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**COMMENTS OF MECA CLEAN MOBILITY
ON THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY'S PROPOSED
MULTI-POLLUTANT EMISSIONS STANDARDS FOR MODEL YEARS 2027 AND LATER
LIGHT-DUTY AND MEDIUM-DUTY VEHICLES
EPA-HQ-OAR-2022-0829-0533**

MECA Clean Mobility (MECA) is pleased to provide comments in support of the United States Environmental Protection Agency's (EPA) Proposed Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles (LDMDV). In the past decade since the Tier 3 regulation was finalized there have been several developments in the light- and medium-duty emission control technology sector. MECA believes an important opportunity exists for performance-based standards to continue to cost effectively reduce NOx, PM, VOCs and GHGs in all segments of the light- and medium duty fleets through the application of advanced internal combustion engine and electrified powertrain system technologies. We also support EPA's proposed measures that will advance efficiency and ensure improved durability and operability of electric vehicles that will benefit owners and contribute to emission reductions.

MECA is a non-profit association of the world's leading manufacturers of technologies for clean mobility. Our members have nearly 50 years of experience and a proven track record in developing and manufacturing emission control, engine efficiency, battery materials, components and charging as well as electric propulsion technology for a wide variety of on-road and off-road vehicles and equipment in all world markets. Our industry has played an important role in the emissions success story associated with light-, medium- and heavy-duty vehicles in the United States, and has continually supported efforts to develop innovative, technology advancing, emission reduction programs to improve ambient and local urban air quality while reducing greenhouse gases.

MECA members represent over 70,000 of the nearly 300,000 North American jobs building the clean mobility technologies that improve the fuel economy, reduce emissions and transition on-road and non-road vehicles to zero tailpipe emissions. These jobs are located in nearly every state in the United States – the top 10 states being Michigan, Texas, Illinois, Virginia, New York, Indiana, North Carolina, Ohio, Pennsylvania, and South Carolina. The mobile source emission control industry has generated hundreds of billions of dollars in U.S. economic activity since 1975 and continues to grow and add more jobs in response to environmental regulations. Emission control, engine efficiency and electric technology manufacturers invest billions of dollars each year in developing the technologies that reduce emissions from mobile sources. In fact, automotive technology suppliers account for approximately 40% of the auto R&D conducted in the U.S. each year[1].

In order to simultaneously meet future NMOG+NOx, PM and GHG emission standards, several pathways are available through a combination of advanced technologies. These include full electrification, hydrogen fuel cell electric vehicles, as well as electrified powertrains with engines employing advanced combustion components such as turbochargers, EGR systems, cylinder deactivation, high pressure fuel injection, exhaust emission control catalysts, substrates and evaporative control system architectures. Finalization of the proposed LDMDV regulatory provisions will provide certainty to technology suppliers and their OEM customers who continue to invest billions of dollars each year in developing the technologies that reduce mobile source criteria and carbon emissions.

Of particular note, technology suppliers rely upon their legacy businesses to make investments in technology development and manufacturing to prepare for the future needs of their customers. Finalization of the proposed rule will provide regulatory certainty to suppliers. However, while electric vehicle technology is mature at this point, there is still considerable uncertainty in the timeline for market penetration. We believe the rate of electrification estimated for compliance in EPA's proposed pathway to be ambitious, and MECA members remain concerned about the rate of charging infrastructure build-out as well as short and medium-term availability of sufficient critical minerals to support their investments. In addition, unforeseen disruptions in electrical power availability have occurred. Our comments suggest measures that EPA should consider related to charging infrastructure and critical minerals to address these concerns.

MECA appreciates the time and effort that EPA staff put into the regulatory process, under a compressed timeframe, and we support this important regulation. We thank EPA staff for their dedication in receiving and incorporating feedback from a broad range of stakeholders.

***Summary***

MECA supports EPA's LDMDV proposal with some modifications, which we feel will strengthen the regulation. Our comments for EPA's consideration are summarized here and explained in greater detail in the text that follows:

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[1] Motor & Equipment Manufacturers Association, Moving America Forward (2013), https://www.mema.org/resource/2013-economic-impact-study-moving-america-forward

1. EPA should try to finalize this proposed rule by the end of 2023 in order to provide lead time that would enable implementation of the medium-duty vehicle requirements prior to MY 2030.
2. Stringent NMOG+NOx requirements will yield substantial air quality benefits.
3. EPA should consider setting a cap of 300 mg/mi for the -7℃ FTP NMOG+NOx standard rather than a fleet average at that level.
4. PM requirements should be implemented at a faster pace based on the combination of the predicted rate of electrification alongside a feasible rate of PM emission control technology implementation. MECA recommends a phase-in schedule of 60% in MY 2027, 90% in MY 2028 and 100% in MY 2029.
5. MECA supports technologically feasible OBD requirements that enable monitoring of technologies for achieving EPA's proposed PM standard.
6. EPA should extend the refueling emission requirements to all incomplete spark-ignition (SI) vehicles as proposed.
7. EPA should consider adopting additional requirements for SI vehicles with pressurized fuel systems for management of fuel vapors from fuel cap removal and refueling (also commonly referred to as puff losses).
8. EPA should finalize provisions for all MD engines in MDVs with GCWR > 22,000 lbs to meet MY 2027 heavy-duty engine certification requirements, and compliance should be in accordance with the heavy-duty standards.
9. Commanded enrichment should be phased-out for all MDVs.
10. EPA should align with CARB's ACCII requirements for PHEV high power cold starts, early drive-away, and mid-temperature engine starts. Similar to CARB, EPA should allow PHEVs with all electric range greater than or equal to 50 miles to be exempt from the high power cold start requirement.
11. EPA should conduct a prospective analysis of appropriate PHEV utility factors based on more recent PHEV models with longer all electric range likely to result in a shift to greater electric operation. PHEVs all electric range greater than 50 miles should be allowed to claim higher utility factors.
12. Rather than permanently removing the requirement for BEV certification to account for upstream electricity generation, EPA should require upstream emission accounting for the generation of energy to power electric vehicles.
13. EPA should consider incentives and potential future requirements that advance efficiency of electric vehicles.
14. MECA supports alignment with UNECE GTR No. 22 for light-duty vehicles and 22b (when finalized) for medium- and heavy-duty vehicles for battery durability and consideration of phase-in to match vehicle useful life in later years.
15. MECA supports EPA's proposed battery and vehicle component warranty requirements.
16. EPA should harmonize battery labeling requirements with ACC II to facilitate vehicle servicing, shipping and recycling.
17. EPA should work with other agencies, like the Joint Office on Energy and Transportation, in setting minimum charger efficiency standards to ensure that

infrastructure funds are spent on chargers with the best utilization of electric power.

18. Advanced technology credit multipliers for PHEV, BEV and FCEV should end before MY 2027.
19. Off-cycle credits provide real-world emission benefits and should continue to be offered.

***EPA should try to finalize this proposed rule by the end of 2023 in order to provide lead time that would enable implementation of the medium-duty vehicle requirements prior to MY 2030.***

MECA appreciates the need for EPA to set standards respective to the lead time requirements stipulated in section 202(a)(3)(C) of the Clean Air Act. For this reason, the NPRM proposes new requirements for vehicles with GVWR > 6,000 lbs. to begin with MY 2030. We support EPA's inclusion of multiple voluntary early compliance pathways for vehicles with GVWR > 6,000 lbs offered in the proposed rule. Our analysis concludes that technologies are commercially available to enable phase-in of proposed medium-duty vehicle criteria pollutant standards starting with MY 2028, which EPA recognized in the proposal by allowing for alternative early compliance pathways. Therefore, we request EPA work to finalize this proposed rule by the end of 2023. We believe this will provide the necessary lead time to begin the required phase-in of criteria pollutant standards for vehicles with GVWR > 6,000 lbs starting with MY 2028.

The previous light-duty GHG and CAFE regulations covering MY 2017-2025 included provisions for mid-term evaluation or review. These regulations were designed to set emission standards further into the future than this regulation proposes. In addition, significant uncertainty existed during the handling of the previous mid-term review. For these reasons, MECA does not support a similar mid-term evaluation provision in this proposal nor compliance "off-ramps" that would be triggered by results of a review.

***Stringent NMOG+NOx requirements will yield substantial air quality benefits.***

Assuming roughly 15 million new vehicles are sold per year and EPA's electrification estimates in the proposal, approximately 40 million light-duty ICE vehicles will be sold between MY 2027 and MY 2032. Many of these will remain on the road until 2050. MECA agrees with EPA's technology neutral regulatory approach that considers a combination of technologies from electrification to improved emission controls on ICE vehicles.

Our analysis of currently available certification data supports that vehicle manufacturers are making substantial progress on the path to the SULEV30 fleet average level with only the inclusion of a modest number of HEVs, PHEVs and BEVs. It has now been over twenty years since the first vehicle was certified to the SULEV30 standard and seven years since the first SULEV20. Advances in catalyst technology and honeycomb substrates have evolved to achieve NMOG+NOx emission levels well below 20 mg/mile and supports both the introduction of certification bins below the current lowest level as well as potential to achieve lower fleet average emission levels. Furthermore, catalyst coating technology combined with targeted precious metal placement has been successful in controlling costs in light of rising raw material prices.

The use of existing engine, hybrid powertrains and exhaust emission control architectures have also facilitated achieving the lowest SULEV20 and SULEV30 NMOG+NOx emission levels and significant $CO_2$ reductions cost-effectively. Today, even larger SUVs and mini-vans with conventional and hybrid powertrains are being certified to the SULEV30 limit while further technology improvements continue to be incorporated into new production vehicles to enable compliance with the declining NMOG+NOx fleet average. The introduction of the additional bins as proposed by EPA will provide greater certification flexibilities to manufacturers that will complement increasing sales of electric vehicles to achieve lower fleet average emission targets.

***EPA should consider setting a cap of 300 mg/mi for the -7℃ FTP NMOG+NOx standard rather than a fleet average at that level.***

MECA commends EPA's proposal to replace the existing -7℃ FTP NMHC fleet average standards with a single -7℃ FTP NMOG+NOx standard of 300 mg/mi for LDV, LDT1 through 4 and MDPVs. We agree with the provisions of not averaging EVs into this fleet average standard, identical useful life coverage, and application of the same standard at high altitude. EPA emissions testing of vehicles in the MY 2019-2021 range at -7°C FTP showed that a 300 mg/mi standard is feasible with a large compliance margin for NMOG+NOx. Furthermore, a combination of revised calibration strategies and heating technologies, available to MY 2027 and later vehicles, could provide additional margin below the 300 mg/mi fleet average. First, vehicles designed for MY 2027 and later standards can incorporate targets based on a new cold temperature standard into new engine calibrations. Second, vehicles could also employ (separately or in tandem with engine calibration changes) electric heat in the exhaust stream via an electric heater or directly to the three-way catalyst (electrically heated catalyst or EHC). For these reasons, MECA suggests EPA consider finalizing a 300 mg/mi cap rather than a fleet average.

***PM requirements should be implemented at a faster pace based on the combination of the predicted rate of electrification alongside a feasible rate of PM emission control technology implementation.***

On January 6, 2023, EPA announced its proposed decision to revise the primary (health-based) annual $PM_{2.5}$ standard from its current level of 12.0 µg/m$^3$ to within the range of 9.0 to 10.0 µg/m$^3$. In September 2021, both the United Nations World Health Organization[2] (WHO) and the Health Effects Institute (HEI) concluded that there is no

[2] World Health Organization. (2021). WHO global air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. World Health Organization. https://apps.who.int/iris/handle/10665/345329.

identified safe threshold for $PM_{2.5}$ or black carbon, at which no damage to health is observed. In particular, the HEI announced[3] that a recent European study using state-of-the-art exposure methods and large cohorts in high income countries found that health impact risks were still evident at levels lower than current ambient standards for $PM_{2.5}$, $NO_2$ and $O_3$. In particular, the study reported that the hazard ratios for natural-cause mortality remained elevated and significant for $PM_{2.5}$ even when the analyses were restricted to observations below 12 $\mu g/m^3$.

