of CEQA. CARB, as a lead agency, prepares a substitute environmental document (referred to as an "Environmental Analysis" or "EA") as part of the Staff Report to comply with CEQA (Cal. Code Regs., tit. 17, § 60005).

The Draft Environmental Analysis (Draft EA) for the proposed regulation is included as Appendix B to this Staff Report. The Draft EA provides a programmatic environmental analysis of illustrative, reasonably foreseeable compliance scenarios that could result from implementation of both the Proposed Zero-Emission Airport Shuttle Regulation and the Proposed ZEPCert Regulation. The proposed Zero-Emission Airport Shuttle Regulation and ZEPCert Regulation have two separate notices and staff reports and will be considered by the Board in separate proceedings. This approach is consistent with CEQA's requirement that an agency consider the whole of an action when it assesses a project's environmental effects, even if the project consists of separate approvals (Cal. Code Regs., tit. 14, § 15378(a)).

The Draft EA provides an environmental analysis which focuses on reasonably foreseeable potentially significant adverse and beneficial impacts on the physical environment resulting from reasonably foreseeable compliance responses taken in response to implementation of the proposed actions within the proposed regulations. The Draft EA is intended to disclose potential adverse impacts and identify potential mitigation specific to the proposed regulation.

Because the proposed warranty and service requirements in the Proposed Zero-Emission Powertrain Certification Regulation will not result in an increase in construction of new facilities and because the testing requirements are functionally similar to tests that are common industry practice and would not require modifications to existing test facilities, the Draft EA determined that the reasonably foreseeable compliance responses associated with Proposed Zero-Emission Powertrain Certification Regulation would not result in adverse impacts to any of the environmental resource areas.

However, the Draft EA concluded, under a conservative approach, that implementation of the Proposed Zero Emission Airport Shuttle Regulation could result in the following beneficial and adverse impacts: beneficial impacts to energy demand, air quality and greenhouse gases; less than significant, or no impacts, to long-term air quality, energy, hazards and hazardous materials, hydrology and water quality, land use planning, mineral resources, noise, population employment, housing, public service, recreation, and transportation and traffic; and potentially significant and unavoidable adverse impacts to aesthetics, agricultural and forest resources, short-term air quality, biological resources, cultural resources, geology and soils, hazards and hazardous materials, hydrology and water quality, land use planning, noise, transportation and traffic, and utilities and service systems.

Written comments on the Draft EA will be accepted starting December 7, 2018 through 5:00 p.m. on January 22, 2019. The Board will consider the Final EA and responses to comments received on the Draft EA before considering adoption of the proposed regulation.

VIII. ENVIRONMENTAL JUSTICE

State law defines environmental justice as the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies. Government Code, section 65040.12, subdivision (c). CARB is committed to making environmental justice an integral part of its activities. The Board approved its Environmental Justice Policies and Actions (Policies) on December 13, 2001, to establish a framework for incorporating environmental justice into CARB's programs consistent with the directives of State law (CARB 2001). These policies apply to all communities in California, but recognize that environmental justice issues have been raised more in the context of low-income and minority communities.

Disadvantaged communities are expected to benefit from the transition of the heavy-duty and off-road sectors to zero-emission technologies. Most, if not all, of CARB's planned heavy-duty and off-road zero emission measures are expected to have the greatest emission impact in disadvantaged communities, because these communities are disproportionately impacted by heavy-duty truck traffic and off-road equipment usage. While emission reductions would not be directly quantifiable for staff's proposal (because staff's proposal would not mandate deployment of additional HDEVs and HDFCVs), it is expected to benefit disadvantaged communities to the extent that it helps ensure the success of CARB's other zero-emission efforts. In addition, staff's proposal could result in higher utilization of zero-emission technology because of more effective and reliable HDEVs and HDFCVs and, potentially, in the accelerated development of a self-sustaining heavy-duty zero-emission market due to increased consumer acceptance.

Staff does not believe the proposed ZEPCert regulation would have any adverse impacts on Environmental Justice communities.

IX. ECONOMIC IMPACTS ASSESSMENT

This chapter provides a summary of the estimated costs incurred to industry and local and state agencies to comply with the proposed regulatory measure. As the following information will affirm, staff does not expect this proposal to have a significant statewide adverse economic impact that directly affects businesses, including the ability of California businesses to compete with businesses in other states, or on representative private persons.

