

# Zero-Emission Powertrain Certification (ZEP Cert)

1st Public Workshop  
El Monte, CA  
November 29, 2017

Meeting materials available at:  
<https://ww2.arb.ca.gov/our-work/programs/zero-emission-powertrain-certification>



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## Agenda

- California's Long-Term Climate and Air Quality Challenges
- Policy Objectives
- Key Technology-Advancing Programs
- ZEP Cert Applicability
- Current On-Road Heavy-Duty Certification Process
- ZEP Cert Framework for On-Road Powertrains
- Optional Off-Road ZEP Cert Process
- Next Steps



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## Written Questions and Comments

Please send written questions & comments to:  
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## California's Long-Term Climate and Air Quality Challenges

- California needs significant additional NO<sub>x</sub> and GHG reductions beyond what can be achieved by existing technologies
- 90% NO<sub>x</sub> reduction needed by 2031 to attain NAAQS in South Coast from Heavy-Duty Mobile Sources
- 80% GHG reduction needed statewide for 2050 climate goals
- Broad deployment of zero- and near zero-emission technologies needed



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## Policy Objectives

- Empower Fleet Decision Making
  - Provide a Pathway for New Technology Providers
  - Support Robust Regulatory Development
  - Support Effective Funding Program Implementation
- Help Accelerate the Transition to Zero-Emission Technologies



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## Key Technology-Advancing Programs Current and Future

- Innovative Clean Transit
- Zero-Emission Airport Shuttle Bus
- Advanced Clean Local Truck
- Zero-Emission Airport Ground Support Equipment
- Zero-Emission Transportation Refrigeration Units
- Advanced Technology Off-Road
- Incentives Programs, such as the Hybrid and Zero-Emission Vehicle Incentive Program and the Carl Moyer Program



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# Zero-Emission Powertrain Certification

## Applicability


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## Applicability

- On-Road: Powertrains installed in zero-emission vehicles not certified under the existing light-duty ZEV program
  - Heavy-Duty Vehicles
  - Incomplete Medium-Duty Vehicles
- Off-Road: Optional, separate process for zero-emission powertrains


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# Zero-Emission Powertrain Certification

## Current On-Road Heavy-Duty Certification Process

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*On-Road*

## Current Heavy-Duty Certification Process

- Separate Engine/Vehicle Certifications
  - Engines certify to criteria-pollutant and HD Phase 1 engine GHG emission standards
  - If applicable, vehicles certify to evaporative emission standards
  - Vehicles certify to HD Phase 1 vehicle GHG emission standards
- Accommodates multi-stage manufacturing process of HD vehicles

 CARB

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On-Road

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## Current Certification Process for Heavy-Duty Zero-Emission Vehicles

- Vehicle Certification per HD Phase 1
  - Identify intended service and applications
  - Provide zero-emission powertrain component specifications
  - No testing required
- No certification requirements/process for zero-emission powertrains



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## Zero-Emission Powertrain Certification

### Conceptual ZEP Cert Framework for On-Road Powertrains




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On-Road

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## Conceptual ZEP Cert Framework

- Required starting with 2023 model year. Optional before then.
- Testing to demonstrate performance and durability
- System monitoring and reporting
- Warranty and repairability
- Pathway for ZEP manufacturers

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## Zero-Emission Powertrain Certification

### Range Testing

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## Powertrain Range Testing

- Goal  
Demonstrate a vehicle's ability to perform zero-emission work (e.g., vehicle range, other work metric?)
- Proposal
  - Testing similar to light-duty ZEV program
  - Information only. No minimum range standard.



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On-Road

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## LD ZEV Range Testing for Battery-Electric Vehicles

- Vehicle Test
- Range Test Procedure
  - Urban: Repeat UDDS (urban) on chassis dynamometer until vehicle falls off trace
  - Highway: Repeat HFEDS (highway) on chassis dynamometer until vehicle falls off trace
  - Measure energy consumption and range
- SAE J1634 could be used in lieu of urban range test



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On-Road

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## LD ZEV Range Testing for Fuel Cell Vehicles

- SAE J2572
- Vehicle test on chassis dynamometer
- May use range test procedures for battery-electric vehicles in lieu of SAE J2572



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## Modified Range Test for ZEPs

- Test cycles and conditions selected to reflect heavy-duty vehicle service class and application
- Include flexible approach that would allow demonstration on a test track in lieu of a chassis dynamometer
- Durability Demonstration