University researchers in the U.S. have reported that light duty gasoline vehicle emissions remain prominent amongst the emission source sectors that cause the largest absolute disparities for persons of color communities (POCs include Blacks, Hispanics, and Asians)[4]. These latest developments highlight the importance of continued tightening of the $PM_{2.5}$ standards to further reduce exposure and the impacts of the remaining light duty gasoline fueled vehicles on underserved communities.

To meet tightening particulate standards in other global regions, including Europe, China and India, fuel injection and gasoline particulate filter (GPF) suppliers have continued to improve their commercially available technologies. In fact, nearly every European GDI engine car is currently certified with a GPF, and LDVs in Europe have been required to meet the approximate equivalent of a 0.5 mg/mile standard since 2017 due to the implementation of a particle number standard. This standard applies to nearly all driving conditions and cycles. China has gone as far as requiring all diesel and gasoline cars to be equipped with the best available control technology, based on wall flow filters, that diesels have used in the US since 2007.

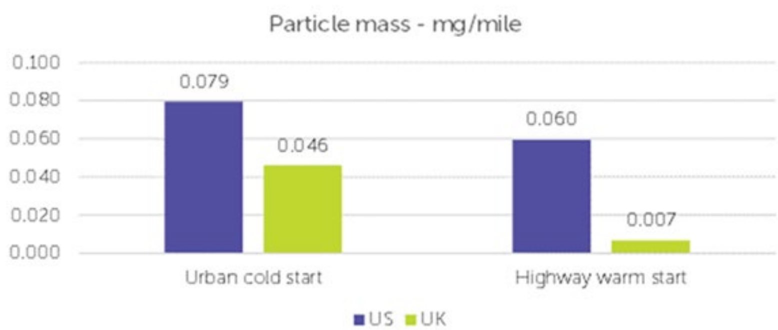


*Figure 1. In-use Particle Mass Comparison from four equivalent vehicle pairs compliant with current U.S. and U.K.*

Source: Emissions Analytics, The Septillion Particle Problem, https://www.emissionsanalytics.com/news/the-septillion-particle-problem-literally

By 2023, four years ahead of the start of EPA's proposed PM limit implementation phase-in, two-thirds of the major automotive producing regions of the world will be

[3] https://www.healtheffects.org/announcements/hei-study-europe-finds-evidence-health-effects-lower-levels-air-pollution

[4] https://www.science.org/doi/10.1126/sciadv.abf4491.

meeting tighter PM emission standards similar to those now proposed by EPA. Recent in-use particle mass measurements made from four equivalent vehicle pairs compliant with current U.S. and U.K. standards[5] illustrate the potential particulate mass reductions that could be obtained from adopting equally protective standards as those in Europe, China and India (Figure 1).

In addition, future Euro 7 standards are expected to further tighten the particle number limit to $1x10^{11}$ per km (ca. <0.5 mg/mile) and regulate solid ultrafine particles down to 10 nm in diameter[7] to reflect the feasibility of the control technologies. Euro 7 regulations will likely also expand the operating window to include lower temperature operation, higher altitude and towing. In anticipation of these tighter limits over extended duty operation, suppliers have improved fuel injection[6,7] as well as diesel and gasoline particulate filters[8] and some OEMs are already achieving these tighter limits in Europe as presented by the CLOVE consortium to the Advisory Group on Vehicle Emission Standards in 2020[9].

To highlight the air quality benefits of more stringent PM requirements, MECA funded a study[10] to model the benefits of a national 0.5 mg/mile PM standard that is approximately equivalent in mass to the particle number standard in other global regions. The environmental impact of the modeled standards was evaluated for the 49-state plus District of Columbia modeling domain using EPA references and tools. The domain was divided into separate certification regions of seventeen Section 177 states (i.e., those that have adopted California standards) and thirty-two states plus DC[11] subject solely to federal certification requirements. Importantly, the magnitude of the emission inventory impact of the modeled standards is significantly influenced by the degree to which the light-duty fleet becomes electrified. The rate of future-year electrification, an uncertain modeling variable, was handled as a range by defining the following 3 scenarios.

- Low range electrification was defined by the electrification forecast of new vehicle sales as completed in the Energy Information Agency (EIA) Annual Energy Outlook 2022 (AEO2022). This represents approximately 17% new vehicle sales in 2050.
- Mid range electrification was defined by a 10 to 15-year delay in achieving the high range scenario targets (by sector) with 100% electrification of all on-road sales by model year 2060.
- High range electrification was defined by the electrification rate if all California zero emission vehicle regulations as well as all federal executive orders and memoranda

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[5] https://www.emissionsanalytics.com/news/the-septillion-particle-problem-literally

[6] Yamaguchi, A., Dillner, J., Helmantel, A., Koopmans, L. et al., SAE 2023-01-0239.
[7] LOW-KAME, J., Oung, R., Meissonnier, G., Da Graca, M. et al., SAE 2023-01-0284.
[8] Obata, S., Furuta, Y., Ohashi, T., and Aoki, T., SAE 2023-01-0394.
[9] https://circabc.europa.eu/sd/a/fdd70a2d-b50a-4d0b-a92a-e64d41d0e947/CLOVE%20test%20limits%20AGVES%202020-10-27%20final%20vs2.pdf

[10] https://www.meca.org/wp-content/uploads/2023/06/LDV_PM_Standard_Final_Report_06272023.pdf
[11] DC enacted California standards by December 2022, after the impact assessment had commenced.

of understanding were achieved. This scenario achieves 100% electrification of all on-road sales by model year 2050 with key sector sales becoming fully electrified as early as model year 2035 (i.e., light-duty vehicles sold in the California certification region).

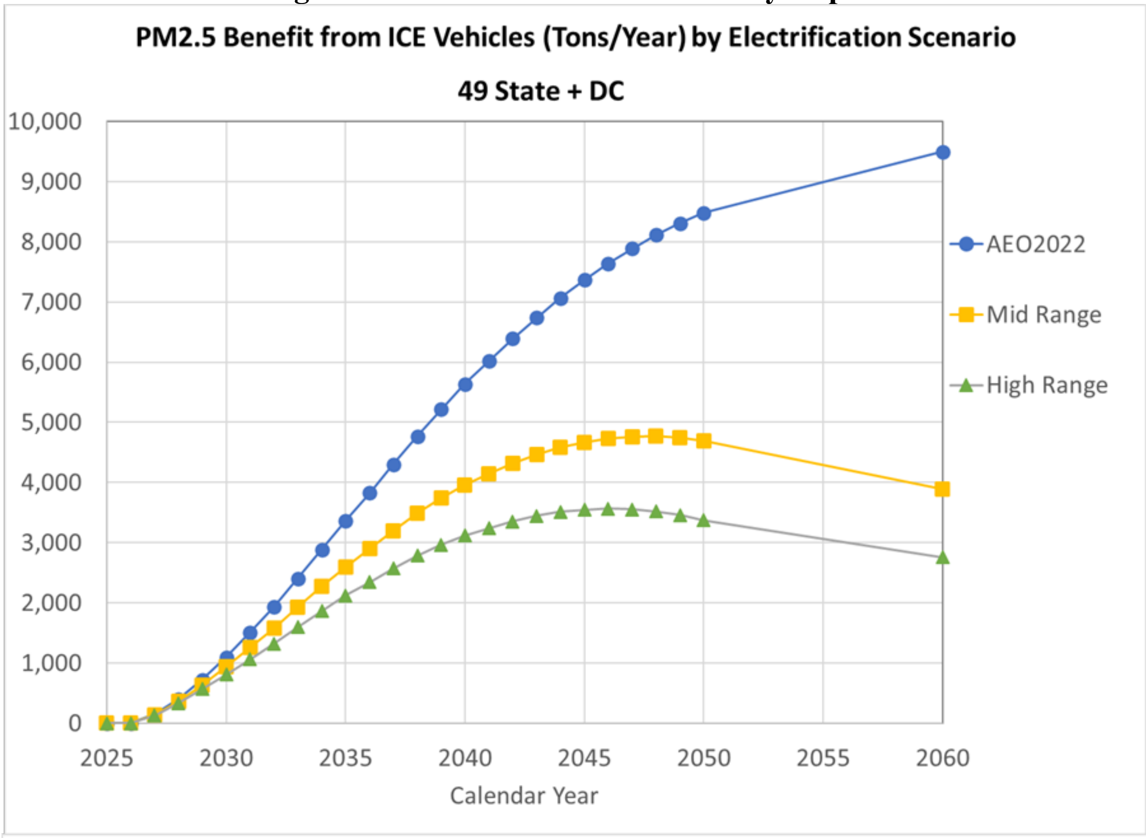
Figure 2 summarizes the annual PM2.5 and BC inventory impacts for the modeling domain for the years 2025 to 2060. Up to an estimated 7 and 10 thousand tons/year of BC and PM2.5 exhaust from internal combustion engine (ICE) vehicles would be eliminated in each year. In the fully phased-in fleet (i.e., CY2060), the pollutant benefits are equal to reductions in the light-duty fleet of 91 and 85% for exhaust BC and PM2.5, respectively. Moreover, the continuation of benefits to CY2060 results indicate that the environmental impact of emission controls on internal combustion engines will be significant well into the future – independent of the electrification rate scenario.

Cumulative heath impact valuations, based on recently updated EPA data from the 2012 PM National Ambient Air Quality Standards (NAAQS) revision, are summarized in Figures 3, 4 and 5 for the low, mid and high electrification scenarios, respectively. The total health valuation, due to the reduced frequency of health incidences under the modeled regulatory case, results in estimated health cost savings of between 18 billion and 163 billion dollars (cumulative through 2050). The range in total valuation is due to (1) incidence rates defined as a range, (2) the discount rate defined as a range, (3) monetary benefits by incidence defined as a range, and (4) the range in PM2.5 benefit realized by electrification rate scenario. These health cost savings come from the estimated 58 to 112 thousand tons of cumulative PM2.5 benefits under the modeled regulatory case.

Within these PM2.5 benefits, an estimated 42 to 81 thousand tons of black carbon would be eliminated. Another way to look at the comparative cumulative benefits presented in Figures 2 and 4 suggests that deploying a regulatory control strategy that includes a combination of electric vehicle penetration and best available exhaust controls on the remaining combustion vehicles approximately doubles the PM2.5 reductions achievable by electrification alone (112 versus 58 thousand tons of PM2.5 or 81 versus 42 thousand tons of BC).

Given the majority of the global vehicle market has, for many years, been deploying commercially available technologies to achieve PM standards more stringent than those proposed by EPA, MECA recommends a more rapid phase-in schedule than EPA's proposed rate of 40%/80%/100% in MY 2027/2028/2029. Rather, we support a schedule of 60% in MY 2027, 90% in MY 2028 and 100% in MY 2029. The basis for this phase in rate is a combination of EPA's assumed rate of electric vehicle penetration and EPA's proposed phase-in rate for the remainder of the ICE sales fleet. In MY 2027, EPA assumes 37% BEV sales. If the remaining ICE vehicle share (63%) is multiplied by the 40% phase-in and added to the 37% BEV share, the total feasible rate of PM standard phase-in is 62.2%. In MY 2028, EPA assumes 45% BEV sales. If the remaining ICE vehicle share (55%) is multiplied by the 80% phase-in and added to the 45% BEV share, the total feasible rate of PM standard phase-in is 89%.