A. Estimated Private Sector Cost Impacts

Staff's proposal would establish a new, alternative certification process that would affect manufacturers of HDEVs, HDFCVs, and the zero-emission powertrains they use. The proposed alternative certification process would be optional, and thus, manufacturers would have the discretion to certify to either the proposed requirements or the more-relaxed certification requirements that exist today. That said, it is possible that a manufacturer, without additional policy/regulatory drivers, would opt to certify an HDEV,

HDFCV, or its zero-emission powertrain to the proposed requirements, for example, to gain a market advantage by "proving" their technology over a more-robust certification process to attract more customers or support a higher price point. However, based on staff discussions with manufacturers, few have explicitly expressed interest in voluntarily certifying to the proposed requirements. Despite this, for the purposes of this analysis, staff chose the most-conservative (i.e., highest cost) approach and assumed that all vehicle manufacturers offering HDEVs or HDFCVs for sale in California today would certify to the proposed ZEPCert requirements.

Staff's proposal is also expected to affect fleets that purchase HDEVs and HDFCVs, and potentially, businesses that perform battery-module testing and third-party repair facilities. While the specific impacts on these businesses were not quantified, they are qualitatively described below.

Further, staff only assessed costs from MY 2021 to MY 2025, after which it is expected that many HDEVs, HDFCVs, and zero-emission powertrains would be certifying to the proposed ZEPCert provisions because of requirements established by other regulatory measures and programs. Therefore, staff's analysis did not include costs for 2026 and later MYs. Because costs could differ greatly for specific regulatory measures or programs, it would be more appropriate that these costs be quantified as part of those individual measures/programs instead.

1. Total Number of Businesses, Types of Businesses, and Number of Small Businesses

Businesses that manufacture HDEVs and HDFCVs would be affected by this proposed regulatory action. Staff used HVIP data[55] to determine the number of vehicle manufacturers that would be affected by staff's proposal. Staff assumed that all vehicle manufacturers that offer an HDEV or HDFCV today have at least one model that is eligible for HVIP funding. There are currently 16 vehicle manufacturers with at least one HVIP-eligible vehicle. Using this, staff conservatively assumed the proposal would impact 16 vehicle manufacturers for the 2021 MY and that each vehicle manufacturer would certify one ZEPCert vehicle family. In addition, the number of HDEV and HDFCV manufacturers were assumed to remain constant between the baseline year of 2018 and the proposed regulation start year of 2021. Subsequent to the 2021 model year, staff assumed that 2 new manufacturers would enter the market each year (based on the past trajectory of eligible manufacturers in HVIP), and each manufacturer would be a small business located in California.

Staff's proposal would also affect manufacturers of zero-emission powertrains. Although more businesses that exclusively manufacture zero-emission powertrains could emerge if the proposed ZEPCert regulation is adopted, most HDEV and HDFCV manufacturers today are also the manufacturer of the zero-emission powertrain that is installed in those vehicles. Therefore, for this analysis, staff assumed that all HDEV and HDFCV manufacturers would also be zero-emission powertrain manufacturers and no business would manufacture powertrains exclusively.

There are a variety of vehicle manufacturers that participate in HVIP today. They represent a wide cross-section of business models, and range from traditional vehicle manufacturers, which offer vehicles across a broad spectrum of weight classes, to "vehicle converters" that acquire a specific incomplete vehicle model and replace its internal combustion engine with a zero-emission powertrain. Seven (7) of the 16 vehicle manufacturers in HVIP today are located in California, and 3 of the 7 are considered to be small business because they are independently owned and operated and have fewer than 100 employees. Most, if not all, out-of-state vehicle manufacturers have business presence within California.

Table 5, below, summarizes the projected number of HDEV and HDFCV manufacturers (by model year) that would be impacted by staff's proposal.

Table 5: Projected Number of HDEV and HDFCV Manufacturers (by model year)	**2021**	**2022**	**2023**	**2024**	**2025**
HDEV/HDFCV Manufacturers	16	18	20	22	24
CA HDEV/HDFCV Manufacturers	7	9	11	13	15
Small Businesses	8	10	12	14	16
CA Small Businesses	3	5	7	9	11

Truck and bus fleets in California could also be affected indirectly, particularly larger fleets that are most likely to be early adopters of zero-emission truck and bus technology. In addition, businesses that perform battery module testing and third-party heavy-duty repair facilities could potentially experience increased demand for their services. These businesses could be located within or outside of California.