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## Zero-Emission Powertrain Certification


### Durability Demonstration

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## Durability Demonstration

- Key Concern: Battery and fuel cell durability and longevity
- Proposal:
  - Establish a powertrain aging requirement
    - Real-world, over-the-road aging
    - Accelerated “bench” aging
  - Perform range test before and after aging
  - Make data available to consumers


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## Zero-Emission Powertrain Certification

### ZEP Certification Families

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- Goal: Minimize testing burden while still generating the data needed
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  - Intended service class: LHD, MHD, HHD (GVWR)
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## Discussion

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## Zero-Emission Powertrain Certification

System Monitoring and Reporting  
Requirements




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## System Monitoring and Reporting Requirements

- OBD-like monitoring
  - Malfunctions
  - System health
  - Diagnostic information
  - Catastrophic component failure
- State of health/charge displayed on dash
- Indicator light to clearly communicate
  - Catastrophic component failure
  - Major malfunctions that could potentially impact operability or longevity of the powertrain/vehicle


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On-Road

## Monitored System Parameters

- Align with OBD II system requirements for LD hybrids
- Energy Storage System (ESS)
  - State of Health; State of Charge; Cell balancing
  - Thermal Management System performance
- Inverter Thermal Management System Performance
- Regenerative braking
- Drive motor operation
- Charger operation
- Other components

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### Warranty and Repairability



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## Warranty and Repairability

- Goal: Key Concern: Vehicle/powertrain durability and longevity
- Proposal
  - Minimum warranty period of 7 years or 70,000 miles, whichever comes first
  - Consistent with the required warranty period for Tier 3 Hybrids per the Innovative Technology Regulation
- Repairability Issues
  - Service and repair networks
  - Service information
  - Parts availability



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## Zero-Emission Powertrain Certification

### Pathway to Market for ZEP Manufacturers

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## Pathway to Market for ZEP Manufacturers

- Staff is investigating whether a new certification pathway is needed to enable ZEP manufacturers that do not manufacture the vehicles in which the ZEPs are installed to bring their technologies to market.
- Staff would like to understand current challenges ZEP manufacturers face and seeks input on potential solutions to those challenges.

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## Zero-Emission Powertrain Certification

### Off-Road Powertrains




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Off-Road

## Optional ZEP Certification Process

- Staff is considering establishing an optional certification process for zero-emission powertrains used in off-road equipment.
- Currently, internal combustion engines used in off-road equipment are required to be certified by CARB, but those certification requirements don't extend to zero-emission powertrains.

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Off-Road

## Optional ZEP Certification Process (cont.)

- Existing and future programs will require off-road equipment to be certified/approved by CARB.
- Staff considering an optional procedure similar to previous approval letter process used for on-road heavy-duty zero-emission vehicles.
  - Information only, no testing requirements
  - Application and sales reporting

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On-Road

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# Zero-Emission Powertrain Certification

California Air Resources Board  
November 29, 2017 Workshop

The information gained under this first phase of testing and certification requirements for the emerging zero-emission powertrain market will inform CARB of the successes and challenges in the transition of commercial fleets and operators to zero-emission technologies. This will also influence how CARB sets the stage for future testing and certification requirements of zero-emission technologies in other market segments.

While this discussion document sets forth key concepts of Zero-Emission Powertrain Certification, other relevant topics may be discussed during the workshop. CARB staff welcomes public comment on this discussion document and the accompanying workshop presentation. For more information, please visit <https://ww2.arb.ca.gov/our-work/programs/zero-emission-powertrain-certification> or contact Matthew Diener, Air Pollution Specialist at (626) 575-6684 or [matthew.diener@arb.ca.gov](mailto:matthew.diener@arb.ca.gov).

## **BACKGROUND**

The South Coast and San Joaquin Valley air basins are the only two areas in the nation in extreme non-attainment of the national ambient air quality standard for ozone. Meeting the federal eight-hour ozone standard will require a 90-percent oxides of nitrogen (NO<sub>x</sub>) emission reduction from 2010 levels in the South Coast by 2031, and will also require significant NO<sub>x</sub> reductions in the San Joaquin Valley and other California regions. In addition, California Executive Order S-03-05<sup>1</sup> sets a greenhouse gas (GHG) target of 80-percent reduction from 1990 levels by 2050. To meet these multiple long-term air quality and climate goals, California must accelerate development and deployment of the cleanest feasible technologies for all vehicle and equipment sectors, with broad deployment of zero- and near zero-emission cars, trucks, and buses.