**Figure 2. Annual Emission Inventory Impact**



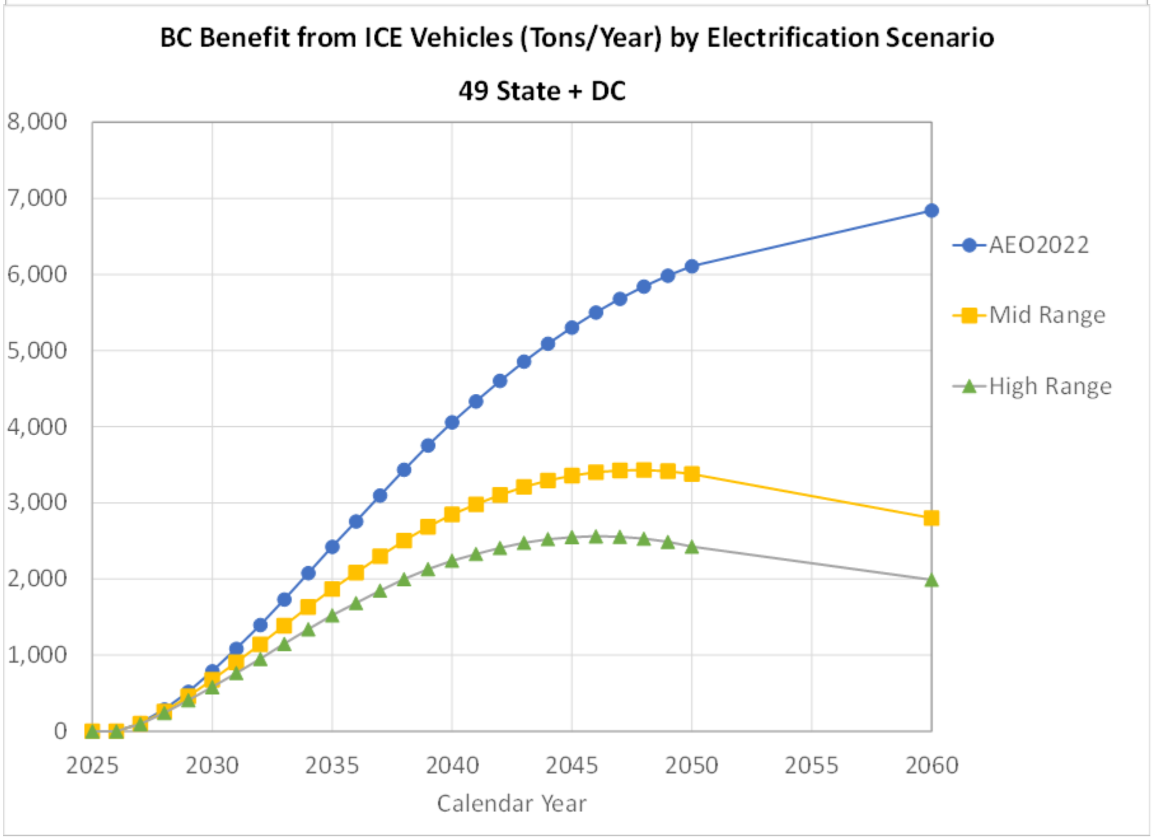



**Figure 3. Cumulative Impact, Low Range Electrification**

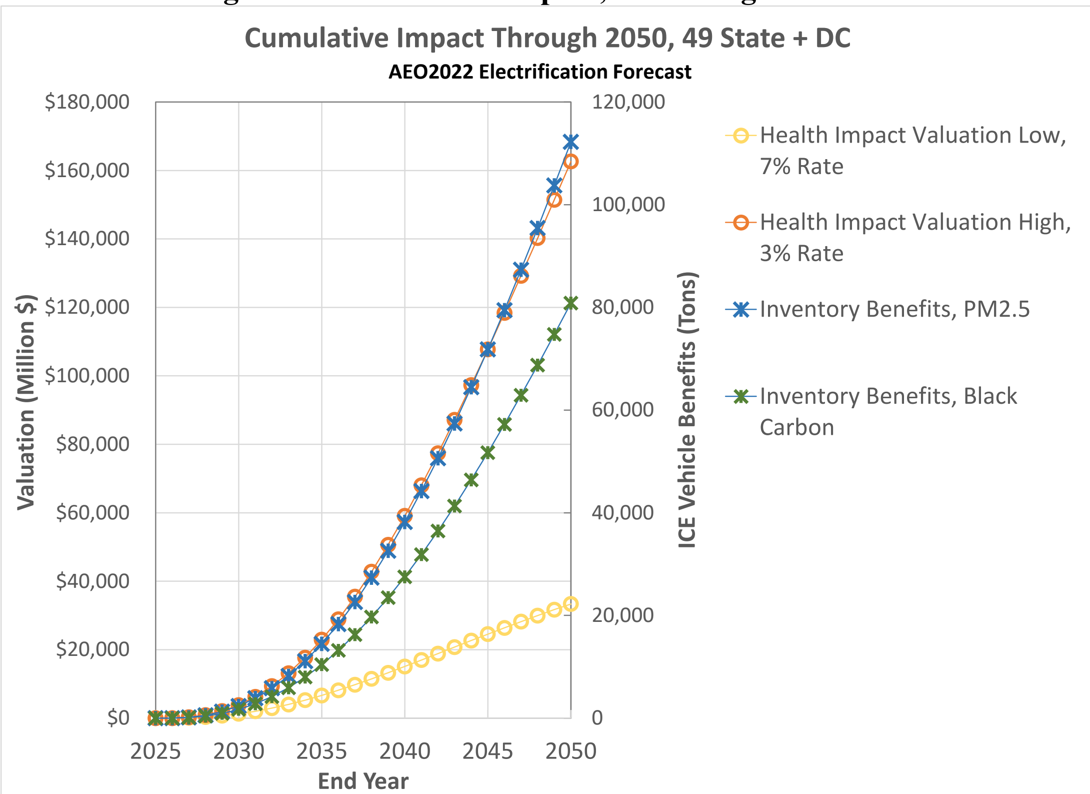



**Figure 4. Cumulative Impact, Mid Range Electrification**

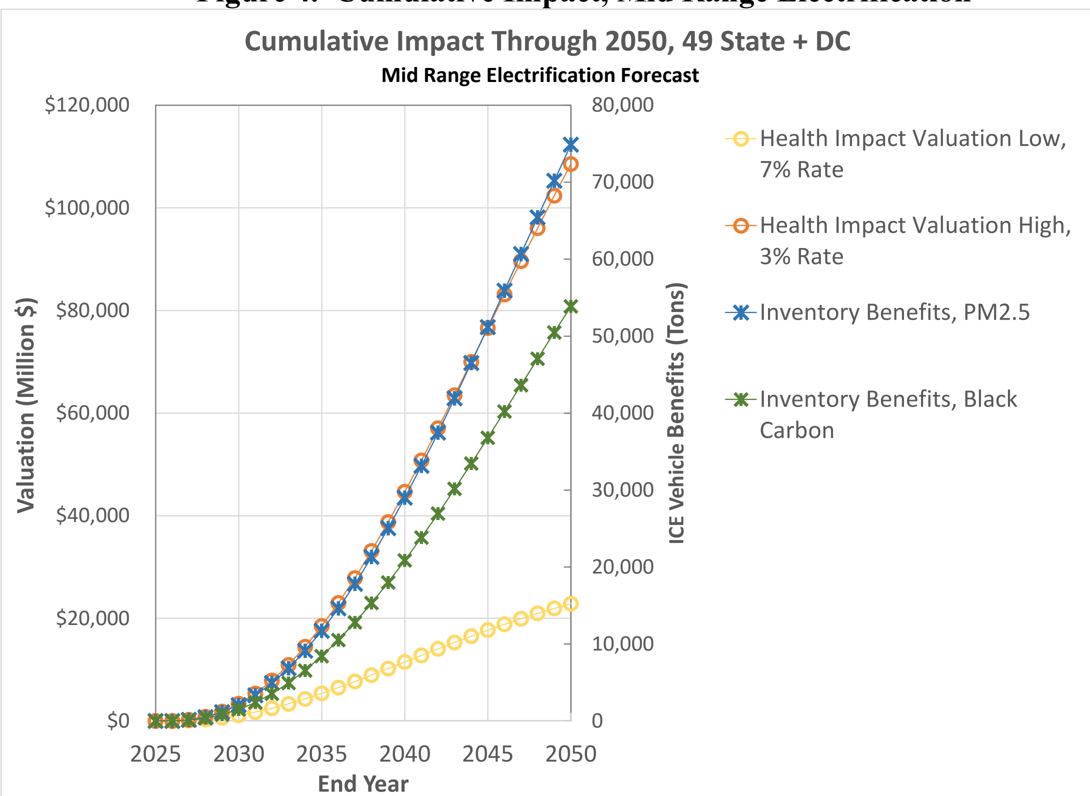
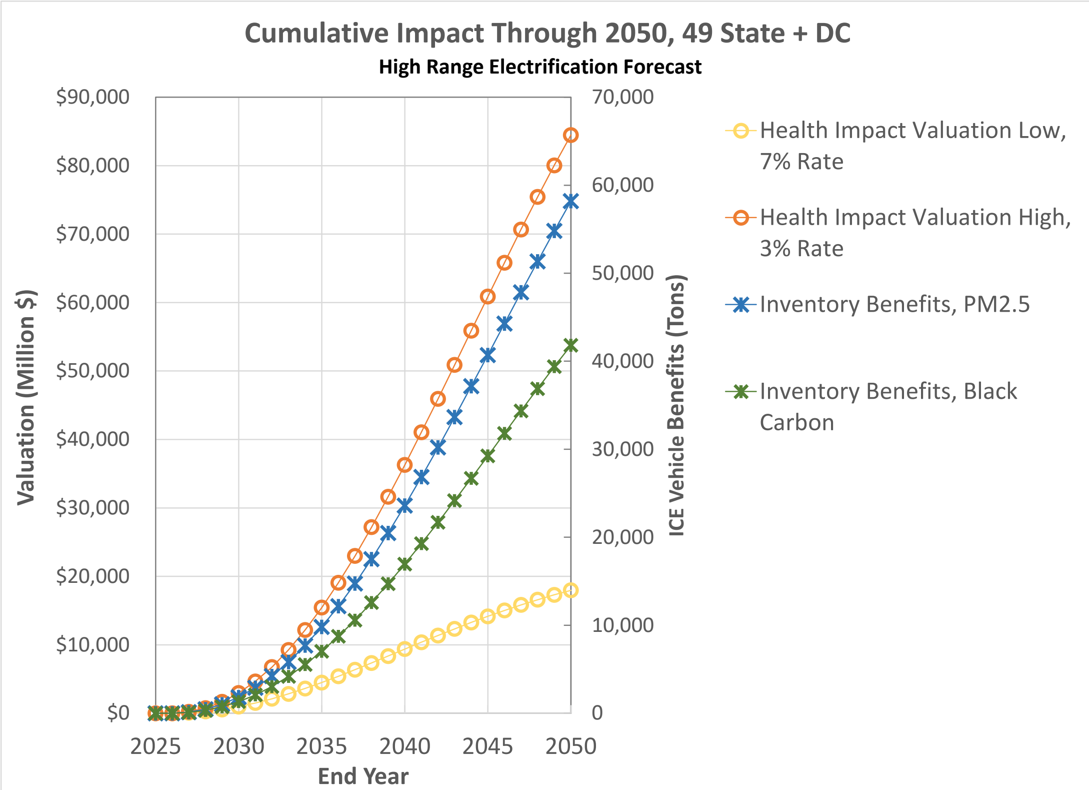


**Figure 5. Cumulative Impact, High Range Electrification**




***MECA supports technologically feasible OBD requirements that enable monitoring of technologies for achieving EPA's proposed PM standard.***

MECA supports EPA's on-board diagnostic (OBD) concepts, with some suggested changes, related to GPF monitoring in response to the likely increase in implementation of PM emission control technologies to meet the more stringent proposed PM standards. OBD is an essential part of emission standards and provides vital information to drivers when repairs are needed in order to maintain vehicle emission performance.

EPA has proposed that for vehicles with engine-out emissions that never exceed 10 mg/mile and which use a GPF, the OBD system must monitor and alert if filtration performance drops below 30% of "normal" filtration. MECA requests that EPA define the term "normal" for these purposes and conduct testing with currently available PM sensors, including those that employ pressure drop, resistive and electrostatic mechanisms for sensing, to set a level to be monitored. At a minimum, the OBD system should detect if a filter has been removed from the vehicle, which is possible to monitor via currently available sensors.