In summary, the businesses (including their NAICS codes*) that could be potentially affected by staff's proposal are:

- Twenty-four (24) zero-emission vehicle manufacturers (NAICS 336111, 541330)
  - Fifteen (15) within California (11 small businesses)
  - Nine (9) out-of-state (5 small businesses)
- Truck and bus fleets (NAICS 484)
- Other businesses that may have testing capability (NAICS 541330)
- Third-party heavy-duty repair facilities (NAICS 811111)

* The North American Industry Classification System (NAICS) classifies business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. economy. The NAICS industry codes define establishments based on the activities in which they are primarily engaged. https://www.census.gov/eos/www/naics/

2. Businesses Creation and Elimination

Staff's proposal is not expected to eliminate any businesses. In addition, while the proposed ZEPCert regulation could result in some expansion of existing businesses, it is not expected to create any new businesses.

With respect to vehicle and zero-emission powertrain manufacturers, while the industry continues to grow, staff's proposal would not require any additional volume of HDEV and HDFCV sales. To the extent the proposed ZEPCert regulation indirectly causes an increase in sales of HDEVs and HDFCVs, some expansion of existing businesses that manufacture such vehicles or powertrains could occur. However, the creation of new businesses would not be expected.

Staff does not expect the proposed ZEPCert regulation to result in any creation of new truck or bus fleets. Should manufacturers choose to certify vehicles or powertrains to the proposed requirements, the only projected impact would be truck and bus fleets would have more-robust HDEV and HDFCV options from which to choose when purchasing a new vehicle.

While laboratories capable of battery-module testing could potentially begin to see increase demand for services, staff does not expect it to be significant. The volume of testing demand is still anticipated to be relatively low in the near term, and staff expects that many zero-emission powertrain manufacturers would opt to conduct the battery testing with in-house resources and existing facilities. Therefore, staff does not anticipate any creation of test laboratories as a result of staff's proposal.

Lastly, third-party repair facilities could also experience increased demand for their services, but given the anticipated volumes of HDEVs and HDFCVs in the near-term, the additional demand would likely be absorbable by existing repair networks.

3. Job Creation and Elimination

As indicated above, to the extent that the proposed ZEPCert regulation indirectly results in increased sales of HDEVs and HDFCVs, some expansion of existing businesses could occur. First, vehicle and powertrain manufacturers could need to increase staffing to support the HDEVs, HDFCVs, and zero-emission powertrains they sell. In addition, test laboratories and third-party repair facilities could need to increase staffing to manage increased demand for battery testing services and repair services, respectively. Lastly, truck and bus fleets that purchase HDEVs and HDFCVs could need to increase staffing for vehicle maintenance or other operational needs. That said, staff expects any job creation that would result from staff's proposal to be minor.

4. California Competitiveness

The proposed regulatory actions are expected to have no noticeable effect on the ability of California businesses to compete with businesses in other states. First, the proposed ZEPCert requirements would be optional and manufacturers that choose to certify to

those requirements would be doing so at their own discretion. Secondly, any future policy action that would require an HDEV, HDFCV, or zero-emission powertrain to certify to the proposed ZEPCert requirements would apply irrespective of where such vehicles or powertrains are produced.

B. Estimated Costs

The proposed ZEPCert regulation would establish an optional certification pathway for HDEVs, HDFCVs, and zero-emission powertrains starting with the 2021 model year. HDEV, HDFCV, and zero-emission powertrain manufacturers that decide to pursue certification through the proposed ZEPCert procedures would face direct costs. The following is an assessment of those costs. All costs are evaluated relative to the baseline of current year 2018 dollars.

While staff's proposal would establish new warranty requirements for zero-emission powertrains for 3 years or 50,000 miles, the required coverage would not exceed what manufacturers already provide today. Through the HVIP program, manufacturers are required to provide a warranty period of 3 years or 50,000 miles, and based on information submitted through manufacturer certification applications, industry standards typically exceeds this warranty period. Therefore, staff did not include warranty costs in this analysis.