Near-term focused electrification and progress towards zero-emission technologies are critical to continue to reduce near-source exposure to air toxics and play a growing role in reducing GHG emissions and petroleum use. The California Air Resources Board's (CARB) 2016 Mobile Source Strategy<sup>2</sup> (MSS), therefore, includes actions to deploy zero-emission technologies across a broad spectrum of sources, including passenger vehicles, targeted truck and bus applications, forklifts, transport refrigeration units, and airport ground support equipment. The estimated benefits of CARB's MSS include an 80-percent reduction in smog-forming emissions and a 45-percent reduction in diesel PM emissions in the South Coast from today's levels. Statewide, the strategy would

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<sup>1</sup> Executive Order S-03-05 (2005). <https://www.gov.ca.gov/news.php?id=1861>

<sup>2</sup> California Air Resources Board; May 2016. *2016 Mobile Source Strategy*.  
<https://www.arb.ca.gov/planning/sip/2016sip/2016mobsrsrc.pdf>

also result in a 45-percent reduction in GHG emissions and a 50-percent reduction in the consumption of petroleum-based fuels.

For zero-emission technologies, the MSS calls for the introduction of such technologies in heavy-duty applications that are best suited to their early adoption. Actions to promote zero-emission technologies in heavy-duty applications, such as local delivery, transit and shuttle buses, and other vocational trucks, are underway and are important to further reduce regional and near-source toxics exposure as well as climate change. In addition, such actions will foster the further development of these technologies as they become suitable for broader use. For example, off-road equipment will need to reflect this same type of transformation to zero-emission technologies.

### **Current Certification Requirements**

California law requires new motor vehicles and engines to be certified by CARB for emission compliance before they are legal for sale, use, or registration in California. Currently, in order to receive an on-road certification, a manufacturer must demonstrate that emissions from their heavy-duty engine or vehicle complies with the criteria-pollutant (exhaust and evaporative) and/or GHG standards applicable to that engine or vehicle.

Currently, for zero-emission heavy-duty vehicles, only the vehicles themselves are required to certify per Heavy-Duty Phase 1 GHG requirements.<sup>3</sup> That is, unlike internal combustion engines, zero-emission powertrains are not subject to powertrain-specific certification requirements.

### **Why is Zero-Emission Powertrain Certification Needed?**

CARB staff is currently developing proposals for a number of new regulatory measures that would increase deployments of zero-emission technologies, particularly in the heavy-duty vehicle<sup>4</sup> and off-road equipment segments. To support these potential future zero-emission technology measures, as well as existing incentive programs, CARB staff is also developing certification requirements and procedures that help ensure zero-emission technologies are capable of meeting the reliability and performance expectations of California fleets without hindering the momentum of the advanced technology industry. Staff believes robust, reliable, proven, and well-integrated zero-emission technologies are essential for these technologies to achieve a market foothold in the aforementioned target segments.

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<sup>3</sup> California Air Resources Board (2014, December 9). *Phase I GHG*. Retrieved from <https://www.arb.ca.gov/msprog/onroad/phaselghg/phaselghg.htm>

<sup>4</sup> For the purposes of this concept paper, “heavy-duty vehicles” shall include incomplete medium-duty vehicles (8,501 – 14,000 pounds gross vehicle weight rating), that is, medium-duty vehicles, for which the engine is certified to the standards set forth in Title 13, California Code of Regulations, Section 1956.8.

Specifically, zero-emission powertrain testing and certification requirements could help meet the following policy objectives:

- Empower Fleet Decision Making: Zero-Emission Powertrain Certification could help reduce the perceived risk attributed to zero-emission technology by making key performance and durability information available to purchasers.
- Establish a Pathway to Market for Zero-Emission Powertrain Manufacturers: Zero-Emission Powertrain Certification could provide a pathway to market for manufacturers of zero-emission powertrains that are not positioned to manufacture and certify the vehicles in which their powertrains are installed.
- Support Effective Funding Program Implementation: Zero-Emission Powertrain Certification could enable CARB to ensure zero-emission truck and bus and off-road technologies meet minimum performance criteria to be eligible for CARB incentive programs. Defined certification criteria could also enable CARB to more-effectively target funding to the most robust and innovative technologies (for example, those that meet a minimum zero-emission range).
- Support Robust Regulatory Development: Zero-Emission Powertrain Certification is needed to support existing and potential future technology-advancing measures, such as the Advanced Clean Local Truck, Zero-Emission Airport Shuttle Bus, and Innovative Clean Transit regulations, by ensuring required zero-emission technologies meet specific standards for performance and durability.