EPA has proposed that for vehicles with engine out emissions that exceed 10 mg/mile and use a GPF, the OBD system must monitor and alert if emissions exceed 10 mg/mile on the FTP. We support this requirement and believe that advanced electrostatic PM sensors being commercialized are able to meet these requirements. Furthermore, we support EPA working with CARB to continually review the OBD monitoring requirements and determine where thresholds may be lowered as sensor technology develops.

Sensor technology commercialization has a long cycle, including testing, design and real-world deployment across many vehicles in the field to make sure sensors are reliable and durable. This cycle is why stringent and predictable standards are an important signal to industry to make investments today for technologies that will be needed in the future. Subsequently reversing adopted standards leaves technology and investments stranded and creates a level of uncertainty in the need for technology innovation. MECA members are engaged in developing a portfolio of sensor options that can be installed on a vehicle to monitor emission performance.

Specifically related to this proposal on GPF monitoring, several advancements in PM sensor technology have been demonstrated in the past few years. Some of this work was completed (unpublished data) as part of the ongoing Particle Sensor Performance and Durability Consortium (https://www.swri.org/consortia/particle-sensor-performance-durability-pspd-consortium) managed by Southwest Research Institute. In addition, a 2020 study[12] highlights the potential of PM sensors to yield more data and greater sensitivity measurement as low as 1 $mg/m^3$. These advanced sensors have been designed to help OEMs comply with the current IUMPR and thresholds adopted by CARB. We encourage EPA and CARB to periodically review the OBD monitoring requirements as PM sensor technologies evolve.

***EPA should extend the refueling emission requirements to all incomplete SI vehicles as proposed.***

EPA's regulatory framework offers the most comprehensive evaporative/refueling control program in the world for chassis certified vehicles. To meet the refueling emission limits, Onboard Refueling Vapor Recovery (ORVR) has been successfully implemented in the U.S. and Canada for over 25 years, and most recently has been implemented in China and Brazil. Within EPA's IUVP program, there have been over 4500 tests conducted on in-use vehicles equipped with ORVR with an average reduction efficiency of 98%[13]. The odometer readings on a large fraction of these vehicles exceeded 100,000 miles. U.S. Tier 2 or California LEV II have reduced evaporative emissions by 90%, and U.S. Tier 3 or California LEV III are 98% effective in reducing evaporative VOC emissions.

Consistent with EPA's proposal, MECA supports extending the refueling emission requirements to all incomplete medium-duty vehicles at a refueling emission standard of 0.20 grams hydrocarbon per gallon of liquid fuel dispensed as now applies to complete

[12] SAE 2020-01-0385
[13] G. Passavant, "Summary and Analysis of 2000-2015 Model Year IUVP Evaporative and Refueling Emission Data," 2017.

LDVs, LDTs, MDPVs, LHDGVs, and HHDGVs. Furthermore, in response to EPA's specific request to comment, MECA suggests EPA extend this requirement to include all incomplete light-duty vehicles in order to prevent any future removal of ORVR from any liquid fueled vehicles. The OEMs have twenty-five model years of experience with the design and certification of ORVR systems, which together with the EPA IUVP data mentioned above, clearly demonstrate the feasibility. MECA believes that the refueling emission control technologies used for the complete version of all vehicles are equally applicable to their corresponding incomplete vehicles.

Consistent with the current requirements for evaporative emission and refueling emission controls for all lighter weight vehicles, MECA supports EPA's proposal to apply a useful life of 15 years/150,000 miles to the MDV refueling emission standard, consistent with existing evaporative emission standards for these vehicles and for complete versions. Given that integrated ORVR/evaporative control system designs share hardware such as the activated carbon canister and purge valve and functions such as vapor transport and canister purge, a common requirement for evaporative and refueling emission standard useful life is logical and necessary.

MECA believes the implementation of ORVR is feasible and practical for primary and secondary manufacturers. OEMs and secondary manufacturers now have decades of experience in working together on measures to ensure that any actions taken by the secondary manufacturer to complete the vehicle do not violate the certificate of conformity or create in-use issues for on-vehicle fuel vapor control systems. In addition, there are now several regulatory provisions within 40 CFR §1037 which provide guidelines on how OEMs and secondary manufacturers may work together under EPA's certification programs[14]. This extensive experience together with these recent regulatory provisions suggest that any concerns have been addressed and there is no need for added regulatory measures. Regarding testing for refueling emissions certification, the ORVR test procedures promulgated in 1994 are fully fit for purpose and, perhaps with minor changes or clarifications, should be applied to medium-duty gasoline vehicles using the driving cycles and SHED-test procedures currently specified in 40 CFR Part 86 Subpart B. MECA supports a compliance demonstration through a full vehicle emission testing and certification as contained in Subpart B plus continuation of the manufacturers' certification option using the compliance demonstration flexibility provided in 40 CFR §1037.103(c).

***EPA should consider adopting additional requirements for SI vehicles with pressurized fuel systems for management of fuel vapors from fuel cap removal and refueling (also commonly referred to as puff losses).***

With respect to Non-Integrated Refueling Canister Only Systems (NIRCOS), or any vehicle with a fuel tank pressure exceeding 2.5 kPa, MECA agrees with the EPA objective to continue to reduce evaporative emissions through adding a requirement designed to control for the release of fuel vapors from fuel cap removal and refueling (also commonly

[14] 40 CFR Part 1037.130, 1037.621, 1037.622.

referred to as puff losses). We believe that the most effective way to control puff loss emissions is to set a performance-based test procedure to include the measurement of both "puff" and re-fueling emissions to ensure that the canister capacity is sufficient and that the entire system operates effectively under elevated ambient temperatures. Since puff loss emissions are normally associated with a refueling event (the fuel cap is most commonly opened prior to refueling), it would be ideal to assess the performance of a puff loss control system in a SHED as part of a refueling emissions test. A testing procedure approach has been used by EPA for all other evaporative emission standards going back to the 1970 model year. In addition, standards based on test procedures are more readily enforceable in-use over a certified vehicle's useful life.

Other major automotive regions have taken initial steps to control puff emissions, and we recommend, at a minimum, that EPA adopt the same approach as is used in the China 6 test procedures for NIRCOS, which is also currently under consideration for incorporation into Euro 7. This procedure includes the fuel cap opening as part of the refueling test in the SHED. Under this approach, any puff loss emissions not captured in the canister would be captured in the SHED and a lack of capacity in the canister could result in a higher level of refueling emissions in the SHED measurement. It ensures the canister is appropriately sized because if the puff goes to the canister and then the vehicle is refueled, the canister must be sized for both the puff loss load and refueling load; otherwise there will be emissions from the canister after it's saturated that the SHED will capture. A key limitation of this approach is that the amount of the puff loss loading is expected to be small under the conditions of the EPA refueling test (80°F soak temperature) and thus may not be representative of the higher puff loss loadings expected in-use (such as a refueling event after a long drive where the fuel system temperatures may be greater than 100°F).

CARB finalized in ACC II a design-based approach that uses an equation to define the minimum evaporative canister capacity for vehicles with sealed fuel tanks. While MECA supported the intent of CARB to control for puff losses, MECA reviewed the terms of the equation and provided written comments to CARB staff noting the deficiencies in this design-based approach.[15] To evaluate the CARB design-based equation approach, MECA analyzed the U.S. EPA certification database[16] to obtain the EPA certified canister capacities for 10 currently certified PHEV/NIRCOS models, including the most popular and top selling models for 2021 and 2022. The EPA certified canister capacities (as retrieved from the evaporative family name codes) of the PHEV/NICROS models were then compared with the predicted minimum canister capacity from the CARB equation using the manufacturer reported tank volume and the recommended default CARB inputs to the equations. Table 1 shows the calculated results from the equation compared to the currently certified canister capacities of PHEV models using sealed fuel tanks. Based on the data, MECA believes the design-based equation approach may lead to back sliding on canister volumes and that it does not provide a method to ensure puff losses are effectively controlled in-use.

[15] https://www.meca.org/wp-content/uploads/2022/06/MECA-ACC-II-Comments-06092022-FINAL.pdf

[16] US EPA Light-Duty Vehicle Certification Database, https://www.epa.gov/compliance-and-fueleconomy-data/annual-certification-data-vehicles-engines-and-equipment

If EPA is to consider using a design-based approach such as the CARB equation, MECA recommends EPA review the terms of the CARB equation to ensure that the application of the equation would efficiently control puff losses under conditions expected in-use while also not leading to back sliding on canister volumes.

*Table 1. EPA Certified Evaporative Canister Capacities Compared to Results Determined by the CARB Final Design-Based Equation*

| Vehicle Model | Nominal Tank Volume (gal) | EPA Certified Canister Capacity (g) | CARB Equation Puff + Refueling Min Canister Capacity (g) |
|---|---|---|---|
| 2021 Toyota Prius Prime PHEV | 11.4 | 130 | 91.4 |
| 2021 Toyota Prius Hybrid | 11.3 | 130 | |
| 2021 Honda Clarity PHEV | 7.0 - 8.7 | 116 | 56.1-69.8 |
| 2021 Honda Accord Hybrid | 12.8 | 122 | |
| 2021 Jeep Wrangler 4XE PHEV | 17.2 | 155 | 138 |
| 2021 Jeep Wrangler Hybrid 4DR 4x4 | 21.5 | 172 | |
| 2021 Mitsubishi Outlander PHEV | 11.3 | 148 | 90.6 |
| 2020 Mitsubishi Outlander 2WD | 15.8 | 135 | |
| 2021 Ford Escape PHEV | 11.1 | 135 | 89 |
| 2021 Ford Escape FHEV | 14.2 | 135 | |
| 2022 Kia Sorento PHEV | 12.4 | 106 | 99.5 |
| 2022 Kia Sorento Hybrid | 17.7 | 137 | |
| 2021/2022 Hyundai Ioniq PHEV | 11.4 | 110 | 91.4 |
| 2021/2022 Range Rover Sport PHEV | 23.8 | 175 | 190.9 |
| 2022 Range Rover Sport (Regular and MHEV) | 27.6 | 175 | |
| 2022 Chrysler Pacifica Hybrid (PHEV) | 16.5 | 125 | 132.3 |
| 2022 Chrysler Pacifica | 19 | 140 | |
| 2022 Subaru Crosstrek PHEV | 16.6 | 154 | 133.1 |
| 2022 Subaru Outback AWD | 18.5 | 143 | |

***Commercially Available Technologies Support Tighter Medium Duty Standards***

Both gasoline and diesel engines feature prominently amongst medium duty vehicles which often share many attributes and powertrain platforms also certified as light-duty trucks or medium duty passenger vehicles. MECA would highlight that the proposed MDV Class 2b and Class 3 NMOG+NOx fleet averages of SULEV150 (Class 2b: 8500 to 10,000lbs) and SULEV175 (Class 3: 10,000 to 14,000lbs) still reflect fleet averages of 5 to almost 6 times higher than that proposed for light duty trucks and SUVs <8500lbs, as well as medium duty passenger vehicles. This despite the fact that Class 2b and 3 vehicles have gross vehicle weights that are equivalent to no more than 18% to 65% heavier.

Regarding Class 2b and 3 gasoline-fueled vehicles, MECA's review of available EPA FTP NMOG+NOx certification data[17], shown in Table 2, indicates ranges in certification level value (corresponding to the actual test results combined with the deterioration factors) of 9 to 192 mg/mile (average ca. 92 mg/mile) for Class 2b and 74 to 120 mg/mile (average ca. 102 mg/mile) for Class 3.