Staff assumed that any in-house labor required by the proposed regulation would be performed by a mechanical engineer. Based on the occupational employment statistics for May 2017 published by the United States Department of Labor, the mean hourly wage for a mechanical engineer was $43.99 (or $45.32 in 2018 dollars). For this analysis, staff rounded up the value to $50, then doubled it to account for benefits and other employment costs. That is, staff assumed a labor rate of $100.[56]

Baseline/Population Information

To estimate these cost impacts, assumptions characterizing the number of annual powertrain certification families, vehicle certification families, and vehicles sales in California were developed. For this analysis, staff assumed, for model year 2021, that each of the 16 vehicle manufacturers would certify one ZEPCert vehicle family and one ZEPCert zero-emission powertrain family. Subsequent to the 2021 model year, staff assumed that 2 new manufacturers would enter the market each year (as described above), and each of them would certify both a zero-emission powertrain and an HDEV or HDFCV to the proposed ZEPCert requirements. In addition, the number of vehicle

sales was projected using the trends in the number of battery-electric vehicle purchased between fiscal years 2014 and 2017 through HVIP.

The projected numbers of ZEPCert vehicle and powertrain families as well as vehicle sales, by model year, are provided in Table 6, below.

Table 6: Projected Number of ZEPCert Families and Annual Sales (by model year)	2021	2022	2023	2024	2025
ZEPCert Vehicle Families	16	18	20	22	24
ZEPCert Powertrain Families	16	18	20	22	24
New HDEV and HDFCV Sales	96	108	120	132	144

Powertrain Certification Costs

The estimated costs for certification of a ZEPCert powertrain family are divided into three categories: one-time certification-family costs, annual certification-family costs, and per-powertrain costs. For a particular certification family, one-time costs are those that a manufacturer would only incur for the first model year of said family. Unless there is a major powertrain redesign, these costs are not expected to recur in future model years. The one-time costs addressed by this analysis are those attributed to battery-module testing using a modified SAE J1798 test procedure or substantially similar test procedure approved by the Executive Officer; modifications of the monitoring and diagnostics system, so that it is capable of sending signals to a generic automotive scan tool; and compiling information about the monitoring and diagnostic system to submit to the Executive Officer.

SAE J1798 is a generic test and verification method for determining electric vehicle battery module performance. Staff's proposal would require a modified, and less-expensive, version of this complete test procedure, and the expected cost per vehicle would be about $7,500. This is based on discussion with Idaho National Labs (a national laboratory overseen by the United States Department of Energy), which has experience running this test.

In addition, the monitoring and diagnostic outputs would need to be capable of being read through a standardized diagnostic connector by a generic automotive scan tool. Staff estimates this cost to be approximately $1,200 per certification family, based on discussions with manufacturers regarding the cost for the actual hardware changes and the reprogramming effort. In addition, this would also include the cost of compiling monitoring and diagnostic information for the certification package.

With respect of annual costs, these would apply each model year to each powertrain certification family. Annual costs would include the cost of the application preparation and the cost of warranty reporting, if applicable. Staff estimates that the annual cost to prepare the certification application would be approximately $100. This amount was

based on the assumption that it would take a mechanical engineer one hour (at a labor rate of $100) to assemble and submit the information to the Executive Officer.

Another annual cost would be the cost of warranty and recall reporting, which staff estimates would be approximately $400 per powertrain family per model year. While warranty and recall reporting would only be applicable if certain component failure rates are exceeded, staff applied the cost to all powertrain certification families for the purpose of the analysis. The cost for the warranty and recall reporting was based on the assumption that it would take an engineer 4 hours (at a labor rate of $100 per hour) to collect, assemble, and submit the necessary information to the Executive Officer.

There would also be a per-powertrain cost for a powertrain label, which staff estimated would be $25.

Vehicle Certification Costs

The estimated costs for certification of a ZEPCert vehicle family would fall into two categories: an annual certification-family cost and per-vehicle costs. The cost to prepare the certification application is the only annual certification-family cost. This cost was estimated to be $100, which is consistent with staff's estimate for a powertrain certification.

In addition, there would also be per-vehicle costs associated with the proposed vehicle certification requirements. Specifically, staff's proposal would require each vehicle to be labeled as certified and delivered with an owner's manual that contains specific information about the vehicle and service centers. The proposed regulation requires the vehicle and powertrain manufacturer to separately create owner's manuals but allows the option for creating a combined owner's manual. Staff assumed the fixed cost for the owner's manual would be absorbed by the vehicle manufacturer. The estimated label costs and owner's manual modification are $80 and $25, respectively, per vehicle.