## **STAFF'S PROPOSAL CONCEPT**

*The following contains staff's initial concept for zero-emission powertrain certification. This information contained within this document is only intended to be a primer for discussion and should not be viewed as a final proposal.*

## **ON-ROAD HEAVY-DUTY ZERO-EMISSION POWERTRAINS**

### Applicability

Zero-Emission Powertrain Certification would apply to all on-road heavy-duty zero-emission powertrains, including powertrains installed in incomplete medium-duty vehicles. That is, this certification would be required for all applicable zero-emission powertrains before they are legal for sale, use, or registration in California.

### Certification of the Powertrain

The current certification process for heavy-duty vehicles differs from the process for light-duty vehicles, in that both heavy-duty engines and vehicles receive separate certifications. In contrast, light-duty vehicles certify as complete vehicles, i.e., no engine certification. The separate engine/vehicle certification paradigm for

heavy-duty vehicles was structured as such to accommodate an industry that is distinctly different than the light-duty vehicle segment, especially in the way vehicles are manufactured. Specifically, because of the many diverse vehicle configurations and the small number of vehicles per configuration in the heavy-duty vehicle segment, vehicles are typically manufactured in stages. This process allows the industry to be sufficiently nimble in order to accommodate even the most uncommon and obscure vehicle requirements. Staff's proposal intends to build upon this existing framework by establishing certification requirements specifically for zero-emission powertrains, consistent with how internal combustion engines are treated today.

### Range Testing

A key area of concern for a purchaser of a zero-emission vehicle is its ability to perform the functions of the legacy internal combustion engine that it replaced. Therefore, similar to the light-duty zero-emission vehicle (ZEV) program<sup>5</sup>, staff is intending to establish certification procedures that would demonstrate a vehicle's ability to do work, e.g., vehicle range. While there would be no minimum standard to which the vehicle must certify, the demonstration results would be made available to consumers so that they would be able to make more-informed purchasing decisions.

As stated above, staff is considering establishing procedures similar to those currently used for light-duty ZEVs.<sup>6</sup> However, certain test elements, such as test cycles and test conditions, could be modified so that they are consistent with the expected operation of heavy-duty vehicles and the conditions in which they typically operate. Additionally, staff is considering a more-flexible approach that would allow demonstration testing on a test track in lieu of a chassis dynamometer (as required in light-duty ZEV procedure).

While testing would be performed on a complete vehicle, the certification would be issued to the *powertrain* and could apply to multiple powertrain configurations assigned to a "bin," potentially based on the ultimate vehicle's gross vehicle weight rating (GVWR). The testing could be required only on the manufacturer's worst-case configuration of a bin, which would reduce the amount of testing a manufacturer would be required to perform while still providing the necessary information to the consumer.

For the purpose of this discussion document, the powertrain includes components,

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<sup>5</sup> California Air Resources Board (2017, October 13). *Zero Emission Vehicle (ZEV) Program*. Retrieved from <https://arb.ca.gov/msprog/zevprog/zevprog.htm>

<sup>6</sup> California Air Resources Board (2015). *California Exhaust Emission Standards and Test Procedures for 2018 and Subsequent Model Zero-Emission Vehicles and Hybrid Electric Vehicles, in the Passenger Car, Light-Duty Truck and Medium-Duty Vehicle Classes*.

[https://www.arb.ca.gov/msprog/levprog/cleandoc/2018+%20my%20hevtps\\_clean%20complete\\_1-16.pdf](https://www.arb.ca.gov/msprog/levprog/cleandoc/2018+%20my%20hevtps_clean%20complete_1-16.pdf)  
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such as battery modules, fuel cell stack, capacitors, battery management system, thermal control hardware, air filtration system, controllers, power electronics, wiring, electric motors, etc.

### Durability Demonstration

Battery and fuel cell durability and longevity is another key concern that purchasers of zero-emission vehicles have. Durability is especially important for the vehicles in the heavy-duty segment because these vehicles are typically used in revenue service and could be very unique in their purpose, i.e., difficult to replace. To address this, staff is proposing to include a powertrain aging requirement. This requirement could be approached in multiple ways as outlined below:

- Real-world, over-the-road aging of a vehicle equipped with the battery or fuel cell system.
- Accelerated “bench” aging of the battery or fuel cell system (e.g., exposure to high temperature, high charge/discharge rate cycling, etc.).