*Table 2. EPA Certified Levels of Class 2b and 3 Medium-Duty Vehicles*

| | NMOG + NOx EPA Certified Level (mg/mile) | |
|---|---|---|
| **Class 2B** (GVW 8500 to 10000lbs) | Gasoline | Diesel |
| FTP - Average | 92 | 147 |
| FTP - Best in Class | 9 | 113 |
| FTP - Worst in Class | 192 | 180 |
| | | |
| US06 - Average | 56 | 76 |
| US06 - Best in Class | 19 | 10 |
| US06 - Worst in Class | 108 | 142 |
| | | |
| **Class 3** (GVW 10001 to 14000 lbs) | | |
| FTP - Average | 102 | 163 |
| FTP - Best in Class | 74 | 136 |
| FTP – Worst in Class | 120 | 190 |
| | | |
| LA 92 - Average | 27 | 284* |
| LA 92 - Best in Class | 22 | |
| LA 92 - Worst in Class | 35 | |

Our review of available EPA FTP certification data for Class 2b and 3 diesel-fueled vehicles finds current reported ranges in certification level value (corresponding to the actual test results combined with the deterioration factors) of 113 to 180 mg/mile (average ca. 147 mg/mile) for Class 2b and 136 to 190 mg/mile (average ca. 163 mg/mile) for Class 3 vehicles.

Given the proportional vehicle weights, reported NMOG+NOx certification values of best-in-class performers, as well as the need to provide further air quality benefits, MECA believes gasoline and diesel fueled medium-duty vehicles are capable of complying with the lower NMOG+NOx standards proposed by EPA. Furthermore, the removal of the

[17] US EPA Light-Duty Vehicle Certification Database, https://www.epa.gov/compliance-and-fuel-economy-data/annual-certification-data-vehicles-engines-and-equipment

highest certification bins (i.e., >160 mg/mile NMOG+NOx) will provide significant emission benefits by removing the highest emitting vehicles from the fleet.

With respect to proposed PM standards for medium-duty vehicles, MECA supports EPA's proposed limits that match light-duty vehicles. The combination of advanced fuel injection and gasoline particulate filters on medium-duty gasoline vehicles can enable compliance with proposed standards. Based on over 15 years of experience with diesel emission controls, medium-duty diesel vehicles that implement DPFs will be able to meet the stringent PM requirements proposed in this rule.

Medium-duty vehicles with Gasoline Engines

Historically, spark-ignition engine FTP tests have shown that the majority of NMHC, CO, and NOx emissions occur during the cold start phase; however, emissions during warmed-up and hot operation, specifically during high-load operation, can also significantly contribute to emissions, especially with heavier MD and HD vehicles. There are a variety of measures that can be utilized on spark-ignition gasoline engines to further reduce emissions.

*Engine Mapping and Calibration*

In order to comply with lower NMOG+NOX and PM emissions standards over certification cycles such as the FTP, US06, SC03, and LA92, manufacturers will employ improved engine maps and calibration strategies of existing engines and emission control related systems. Other design changes to system architecture can be deployed to manage engine-out emissions and exhaust flows, reduce catalyst light-off times, increase exhaust temperatures during periods of low-load or idle and reduce excessive warmed-up and hot running emissions to protect engine and emission control components which are susceptible to deterioration from extended exposure to severe exhaust temperatures.

*Exhaust Emission Control Technologies*

Several emission control choices can be made to improve and optimize emission control performance. For gasoline engines, the technology base of advanced three-way catalysts deposited on high cell density (as high as 1200 cells/in$^2$), thin-walled substrates (approaching 0.05mm) have evolved dramatically for light- and medium-duty chassis certified vehicles to comply with Tier 3/LEV 3 standards. Recent advances have yielded high porosity, low thermal mass substrates with narrow pore size distributions, which enable high emission reduction efficiency with less precious metal loading [18, 19]. Catalyst manufacturers have also developed coating techniques based on layered or zoned

[18] T. Asako, D. Saito, T. Hirao and E. Popp, SAE 2022-01-0543.

[19] J. Warkins, T. Tao, M. Shen and S. Lyu, SAE 2020-01-0652.

architectures to strategically deposit precious metals in ways that optimizes their performance and cost. These advanced catalysts are then packaged using specially designed matting materials and passive thermal management strategies which can be used to allow chassis certified medium-duty trucks to meet the stringent Tier 3 emission fleet average limit of 30 mg/mile or approximately 100 mg/bhp-hr.

*Reducing Cold Start Emissions*

Close-coupled catalyst exhaust architectures (with or without a secondary underfloor converter) have been used on light-duty vehicles starting with Tier 2 LDV standards and are an effective strategy for addressing cold-start or low-load operation.

Secondary air injection can also be used to accelerate catalyst activation under cold-start conditions in spark ignition engines. Using a richer air/fuel ratio via intake air throttling, retarding fuel injection, or post combustion in-cylinder fuel additions during the exhaust stroke while injecting air directly into the exhaust port of the engine, results in excess fuel combustion within the exhaust manifold, creating additional heat that results in increasing catalyst temperatures to achieve faster catalyst light-off. These strategies can also be coupled with exhaust gas recirculation.

Spark-ignition engines that employ a richer cold start calibration used in combination with a secondary air injection system experience improved combustion stability. In addition, the richer calibration is less sensitive to variations in fuel volatility since less volatile fuels may lead to poor start and idle performance on engines calibrated to run lean during cold operation[20,21] (Serrano, et al., 2009) (Lee & Heywood, 2010).

In support of the Tier 3 light-duty regulation[22], EPA tested a 2011 LDT4 pick-up truck with a 5.3L V8 engine that included a MECA supplied aftertreatment system. The aftertreatment package consisted of advanced catalyst coating on 900 cpsi substrates in the close-coupled location as well as underfloor catalysts and was aged to 150,000 miles. The system was combined with cylinder deactivation and achieved an FTP NMHC+NOx level of 18 mg/mile. We believe that these same technology approaches can be deployed on medium-duty gasoline engines to meet more stringent emission levels than those being currently proposed.

Medium-duty Vehicles with Diesel Engines

With regards to diesel engine emissions, MECA members have been developing and commercializing a full suite of technologies to help medium and heavy-duty engine

[20] Serrano, D., Lavy, J., Kleeman, A., Zinola, S., Dumas, J., Le Mirronet, S., & Heitz, D., SAE 2009-01-2706.

[21] Lee, D., & Heywood, J., SAE 2010-01-2124.

[22] https://www.epa.gov/regulations-emissions-vehicles-and-engines/proposed-rule-and-related-materials-control-air-pollution

manufacturers to comply with the MY 2027 heavy-duty engine standards and these technologies can be readily applied to medium-duty chassis certified vehicles as well. Exhaust and emission control technologies include next generation close coupled and under chassis selective catalytic reduction (SCR), oxidation and diesel soot ignition catalysts with high porosity, low thermal mass substrates with heated catalyst and urea dosing strategies. These can be combined with engine thermal management strategies such as cylinder deactivation and advanced forms of turbocharging and EGR. These technologies already exist on some passenger car applications in Europe where real driving emission test procedures demand them. We further elaborate on these technologies below.

*Cylinder Deactivation and Variable Valve Actuation*

Cylinder deactivation (CDA) is an established technology on light-duty gasoline vehicles, with the primary objective of reducing fuel consumption and $CO_2$ emissions. This technology combines hardware and software computing power to, in effect, "shut down" some of an engine's cylinders, based on the power demand, and keep the effective cylinder load in an efficient portion of the engine map without burning more fuel. Based on decades of experience with CDA on gasoline passenger cars and trucks, CDA is now being adapted for diesel engines. On a diesel engine, CDA is programmed to operate differently than on gasoline engines, with the goal of the diesel engine running hotter in low-load situations by having the pistons that are firing do more work. This programming is particularly important for vehicles that spend a lot of time in creep and idle operation modes. During low-load operation, CDA has resulted in exhaust temperatures increasing by 50°C to 100°C when it is most needed to maintain effective conversion of NOx in the selective catalytic reduction (SCR) catalyst bed. In some demonstrations, CDA has been combined with a 48V mild hybrid motor with launch and sailing capability to extend the range of CDA operation over the engine, and this may deliver multiplicative $CO_2$ reductions from these synergistic technologies[23].

The use of variable valve actuation (VVA) is another approach for active thermal management. VVA approaches include: early exhaust valve opening (EEVO), early intake valve closing (EIVC) or late intake valve closing (LIVC), all considered active thermal management strategies. Both EIVC and LIVC reduce the amount of air trapped at valve closing. Both methods reduce the effective compression ratio and volumetric efficiency, resulting in lower NOx emissions and reduced air-fuel ratio, and in turn, hotter exhaust temperature. EEVO results in hotter exhaust gas to heat-up aftertreatment; however, more fueling is needed to maintain brake power output. This results in a $CO_2$ emissions penalty that must be accounted for in calibrating for better fuel economy and higher engine-out NOx during hot operation when the SCR can be used to remediate NOx emissions. VVA offers some potential cost savings and is therefore used in some medium-duty applications as a fast heat-up strategy. OEMs will have multiple pathways at varying costs to achieve their thermal management objectives and achieve ultra-low NOx emissions in low-load and low-speed operation.

[23] https://www.meca.org/wp-content/uploads/resources/MECA_2027_Low_NOx_White_Paper_FINAL.pdf

*Modern Turbochargers*

Modern turbochargers have a variety of available design options enabling lower $CO_2$ emissions by improving thermal management capability, such as: i) state of the art aerodynamics, ii) electrically-actuated wastegates that allow exhaust gases to by-pass the turbocharger to increase the temperature in the aftertreatment, and iii) advanced ball bearings to improve transient boost response. These and other technologies are available to support further reductions in $CO_2$ and other emissions. More advanced turbochargers are designed with a variable nozzle that adjusts with exhaust flow to provide more control of intake pressure and optimization of the air-to-fuel ratio for improved performance (e.g., improved torque at lower speeds) and fuel economy. These variable geometry turbochargers (VGT), also known as variable nozzle turbines (VNT) and variable turbine geometry (VTG), also enable lower $CO_2$ emissions through improved thermal management capability to enhance aftertreatment light-off. Finally, modern turbochargers have enabled engine and vehicle manufacturers the ability to downsize engines, resulting in fuel savings without sacrificing power and/or performance. The latest high-efficiency turbochargers are one of the more effective tools demonstrated in the DOE SuperTruck program[24]. In addition to affecting the power density of the engine, turbochargers play a significant role in NOx and $CO_2$ regulations compliance. Continuous improvement in turbocharger technology is making it possible to run very lean combustion (high air/fuel ratios), which increases efficiency. This improvement allows for very low particulate generation and even lower engine-out NOx.

*Turbo-compounding*

Turbo-compounding is a variant of turbocharger technology that allows for the energy from the exhaust gas to be extracted, converted to mechanical or electrical energy and either mechanically added to the engine crankshaft through a transmission or stored electrically for opportunistic use in other driving conditions. Mechanical turbo-compounding has been employed on some commercial diesel engines, and EPA estimated penetration to reach 10% in the U.S. by the time the Phase 2 GHG Regulation is fully implemented in 2027[25]. An early 2014 version of a turbo-compound-equipped engine was used during the first stage of testing at SwRI under the HD Low NOx Test Program, and the results from this engine with advanced aftertreatment have been summarized in several

[24] Navistar, "Final Scientific/Technical Report for SuperTruck Project: Development and Demonstration of a Fuel-Efficient, Class 8 Tractor & Trailer Engine System," 2016.

[25] U.S. EPA, "Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles -- Phase 2," Federal Register, pp. 73478-74274, 25 October 2016.

SAE technical papers[26,27,28]. While turbo-compounding has the potential to reduce fuel consumption, it can result in lower exhaust temperatures that can challenge aftertreatment performance. Therefore, it is important to consider turbo-compound designs that incorporate bypass systems during cold start and low load operation or electrically driven turbo-compounding systems where the unit can be placed after the aftertreatment system.