Table 7, below, presents a summary of the estimated costs that manufacturers would incur under the proposed regulation. The "Powertrain Certification Family Costs" column includes one-time costs associated with the tasks that must be performed prior to the initial submittal of a powertrain certification application as well as annual costs associated with the preparation of powertrain certification applications and the tracking and reporting of powertrain warranty claim information. The "Vehicle Certification Family Costs" column includes the annual costs associated with the preparation of vehicle certification applications. The "Incremental Vehicle Costs" column describes the costs associated with the vehicle labeling and owner's manual requirements.

Table 7: Total Projected Costs of the ZEPCert Proposal (in dollars by model year)

	Powertrain Certification Family Costs		Vehicle Certification Family Costs	Incremental Vehicle Costs	Total MY Costs	Number of Vehicles Sold	Cost per Vehicle Sold
	One-Time	Ongoing					
2021	139,200	8,000	1,600	17,760	166,560	96	1,802
2022	17,400	15,400	1,800	19,980	54,580	108	631
2023	17,400	23,600	2,000	22,200	65,200	120	723
2024	17,400	26,200	2,200	24,420	70,220	132	714
2025	17,400	28,800	2,400	26,640	75,240	144	706
Total	208,800	102,000	10,000	111,000	431,800	600	Weighted Average 720

Staff projects that the proposed ZEPCert regulation would result in a total cost of $431,800[57] from 2021 through 2025. Based on the projected sales of 600 ZEPCert vehicles within that same timeframe, staff's proposal would add $720 (sales weighted average) to the cost of each vehicle. That said, because the purchase of such a vehicle would be at the discretion of the consumer, staff expects that, if such a purchase is made, the anticipated benefits of the purchase would offset its incremental cost in that consumers would be served with a product that is more likely to operate reliably with less downtime and be capable of performing the needed work.

Future Measures Requiring ZEPCert

The cost analysis for staff's proposal does not include the potential future costs associated with other regulatory measures requiring certification to the proposed ZEPCert requirements. However, if a manufacturer is expected to create a new ZEPCert family due to a future regulatory measure, the projected cost of certifying a new powertrain certification family would be $9,200, and the projected cost of certifying a new vehicle certification family would be $100. If new certification families do not need to be created, the incremental cost of each additional vehicle from an existing ZEPCert vehicle family would be $185.

1. Summary of Costs to California Businesses

Based on the manufacturers currently with a product eligible for HVIP funding, seven out of 16 are located inside California. In addition, as previously mentioned, staff assumed two California-based manufacturers would enter the market each year after the 2021 model year. Based on these assumption, the estimated impact of staff's proposal from model year 2021 through model year 2025 would be $251,350.

2. Summary of Costs to Small Businesses

Based on the manufacturers currently with a product eligible for HVIP funding, 8 out of 16 are considered a small business, 3 in California. In addition, as previously mentioned, staff assumed two small businesses would enter the market each year after the 2021 model year. Based on these assumptions, the cost estimated for all small businesses nationwide would be $271,400, and the cost estimated for California small businesses would be $171,150.

3. Summary of Costs to Individuals

Staff believes that the costs of this regulation ($431,800) would be initially taken up by the manufacturer and passed onto the purchaser (i.e., fleet). However, because the purchase of a ZEPCert vehicle would be at the discretion of the purchaser, staff expects the anticipated benefits, like greater efficiency and lower net cost with incentives, to be considered. Therefore, staff does not believe costs would ultimately be passed onto individual consumers.

C. Economic Impact Statement

1. Fiscal Effect on Local Government

If a manufacturer chooses to certify an HDEV or HDFCV to the proposed requirements and a local government agency chooses to purchase such vehicle, the cost impact on said local government agency would be the estimated per-vehicle incremental cost of $720. However, because the purchase of such vehicle would be at the discretion of the purchaser, if such a purchase is made, staff believes it would be because the associated benefits are anticipated to offset its incremental cost.

2. Fiscal Effect on State Government

Similar to local governments, should the state choose to purchase HDEVS or HDFCVs for their fleet, a small incremental cost could increase of the vehicle purchase price; the anticipated benefits are expected to offset such cost.