Staff has not yet determined what an appropriate aging threshold should be, but it should sufficiently stress the powertrain and provide durability information that is useful. Staff is seeking comments (and data) on appropriate durability demonstration procedures that would provide quantifiable and reliable data on durability as well as help drive the development and deployment of robust zero-emission powertrains.

### System Monitoring and Reporting

Currently, no standardized monitoring or open access communication protocol exists for zero-emission vehicles to communicate system malfunctions or system state of health to the operator. As a starting point for discussion, staff is considering to establish requirements to monitor the same parameters currently being monitored in hybrids per on-board diagnostics (OBD) provisions.<sup>7</sup> Such parameters currently include, but are not limited to, state of health, state of charge, and cell balance of the energy storage system as well as thermal-management and regenerative-braking performance.

Staff is also considering to establish requirements to display certain information via the vehicle dashboard, so that the operator is aware at all times of the current

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<sup>7</sup> California Air Resources Board (2016). California Code of Regulations, Title 13, Section 1968.2; *Malfunction and Diagnostic System Requirements – 2004 and Subsequent Model-Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines*.

[https://govt.westlaw.com/calregs/Document/IBDFC18179E764C58A4E91F0BB6CCA0D9?originationContext=Search+Result&listSource=Search&viewType=FullText&navigationPath=Search%2fv3%2fsearch%2fresults%2fnavigation%2fi0ad62d34000015fcb4bcf0681f361a3%3fstartIndex%3d1%26Nav%3dREGULATION\\_PUBLICVIEW%26contextData%3d\(sc.Default\)&rank=1&list=REGULATION\\_PUBLICVIEW&transitionType=SearchItem&contextData=\(sc.Search\)&t\\_T1=13&t\\_T2=1968.2&t\\_S1=CA+ADC+s](https://govt.westlaw.com/calregs/Document/IBDFC18179E764C58A4E91F0BB6CCA0D9?originationContext=Search+Result&listSource=Search&viewType=FullText&navigationPath=Search%2fv3%2fsearch%2fresults%2fnavigation%2fi0ad62d34000015fcb4bcf0681f361a3%3fstartIndex%3d1%26Nav%3dREGULATION_PUBLICVIEW%26contextData%3d(sc.Default)&rank=1&list=REGULATION_PUBLICVIEW&transitionType=SearchItem&contextData=(sc.Search)&t_T1=13&t_T2=1968.2&t_S1=CA+ADC+s)

system state of health and/or state of the charge, if applicable. A dashboard indicator, similar to the malfunction indicator light in OBD, could be required for catastrophic component failures or major malfunctions that could potentially impact the operability or longevity of the vehicle.

#### Warranty and Repairability

Staff is considering a warranty period of 7 years or 70,000 miles, whichever comes first. This is in line with the required warranty period for Tier 3 hybrid conversions per the Innovative Technology Regulation.<sup>8</sup>

In addition, staff would like to establish provisions that facilitate the expedient repair of certified zero-emission vehicles under warranty as well as an operator's ability to repair a vehicle after the warranty period has expired. Therefore, staff would like to discuss concepts, such as required service-and-repair networks and availability of vehicle service information.

#### Pathway to Market for Zero-Emission Powertrain Manufacturers

Staff is considering provisions that provide a pathway to market for powertrain manufacturers who develop robust, reliable, and well-integrated zero-emission technologies, but are not positioned to manufacture or certify the vehicles in which the technologies will be installed. Staff believes establishing such a pathway will promote and encourage new technology providers to enter the industry thereby driving increased market competition, product innovation, and consumer choice.

### **OFF-ROAD ZERO-EMISSION POWERTRAINS**

Staff is also considering to establish a certification process for zero-emission powertrains used in mobile off-road equipment. Like heavy-duty vehicles, internal combustion engines of off-road equipment are currently required to be certified by CARB, but the certification requirements do not extend to zero-emission powertrains. Therefore, through this measure, staff will also be evaluating the possibility of establishing an optional certification pathway for off-road zero-emission powertrains.

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<sup>8</sup> California Air Resources Board (2017). *California Certification and Installation Procedures for Medium- and Heavy-Duty Vehicle Hybrid Conversion Systems*. <https://www.arb.ca.gov/regact/2016/itr2016/hybconvproc.pdf>  
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