*Driven Turbochargers*

Driven turbochargers can be used to control the speed of the turbomachinery independently of the engine's exhaust flow and vary the relative ratio between engine speed and turbo speed. Driven turbochargers may be utilized for several reasons, including performance, efficiency, and emissions. Considered an 'on-demand' air device, a driven turbocharger also receives transient power from its turbine. During transient operation, a driven turbocharger will behave like a supercharger and consume mechanical or electrical energy to accelerate the turbomachinery for improved engine response. At high-speed operation, the driven turbocharger will return mechanical or electrical power to the engine in the form of turbo-compounding, which recovers excess exhaust power to improve efficiency. This cumulative effect lets a driven turbocharger perform all the functions of a supercharger, turbocharger, and turbo-compounder. NOx emission control uniquely benefits from the application of driven turbochargers in several ways, including the ability to decouple EGR from boost pressure, reduce transient engine-out NOx, and improve aftertreatment temperatures during cold start and low load operation. Bypassing a driven turbine can provide quick temperature rises for the aftertreatment while still delivering the necessary boost pressure to the engine through supercharging, which also increases the gross load on the engine to help increase exhaust temperature[29]. Testing has shown that routing engine exhaust to the aftertreatment by bypassing a turbocharger is one of the most effective methods to heat up the aftertreatment[30].

## Hybridization

*Mild Hybridization*

48-volt mild hybrid electrical systems and components are expected to make their way onto commercial diesel vehicles in the near future. These 48-volt systems can be found on many light-duty vehicle models (primarily in Europe) from Mercedes, Audi, VW,

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[26] C. Sharp, C. C. Webb, G. Neely, J. V. Sarlashkar, S. B. Rengarajan, S. Yoon, C. Henry and B. Zavala, SAE 2017-01-0958.

[27] C. Sharp, C. C. Webb, G. Neely, M. Carter, S. Yoon and C. Henry, SAE 2017-01-0954.

[28] C. Sharp, C. C. Webb, S. Yoon, M. Carter and C. Henry, SAE 2017-01-0956.

[29] J. Brin, J. Keim, E. Christensen, S. Holman and T. Waldron, SAE 02-14-03-0032.

[30] Navistar, "Final Scientific/Technical Report for SuperTruck Project: Development and Demonstration of a Fuel-Efficient, Class 8 Tractor & Trailer Engine System," 2016.

Renault and PSA. In the U.S., Stellantis is offering a 48-volt system on the RAM 1500 pick-up and the Jeep Wrangler under the eTorque trademark. Because the safe voltage threshold is 60 volts, which is especially important when technicians perform maintenance on the electrical system, 48-volt systems are advantageous from an implementation standpoint. From a cost perspective, 48-volt systems include smaller starter and wire gauge requirements, offering cost savings from a high voltage architecture of a full hybrid. The U.S. Department of Energy's SuperTruck II program teams employed 48-volt technologies on their vehicles to demonstrate trucks with greater than 55% brake thermal efficiency. A recent study demonstrated through model-based simulations that a 48-volt technology package combined with advanced aftertreatment can achieve a composite FTP emission level of 0.015 g/bhp-hr[31].

Similar to the passenger car fleet, truck OEMs are considering replacing traditionally mechanically-driven components with electric versions to gain efficiency. Running accessories off 48-volt electricity rather than 12-volts is more efficient due to reduced electrical losses and because components that draw more power, such as pumps and fans, have increased efficiency when operating at higher voltages. The types of components that may be electrified include, electric turbos, electronic EGR pumps, AC compressors, electrically heated catalysts, electric cooling fans, oil pumps and coolant pumps, among others. Another technology that 48-volt systems could enable is electric power take-offs rather than using an engine powered auxiliary power unit or idling the main engine during hoteling while the driver rests. MECA members supplying commercial 48V components for commercial vehicles believe that the technology may be feasible to apply to a limited number of engine families by 2024, and it is likely to see greater penetration by 2027, especially on Class 8 line-haul where full hybridization is less practical.

Mild hybridization covers a range of configurations, but a promising one includes an electric motor/generator, regenerative braking, electric boost and advanced batteries. Stop/start deployment also provides a thermal management benefit to the aftertreatment by preventing cooling airflow through the aftertreatment during hot idle conditions. In this way, 48-volt mild hybridization is complementary technology to CDA and start-stop capability, allowing the combination of multiple technologies on a vehicle to yield synergistic benefits and justify the cost. By shutting off the engine at idle or motoring using start/stop, micro hybrid technology can help to maintain aftertreatment temperature by avoiding the pumping of cold air through the exhaust. Capturing braking energy and storing it in a small battery for running auxiliary components when the engine is off offers another $CO_2$ reducing strategy for OEMs to deploy.

In lighter medium-duty applications, advanced start-stop systems have been developed that use an induction motor in a 48-volt belt-driven starter-generator (BSG). When the engine is running, the motor, acting as a generator, will charge a separate battery. When the engine needs to be started, the motor then applies its torque via the accessory belt and cranks the engine instead of using the starter motor. The separate

[31] F. Dhanraj, M. Dahodwala, S. Joshi, E. Koehler, M. Franke and D. Tomazic, 2022-01-0555.

battery can also be recharged via a regenerative braking system. In addition to the start-stop function, a BSG system can enhance fuel economy even during highway driving by cutting off the fuel supply when cruising or decelerating. Such systems can also be designed to deliver a short power boost to the drivetrain. This boost is typically 10 to 20 kW and is limited by the capacity of the 48V battery and accessory belt linking the motor to the crankshaft. New designs are linking the BSG directly to the crankshaft and allowing additional power boost of up to 30kW to be delivered, giving greater benefits to light and medium commercial vehicles.[32]

*Full hybridization and plug-in hybrids*

Full hybrid configurations are currently found on several models of light-duty passenger cars and light trucks in the U.S. and a limited number of medium-duty trucks. These include PHEV models that can also be plugged-in to enable all-electric operation over a defined all-electric range (AER). A full hybrid can enable electrification of many of the components described above for mild hybrid vehicles, but the higher voltages allow for more parts to be electrified and to a larger degree of efficiency. Full hybrids implementing larger electric motors and batteries, can also support greater acceleration capability and regenerative braking power. Full hybrid vehicles have made the highest penetration into parcel delivery, beverage delivery and food distribution vehicles because they can take advantage of regenerative braking in urban driving[33]. We expect to see some application of full hybrids combined with low NOx engines to reduce $CO_2$ emissions in several vocational and local delivery applications. Integrated electric drivetrain systems, consisting of a fully qualified transmission, motor and power electronics controller, are now commercially available. With power levels of over 160kW and the ability to meet high torque requirements, these systems enable electrification of medium-duty commercial vehicles. There is also an increasing number of electric drivetrain solutions up to 300kW that are suitable for medium and heavy-duty vehicles that can be used with either battery or fuel cell power sources[30].

Plug-in hybrids (PHEVs) can be practical for light and medium- duty trucks (e.g., Class1 through 3) that do not travel long distances or operate for long periods of time without returning to a central location. In addition, serial plug-in hybrids which employ an engine operating only as a generator to charge the traction battery to extend range, offer operational flexibility for commercial vehicles while full electric vehicles and their needed infrastructure are established. It is worth noting that both HEVs and PHEVs are able to achieve significant GHG benefits compared to their conventional vehicle counterparts by employing relatively low-capacity batteries. Further discussion on efficient use of battery critical materials is presented below and displayed in Table 1.

[32] https://www.meca.org/wp-content/uploads/resources/MECA_2027_Low_NOx_White_Paper_FINAL.pdf
[33] CARB, "Draft Technology Assessment: Heavy-Duty Hybrid Vehicles," 2015.

***EPA should finalize provisions for all MD engines in MDVs with GCWR > 22,000 lbs to meet MY 2027 heavy-duty engine certification requirements, and compliance should be in accordance with the heavy-duty standards.***

MECA supports EPA's proposal that medium-duty engines in chassis certified medium duty vehicles (MDVs) should be required to meet the same requirements as those EPA finalized in December 2022 for MY 2027 and later heavy-duty engines. We agree with the agency that this is a viable way to address the current disparities between chassis and engine-based standards.

Results from the SwRI Heavy Duty Low NOx demonstration program, included diesel exhaust emission control components that were aged to current (435,000 miles) and future (650,000/750,000 miles) heavy heavy-duty durability requirements and then tested over several field duty cycles and in-use compliance results calculated with the new two bin moving average window (3B-MAW) methodology. Given durability requirements for the light heavy-duty classes are due to increase to 270,000 miles, the results from 435,000 mile aged heavy-heavy duty parts could be used to extrapolate for MY 2027 and later medium-duty engines.

Even in the short time since the latest emission control system was provided to SwRI for the demonstration program, improvements have continued to substrates and catalysts. For example, a recent paper published at the 2022 SAE WCX conference describes development of high-porosity honeycomb substrates with thinner wall thickness and high cell density that can be coated with SCR catalyst. The combination of developments on this substrate enables higher surface area and lower thermal mass, which improves coating efficiency, reduces catalyst heat-up time, and reduces pressure drop. These result in performance improvements that are especially prominent at low temperature operation. At engine exhaust temperatures of 175°C, the NOx conversion efficiency improved by 14% compared to earlier generation substrates[34] (Ido, et al., 2022).

Catalyst suppliers have already developed a next generation of SCR catalysts with higher NOx reduction efficiency and better durability compared to the Stage 3 parts tested in the SwRI demonstration program. Through the use of sophisticated models that incorporate the latest learnings on both thermal and chemical aging effects, it is possible to project the gains in efficiency provided by these new materials. A similar methodology was used to that discussed in the MECA 2027 white paper, incorporating exhaust information from the latest engine calibration from SwRI and an optimized dosing calibration for the new downstream SCR catalyst. The catalysts were laboratory aged both thermally and chemically using sulfur containing simulated exhaust gas to represent 435,000 miles of equivalent engine aging. The catalysts were modeled over the FTP, RMC

[34] Ido, Y., Kinoshita, K., Goto, C., Toyoshima, H., Hirose, S., Ohara, E., et al., SAE 2022-01-0550.

and LLC certification cycles and demonstrated lower emissions than the Stage 3 system at SwRI. The not yet published results suggest that the latest generation SCR catalyst would provide OEMs with additional margin to a 0.02 g/bhp-hr standard.

This example of continual improvement and optimization is a testament to the ongoing innovative technology development occurring in the industry between suppliers and their OEM customers. Each time a test is run, new information is obtained and applied to the next iteration. This has been going on continually over the past 15 years of advanced emission controls on trucks. In fact, over the life of the SwRI program, catalyst suppliers have deployed new catalyst formulations and coating techniques to continually improve the durability and performance of the SCR system in order to build greater compliance margin relative to the program targets. Our industry has seen a tremendous amount of innovation on both engines and aftertreatment since the U.S. 2010 on-road diesel standards were implemented. This learning has been applied to improve manufacturing and reduce variability that has allowed systems to be downsized by about 60% and reducing their costs by about 30%.

***Commanded enrichment should be phased-out for all MDVs.***

MECA supports the elimination of commanded enrichment for all MDVs under the phased schedule proposed by EPA. Heavier medium-duty and heavy-duty gasoline vehicles can operate at higher loads and exhaust temperatures (i.e., due to towing) which can impact catalyst durability. Moving the catalytic converter closer to the exhaust manifold to improve cold start performance can result in increasing the time it is exposed to higher temperatures under higher load conditions. Manufacturers may use fuel enrichment modes to ensure cylinder head, exhaust manifold and catalyst temperatures are maintained below design durability thresholds. Using fuel enrichment to control catalyst temperature while effective, can cause significant increases in both criteria pollutant emissions and fuel consumption.

Catalyst manufacturers have continued to improve the thermal stability of supporting catalyst washcoats and performance of precious metal catalysts under higher exhaust temperatures that occur when converters are close coupled to reduce the need to employ fuel enrichment modes. Modern gasoline engines also have several design, calibration and advanced technologies that could be used to reduce the occurrence of higher exhaust temperatures by modifying combustion or load characteristics. Examples of engine-based technologies include exhaust gas recirculation (EGR), modified valve timing, electronic throttle airflow, cylinder heads with improved cooling and exhaust manifolds which are partially integrated into the cylinder head, and cooled exhaust manifolds.

In addition, engine down-speeding or governing of the engine operating range can reduce exhaust temperatures and the need to employ enrichment for thermal protection. This strategy will allow the emission controls to remain in stoichiometric air-fuel control (i.e. closed loop) where the catalysts can maintain peak emissions reduction efficiency for a broader range of operation.