Staff estimates that one CARB Air Resources Engineer (ARE) would be needed starting in fiscal year 2020/2021 to handle the additional administrative workload. Staff estimates this cost to be $182,000 per year. The additional ARE costs could be covered by the use of the Motor Vehicle Account (MVA) initially. Staff plans to explore different funding options like the Air Pollution Control Fund (APCF).

Staff does not anticipate that ZEPCert would affect funding of state programs.

D. Major Regulations

For a major regulation proposed on or after November 1, 2013, a standardized regulatory impact analysis is required. A major regulation is one "that will have an economic impact on California business enterprises and individuals in an amount exceeding fifty million dollars ($50,000,000) in any 12-month period between the date the major regulation is filed with the Secretary of State through 12 months after the regulation is estimated to be fully implemented, as estimated by the agency (Government Code Section 11342.548). The economic impacts of the proposed regulatory actions do not exceed $50 million.

For purposes of Health and Safety Code Section 57005(b), "major regulation" means any regulation that will have an economic impact (compliance cost) on the state's business enterprises in an amount exceeding ten million dollars ($10,000,000) in any year, as estimated by the board, department, or office within the agency proposing to adopt the regulation in the assessment. The economic impacts of the proposed regulatory actions do not exceed $10 million in any year.

X. EVALUATION OF REGULATORY ALTERNATIVES

Government Code section 11346.2, subdivision (b)(4) requires CARB to consider and evaluate reasonable alternatives to the proposed regulatory action and provide reasons for rejecting those alternatives. This section discusses alternatives evaluated and provides reasons why these alternatives were not included in the proposal. As explained below, no alternative proposed was found to be less burdensome and equally effective in achieving the purposes of the regulation in a manner than ensures full compliance with the authorizing law. Further, the Board has not identified any reasonable alternatives that would lessen any adverse impact on small business.
In developing the proposed ZEPCert regulatory proposal, staff considered three alternative proposals. Brief descriptions of the three alternative proposals, including the reasons the three alternatives were rejected, are listed below:

Alternative 1: No zero-emission powertrain warranty reporting and recall requirements

Alternative 1 describes a scenario in which the warranty recall requirements as well as the warranty reporting requirements are removed from the ZEPCert proposal. For zero-emission powertrains, the proposed requirements include warranty reporting at the greater of 1% of sales or 10 warranty claims on a single component and warranty recall at the greater of 4% of sales or 25 warranty claims on a single component. The standard baseline warranty of 3 years, 50,000 miles would remain unchanged in this alternative scenario.

Staff rejected this alternative because it would greatly reduce the ability of the program to address persistent powertrain component failures in the field. One of the objectives of this proposal is to ensure zero-emission powertrains deployed in their intended applications are as effective and reliable as the internal combustion engines they replace. The proposed recall requirements would serve as an instrument by which to fulfill that objective.

Alternative 2: Include Communications Network Requirement

Alternative 2 describes a scenario in which the ZEPCert proposal includes a requirement that powertrain and vehicle manufacturers design their vehicle communications network to a standardized communication language set forth in SAE J1939, "Recommended Practice for a Serial Control and Communications Vehicle Network"[58]. SAE J1939 contains the recommended practice for designing a communications and diagnostics protocol for vehicle components, and facilitates the ability to read malfunction codes and other performance information from the engine control unit using a generic automotive scan tool. Staff rejected this alternative, primarily because of the anticipated costs of implementing a fully SAE J1939-compliant system. That said, staff's current proposal still achieves the original intent of the requirement, which was to push industry towards standardization of HDEV and HDFVC diagnosis and repair.

Through discussions with manufacturers, staff has learned that many different vehicle communication languages are currently being used by the industry today, and to convert a noncompliant communications network to fully comply with SAE J1939 could cost over $100,000 per certification family. Furthermore, SAE J1939 currently does not address all the parameters that are relevant to HDEVs and HDFCVs. Therefore, instead of requiring the communication and diagnostics to be fully SAE J1939-compliant, staff is only proposing to require that specific parameters and all malfunction codes be made available through a generic scan tool, so manufacturers would not be required to completely overhaul the systems they are using today. Staff's proposal, which would act as a stepping stone towards more-standardized access to diagnostic information, would minimize the financial impact on manufacturers while still addressing the most critical parameters for diagnosing HDEV and HDFCV issues.

Alternative 3: No Action

This alternative was rejected because staff believes the proposed ZEPCert regulation is necessary to support the many zero-emission efforts currently underway or planned in California. If no action is taken, the market will continue to lack the transparency, consistency, and stability needed to accelerate the transition of the heavy-duty sector to zero-emission.

Small Businesses

Staff did not evaluate an alternative approach for small businesses because the proposed ZEPCert provisions would not be required of any manufacturer. Should the proposed ZEPCert pathway be incorporated as a requirement in future zero-emission measures, it would be more appropriate to evaluate alternative approaches for small businesses in those individual measures.

Health and Safety Code section 57005 Major Regulation Alternatives

The proposed regulation will not result in a total economic impact on state businesses of more than $10 million in one or more years of implementation. Therefore, this proposal is not a major regulation as defined by Health and Safety Code section 57005.

XI. JUSTIFICATION FOR ADOPTION OF REGULATIONS DIFFERENT FROM FEDERAL REGULATIONS CONTAINED IN THE CODE OF FEDERAL REGULATIONS

While staff's proposal would not duplicate or conflict with federal regulation, it would establish an optional certification pathway for HDEVs and HDFCVs that contains enhanced (i.e., more-robust) requirements. The current federal certification requirements for such vehicles, which are substantially similar to California's existing Phase 2 requirements, would be appropriate if the pace at which the heavy-duty sector transitions to zero-emission technology was left to be determined by market forces. However, given California's aggressive efforts to accelerate this transition, more-robust certification procedures are needed.

XII. PUBLIC PROCESS FOR DEVELOPMENT OF THE PROPOSED ACTION (PRE-REGULATORY INFORMATION)

CARB staff developed the proposed regulatory actions through an extensive public process. Staff made a considerable effort to inform, involve, and update the public and stakeholders of its progress during development of the proposed regulation and amendments. CARB staff held stakeholder meetings, conducted public workshops, and met with interested parties to discuss issues and seek comments. This section presents a summary of these efforts.

Public Workshop and Work Group Meetings

Staff conducted four public workshops and three work group meetings between November 29, 2017, and July 25, 2018 to discuss issues and seek comment. Interested stakeholders participated in the workshop in person or via webinar or teleconference. The workshop and work group meeting notices were posted on the Zero-Emission Powertrain Certification Regulation webpage at: https://ww2.arb.ca.gov/our-work/programs/zero-emission-powertrain-certification and distributed to subscribers on the ZEPCert Listserve, which includes over 636 subscribers as of August 28, 2018.

Stakeholder Meetings

Staff held numerous meetings with the Truck and Engine Manufacturers Association (EMA) to discuss development of the proposed ZEPCert regulation and solicit feedback. Several EMA members participated in each meeting, some in person, and others over the phone.

Staff also held numerous individual meetings with vehicle, engine, and technology manufacturers, including both relatively smaller technology manufacturers as well as major engine and vehicle manufacturers, to solicit feedback and to understand the unique concerns of every manufacturer type.

Staff also interviewed several fleets with HDEV and HDFCV experience to learn about their concerns and solicit feedback. Staff used HVIP information to generate the fleet contact list. Overall, staff spoke with 16 different fleets (eight public, eight private) representing over 300 HDEVs and HDFCVs.

Staff also met with other stakeholders, including testing laboratories, scan tool manufacturers, other governmental agencies, and environmental groups, during the development of the ZEPCert proposal.

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XIV. APPENDICES

Appendix A	Proposed Regulation Order for Alternative Certification Requirements and Test Procedures for Heavy-Duty Electric and Fuel-Cell Vehicles and Proposed Standards and Test Procedures for Zero-Emission Powertrains
Appendix B	Draft Environmental Analysis For the Proposed Zero-Emission Airport Shuttle Regulation and Zero-Emission Powertrain Certification Regulation
Appendix C	Proposed Zero-Emission Powertrain Certification Amendments to California Greenhouse Gas Exhaust Emission Standards and Test Procedures for 2014 and Subsequent Model Heavy-Duty Vehicles
Appendix D	Proposed California Standards and Test Procedures for New 2021 and Subsequent Model Heavy-Duty Zero-Emission Powertrains
Appendix E	Purpose and Rationale for Each Regulatory Provision