Finally, it is possible to replace a close-coupled catalyst with an electrically heated three-way catalyst (EHC) or electric heater located in front of a three-way catalyst in a downstream location farther from the engine in order to protect it from thermal exposure during times of high engine load. These commercially-available technologies employ electrically generated heat to improve catalyst light-off, especially at cold start and times of low exhaust temperature. This configuration is further enabled by 48-volt system architectures described in more detail above.

In 2005, MECA applied some of the above-mentioned strategies to two full-sized 2004 pick-up trucks equipped with a 5.4L and 6.0L engine[35]. The aftertreatment systems were packaged with dual-wall insulated exhaust systems and fully aged to represent 120,000 miles of real-world operation. Even with 15-year-old engine technology and limited engine calibration on one of the vehicles, both vehicles achieved FTP NMHC+NOx emissions of 60-70 mg/mile. Although the cast-iron exhaust manifolds on these vehicles were retained, an OEM likely would take advantage of such cost effective passive thermal management strategies, including dual-wall insulated exhaust or integrated exhaust manifolds, to further reduce cold-start emissions.

MECA would like to note that although the technology (described above) is ready, we support a phase-in of this requirement as many engine applications require component modifications that take time to industrialize and apply to market, including full consideration of durability and emission development. Therefore, retention of a phased approach consistent with the phase-in of other new requirements is appropriate.

***EPA should align with CARB's ACC II requirements for PHEV high power cold starts, early drive-away, and mid-temperature engine starts. Similar to CARB, EPA should allow PHEVs with all electric range greater than or equal to 40 miles to be exempt from the high-power cold start requirement.***

MECA supports EPA's proposed alignment with CARB ACC II provisions to address emissions from operation previously not considered by certification testing, including high power cold starts of plug-in hybrid electric vehicles, shortened idle and early drive-away after start-up, and short to intermediate soak times in between engine starts. MECA believes that emissions after engines are restarted after intermediate soak time, between three and eight hours, can be readily addressed with engine calibration revisions without the need for additional technology, and this is a cost-effective way to reduce these off-cycle emissions that are found during real world operation.

[35] J. W. Anthony and J. E. Kubsh, SAE 2007-01-1261, 2007.

Regarding drive-away emissions, we believe that faster system warm-up can be achieved through improvements in calibration as well as the use of commercially available engine technologies, such as turbochargers, exhaust gas recirculation (EGR), and cylinder deactivation (CDA). Extensive engine calibration and combustion strategies, such as the use of variable valve timing (VVT), have been developed to enable faster exhaust heat-up in order to increase catalyst performance. Higher voltage hybrid architectures ranging from 48V mild to full hybrids also create opportunities to incorporate electrically-heated catalysts (EHCs) to address these shorter cold-start idle times. Additional aftertreatment efficiency gains have been and continue to be developed through improvements in catalyst materials to enable higher performance at lower exhaust temperatures. Furthermore, new system architectures, more robust thermal management controls and advanced thermal insulation materials facilitate faster heat-up and heat retention during real world operation.

MECA acknowledges the need to better control PHEV high power demand engine cold start emissions. In particular, MECA is aware of published work highlighting the use of engine and exhaust emission control strategies to address high power starting emissions used in other electrified hybrid powertrains[36]. Several of the technologies and strategies listed above to address “quick drive-away” emissions can also be employed to address emissions from off-cycle high power starts. MECA believes that the proposed PHEV minimum requirements in CARB ACC II address the shortcomings of some earlier generation PHEVs. To that end, EPA should be finalized as proposed to harmonize with CARB ACC II on the Step 2 PHEV high power cold start standard that exempts PHEVs with a cold start US06 all electric range of at least 40 miles.

***Efficient Utilization of Battery Critical Materials***

MECA supports EPA’s technology neutral, performance-based approach to reduce both criteria and GHG emissions from light-duty vehicles through improvements in the efficiency of today’s vehicles combined with accelerated introduction of battery electric vehicles. We agree with the Agency’s conclusion that projected penetration of electric vehicles will provide significant emission benefits from the light-duty fleet. However, based on current sales rates of electric vehicles, there is still considerable uncertainty in the projected pace of future electric vehicle penetration.

Table 3 compares the fuel economy, tailpipe & upstream greenhouse gas emissions and utilized battery capacities of equivalently sized conventional, full hybrid, plug-in hybrid and battery electric vehicles using available data from the EPA/DOE fueleconomy.gov website.

On a vehicle basis, the tailpipe & upstream greenhouse gas emissions of the battery electric vehicle (Tesla Model Y Long Range AWD) would avoid 311 g/mile of $CO_2$ (i.e., $381_{\text{conventional RAV4}} - 70_{\text{Tesla Model Y}} = 311$) compared to avoiding 231 g/mile with the plug-in

[36] Kawaguchi, B., Umemoto, K., Misawa, S., Hirooka, S. et al., SAE 2019-01-2217.

hybrid (Toyota RAV4 Prime) assuming that only 69.3% of its operation is all-electric. However, on an equivalent battery capacity basis, the last row of Table 3 shows that HEVs and PHEVs use the available battery materials more efficiently than BEVs avoiding considerably higher amounts of $CO_2$ per kWh of battery capacity. This improved efficiency of hybrids is due to the higher rate of cycling their smaller battery capacities.

*Table 3. Comparison of Battery Capacities of Conventional, Full Hybrid, Plug-in Hybrid and Battery Electric Vehicles*

| | 2023 Toyota RAV4 AWD 2.5L, 4cyl.   | 2023 Toyota RAV4 AWD Hybrid 2.5L, 4cyl.   | 2022 Toyota RAV4 Prime AWD PHEV 2.5L, 4cyl.   | 2023 Tesla Model Y Long Range AWD BEV   |
|---|---|---|---|---|
| EPA Fuel Economy (MPGe) | 28 | 40 | Elec + Gas: 94<br>Gas only: 38 | Electric<br>122 |
| Tailpipe & Upstream GHG (grams/mile) | **383** | **268** | **190**<br>***assumes 69.3% electric only operation** | **110**<br>****based on U.S. Average grid intensity** |
| $CO_2$ Avoided (grams/mile)<br>***with respect to RAV4 AWD conventional gasoline vehicle | -na- | **115** | **193** | **273** |
| Vehicle Battery Capacity (kWh) | -na- | 1.6 | 18.1 | 100 |
| Vehicles Produced from 100 kWh battery capacity | -na- | 62 | **5.5** | **1** |
| $CO_2$ Avoided per kWh Battery Capacity (grams/mile) | -na- | **71.3** | **10.6** | **2.7** |

Table 3 displays fueleconomy.gov data with stated battery capacities for selected vehicles. It should be noted that the amount of battery material needed to manufacture each full battery electric vehicle could be deployed to manufacture five PHEVs. One can calculate the amount of $CO_2$ reduced each year as a function of battery capacity (kWh) and miles driven. Assuming an all-electric operation of 69.3%[37] of the PHEV, a far greater cumulative amount of avoided $CO_2$ (5 x 191 g/mile = 955 g/mile of avoided $CO_2$) can be realized by deploying the PHEVs compared to 271 g/mile of avoided $CO_2$ realized by the operation of the one BEV.

To fully electrify a medium-duty vehicle, a minimum of a 75 to 100kWh battery would be needed. We ran the same calculation above to compare example medium-duty vehicles with varying degrees of electrification. The result is that the latest generation full hybrid powertrain would eliminate over 700kg $CO_2$/kWh/year, whereas a plug-in hybrid would yield 127 kg$CO_2$/kWh/year and a BEV would yield 31 kg$CO_2$/kWh/year.

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[37] The assumption of 69.3% electric operation for the RAV4 PHEV is found on www.fueleconomy.gov.

These analyses illustrate that strategically deploying HEV and PHEV powertrains as well as BEVs can yield significantly greater $CO_2$ reductions on a battery capacity basis thus reducing battery critical mineral supply chain pressures and providing fleets and manufacturers greater flexibility in achieving GHG emission goals. Further reductions in the carbon intensity of liquid fuels would complement hybrid vehicle adoption by reducing the engine-based $CO_2$ emissions from these vehicles.

***EPA should conduct a prospective analysis of appropriate PHEV utility factors based on more recent PHEV models with longer all electric range likely to result in a shift to greater electric operation.***

PHEVs will continue to be an important compliance strategy which can integrate and optimize the best of combustion and electric technologies to increase vehicle efficiency and facilitate the transition to fully zero tailpipe emissions vehicles. This will be particularly important as the charging infrastructure and supply chains develop that are necessary for battery electric vehicle adoption at the rates projected in the proposal. PHEVs also serve as a bridge technology that can provide consumers confidence in electric vehicle technology while alleviating range anxiety for those who drive long distances.

Similar to previous EPA technology analyses prepared to support future rulemakings, MECA requests that EPA conduct a prospective analysis of utility factors of PHEVs based on the direction of the technologies being released into the market place today as well as announcements of future releases. Of particular note, EPA relied upon past data of older technology PHEVs with limited all electric ranges to justify the proposed reduction in the PHEV utility factors from today's acceptable values that are based on SAE J2841.[38]

While EPA is not proposing to adopt the minimum range requirements for PHEVs that are included in CARB ACC II, MECA believes that these requirements along with the market will drive PHEVs with longer all electric ranges. In fact, VW recently announced a PHEV Tiguan SUV available for MY 2025 with an all-electric range of 62 miles.[39] This in combination with build out of charging infrastructure, especially from Inflation Reduction Act and Infrastructure Investment and Jobs Act funding sources, will provide consumers with easier access to charge PHEVs and enable them to drive more miles on electricity rather than petroleum. The result will be that future fleet utility factors will increase rather than decrease. MECA suggests that EPA consider these developments, including studying the correlation between fleet utility factor and workplace charger availability, and not base utility factors on older PHEV technology. Finally, MECA suggests that EPA allow PHEVs certifying with all electric range greater than 50 miles to claim higher fleet utility factors, and consider scaling utility factor with a vehicle's all electric range.

[38] https://www.sae.org/standards/content/j2841_201009/
[39] https://www.caranddriver.com/volkswagen/tiguan

***Rather than permanently removing the requirement for BEV certification to account for upstream electricity generation, EPA should require upstream emission accounting for the generation of energy to power electric vehicles.***

MECA supports EPA's continued use of lifecycle analysis to analyze the regulatory impacts of its vehicle regulations. However, to drive future U.S. technology leadership and incentivize efficiency improvements in all vehicles, EPA should recognize the need to include life cycle analysis in the design of standards and compliance. When EPA began regulating GHG emissions from light-duty vehicles starting with MY 2012, the Agency decided to allow electric vehicles and fuel cell vehicles to claim 0 g/mile GHG in order to encourage the initial commercialization of these promising technologies.[40,41] However, the Agency also finalized requirements for upstream emissions to be factored into electric and fuel cell vehicle certification levels as penetration of these vehicles increased. The justification given by EPA was that "upstream GHG emission values associated with electric vehicles are generally higher than the upstream GHG emission values associated with gasoline vehicles, and that there is currently no national program in place to reduce GHG emissions from electric powerplants."

EPA is now proposing to make the 0 g/mile GHG treatment of battery and fuel cell vehicles permanent. The Agency's rationale is that "the program has now been in place for a decade, with no upstream accounting and has encouraged the continued development and introduction of electric vehicle technology." EPA further reasons that "these emission reduction technologies are now coming into the mainstream and can serve as the primary technologies upon which EPA can base more stringent standards" and that "power sector emissions are declining and the trend is projected to continue." Finally, EPA concludes that the "approach of looking only at tailpipe emissions and letting stationary source GHG emissions be addressed by separate stationary source programs is consistent with how every other light duty vehicle calculates its compliance value."

Regarding the first two points, while the program has indeed been in place for a decade, the sales volumes of electric and fuel cell vehicles remain in the minority of new vehicle sales (<10%). As sales increase, there is a potential for erosion of benefits if the pace of grid decarbonization and charging infrastructure build-out do not meet projections. Regarding EPA's final point, the agency previously recognized the inconsistency in treatment of upstream emissions of the power sector versus the oil and gas sectors. The Agency's justification then, and still valid today, is that upstream emissions related to power production to propel battery electric vehicles is higher than the upstream GHG emissions associated with gasoline vehicles, and there remains no final federal regulation to reduce GHG emissions from electric power plants.

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[40] https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-model-year-2012-2016-light-duty-vehicle

[41] https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-model-year-2017-and-later-light-duty-vehicle

For these reasons, MECA suggests that EPA maintain an upstream accounting mechanism for the GHG emissions from electricity generation to charge electric vehicles in its requirements. Rather than removing the upstream accounting provision entirely, MECA suggests that the Agency postpone it to a future year as has been the Agency's practice in previous light-duty GHG regulations. It is important to consider the emissions generated from the energy used for propulsion of all vehicles. Currently, this is well established for ICE vehicles since the emissions from fuel combustion are measured at the tailpipe. However, the electricity used to power electric vehicles comes from a mix of sources that includes combustion of fuel, and those emissions could reasonably estimated and reported during certification. It should be noted that we are not suggesting a full life cycle certification method at this time due to the complexity of such an approach. Our suggestion is to exclude the upstream emissions associated with the fuel production (mining, drilling, refining) and delivery that would affect both the fuels supplied to ICE power plants and the fuels used by ICE vehicles. We believe that a simplified approach could be applied while the Agency works with stakeholders to assess the potential of a full life cycle method that could be implemented in a future regulation.

For a simplified approach, EPA could include in the final rule an annual U.S. average grid carbon intensity based on the one used to determine the upstream GHG emissions impacts of this rule in the Agency's Regulatory Impact Analysis. This lookup table could be used by all manufacturers to certify their electric vehicles with the same grid carbon intensity values such that all manufacturers are treated equally. The manufacturer would then use a test determined electric vehicle efficiency value multiplied by the grid carbon intensity averaged over the useful life of the vehicle to report a gram per mile $CO_2$ value for an electric vehicle at certification. By assigning realistic "non-zero" emission values to electric and fuel cell vehicles, EPA will provide a regulatory incentive to further improve the electric efficiency of components and powertrain technologies that will further reduce vehicle related environmental impacts.

***EPA should consider incentives and potential future requirements that advance efficiency of electric vehicles.***

Efficiency incentives and regulations have historically driven vehicle manufacturers and technology suppliers to continue to innovate and develop better materials, components, and vehicle systems to reduce energy demand, operating costs and related emissions of vehicles. Electric vehicle efficiency does not provide large benefits at today's EV sales penetration rates. However, if the goals of this rule are met by 2032, electric vehicle sales will be over 60% and EVs will make up a much larger fraction of the in-use passenger car fleet. Therefore, small improvements in efficiency will result in large reductions in grid demand. MECA suggest that EPA consider a range of both incentives and requirements to advance the efficiency of technologies that reduce the emissions footprint of all mobile sources, regardless of the source of propulsion energy. As noted above, setting non-zero certification values for battery electric and fuel cell vehicles will continue to motivate vehicle manufacturers to work with suppliers to improve vehicle efficiency.

MECA requests that EPA explore additional incentivization structures that would allow consumers to make informed choices when purchasing electric and fuel cell vehicles. For example, EPA could institute a labeling requirement for electric vehicles with similarities to Energy Star and displaying how an electric vehicle compares to other similar electric vehicles in its class. The simplified Energy Star graphic is recognizable and understood by the majority of consumers who might not be able to interpret the value of an electric vehicle efficiency in kilowatt-hours per 100 miles, which is currently on the window sticker.

MECA members are commercializing components for electric and hydrogen fuel cell vehicles. This includes battery materials for the manufacture of both cathode and anodes utilizing unique macrostructure and composite formulations to improve efficiency and energy density. Electric component manufacturers are using state of the art transistor materials in their motors and power electronics that operate at higher voltages and temperatures thus requiring simpler cooling strategies. These next generation component designs reduce switching losses and improve electric efficiency of the system architecture in electric powertrains. To facilitate integration, component suppliers are integrating the motor, inverter and transmission into electric drive units to simplify the thermal management of the electric components and ease integration into vehicles.

As demonstrated for combustion vehicles over the past 50 years, the market can not always be relied upon to drive innovation towards conservation of critical resources and energy security by improving the efficiency of vehicles. This has led agencies to set fuel efficiency and GHG standards. There is a significant disparity in the electric efficiency of similarly sized passenger electric vehicles today, as shown in Table 4. We urge EPA to begin compiling electric efficiency information and consider setting a minimum efficiency or energy consumption by weight class in a future rulemaking.

*Table 4. Comparison of Energy Efficiency of BEV and PHEV Models*

| | |
|---|---|
| **Tesla Model Y AWD EV**<br>Battery Pack: 75 kWh<br>Range: 279 miles<br>**Efficiency: 3.6 miles/kWh** | **Volvo XC40 Recharge Twin EV**<br>Battery Pack: 75 kWh<br>Range: 223 miles<br>**Efficiency: 2.6 miles/kWh** |
| **Toyota RAV4 Prime PHEV**<br>Battery Pack: 18.1 kWh<br>Range: 42 miles EV; 600 miles total<br>**Efficiency: 2.8 miles/kWh electric** | **Land Rover Range Rover Sport PHEV**<br>Battery Pack: 12 kWh<br>Range: 19 miles EV; 480 miles total<br>**Efficiency: 1.25 miles/kWh electric** |
| **2022 Ford F-150 Lightning EV**<br>Battery Pack: 98 or 131 kWh<br>Range: 230 or 320 miles<br>**Efficiency (estimated): 2 miles/kWh** | **GMC Hummer EV**<br>Battery Pack: 212.7 kWh<br>Range: 329 miles<br>**Efficiency: 1.55 miles/kWh** |

***MECA supports alignment with UNECE Global Technical Regulations for battery durability and consideration of phase-in to match vehicle useful life in later years.***

MECA supports new battery durability monitoring and performance requirements for light-duty BEVs and PHEVs, and battery durability monitoring requirements for Class 2b and 3 BEVs and PHEVs, beginning with MY 2027 in alignment with UNECE GTR No. 22 and soon to be completed GTR 22b for medium-duty vehicles. These include SOH monitors and usable battery energy (UBE) measurement requirements, vehicle range and virtual miles traveled for medium-duty vehicles with power take-off (PTO) or vehicle-to-X capability of light-duty vehicles. This information will serve to generate durability data to support future EPA programs, as well as industry and consumer needs. While the EVE IWG chose not to set an MPR for Category 2 (MDV) plug-in electric vehicles at this time, MECA supports EPA aligning with a future minimum performance requirement for MDVs when the UNECE finalizes an applicable GTR.

As experience with battery durability develops, MECA requests the requirements be revisited and durability requirements be extended to match the useful life of light- and medium-duty vehicles. Most consumers expect the battery to last the life of the vehicle in these classes, and alignment of the durability period with the vehicle useful life will facilitate consumer acceptance and drive innovation in battery technology.

***EPA should harmonize battery labeling requirements with ACC II to facilitate recycling.***

MECA believes that mandated standardized battery labeling requirements to identify the chemistry and technology in the battery pack will facilitate in-use vehicle service and end-of-life battery recycling. Towards this goal, EPA should align battery labeling requirements with those required under California's ACC II light-duty regulation. We have previously noted that some important designations to consider on the label might include: cell type, chemistry, battery ratings (V, Ah, kWh etc.), and if any internal cooling or other fluids and hazardous materials are present within the battery pack to facilitate end- of- life handling. Such labeling will protect the environment, benefit repair, maintenance and recycling personnel as well as assist second life re-applications of automotive batteries and battery recycling. EPA could also consider incentive programs that support the implementation and continuous improvement of battery re-use and recycling and sustainable use of strategic battery materials.

***MECA supports EPA's proposed battery and vehicle component warranty requirements.***

MECA supports EPA's proposed new warranty requirements for BEV and PHEV batteries and associated electric powertrain components, such as electric machines, power electronics, and similar key electric powertrain components. We agree with the concept of building on existing high value component warranty provisions, such as emission controls. We support designating the high-voltage battery and associated electric powertrain components for light-duty electric vehicles as specified high value components subject to a warranty period of 8 years or 80,000 miles. In addition, we support the same warranty periods for components in medium-duty BEVs and PHEVs. This will give consumers confidence in the reliability of any powertrain they chose for their vehicle.

***EPA should work with other agencies, like the Joint Office on Energy and Transportation, in setting minimum charger efficiency standards to ensure that infrastructure funds are spent on chargers with the best utilization of electric power.***

The prioritization of building forward-looking vehicle charging infrastructure is critical to the penetration of electric vehicles. Furthermore, analogous to vehicle electronic design and material selection impacts to electric vehicle efficiency, similar approaches can be used to improve charger efficiency in delivering the maximum power to the vehicle.

While overnight charging at lower power may be appropriate for most light-duty vehicle use and certain medium-duty vehicle applications, we recommend the EPA prioritize the planning and building of direct current fast chargers (DCFC). The planning of public DCFCs is indispensable to allow in-service electric vehicles to address unforeseen day-to-day vehicle use variables (i.e., weather, traffic conditions, needed route changes, etc.). The availability of strategically placed, publicly accessible DCFCs prevents vehicles becoming inoperable due to these use variables, allowing vehicles to be rapidly charged and quickly placed back into service while minimizing interruptions to vehicle operations, traffic disruptions from vehicle strandings and maximizing the utilization of available space for heavy-duty vehicle recharging.

DCFC is also crucial to address long-term medium-duty vehicle charging needs. Many commercial EVs will need to achieve fast charging times to encourage fleet owners to transition to e-mobility. This is particularly true for those vehicle operators who do not have access to charging at their own facilities. EV fleet adopters with slower rate overnight charging should also diversify their charging assets with DCFCs to have more flexibility as their fleets grow and unforeseen needs arise to charge vehicles and return them to service.

Additionally, DCFCs futureproof infrastructure investments by allowing fleet operators to immediately convert and deploy BEVs while also allowing them to remain up to date with advancements in battery technology. Vehicle batteries are quickly improving in size, chemistry, energy density, and efficiency resulting in increased vehicle range. This range improvement will, however, require faster charging capabilities. While medium-duty BEV vehicles typically require larger batteries with increasing power density than light-duty vehicles, DCFCs enable quicker and more efficient charging of these vehicles. In addition, site and infrastructure owners maximize their investment because DCFCs enable site-readiness for future DCFC expansions while allowing the best utilization of available space and higher turnover of serviced vehicles.

DCFCs also allow for bidirectional charging which futureproofs infrastructure investment further by providing support for increasing electricity demand. Vehicle-to-Grid (“V2G”) technology can help address energy use and manage peak demand times and costs, as well as serve as backup power during an outage. As EV adoption increases, this technology becomes more critical to enable sustainable grid management, grid resilience, utilization, and national security protection.

MECA also recommends the EPA consider national certification, such as UL Certification, for EV supply equipment to provide consistency, quality, safety, efficiency and compliance. A Certificate of Compliance will mean the product has passed a series of rigorous tests to demonstrate performance, safety, quality, and serviceability, while enhancing sustainability, strengthening security, and managing risk. National certification also supports local permitting efficiency, therefore, helps fast track deployment of charging stations.

For these reasons, MECA urges EPA to work with other government agencies, such as the Joint Office for Transportation and Energy, and industry to develop national standards for minimum charger efficiency which will ensure the efficient energy utilization and lowest operating cost for electric vehicles. With regards to technology, several suppliers of vehicle power electronics are applying similar electric efficiency technology innovation to the development of more efficient chargers to minimize switching losses and deliver maximum power to the battery. This is important to consumers and fleets as charging losses reduce the total energy to the battery and increase operating cost. Furthermore, it is important to the environment because these losses represent electricity that is generated but never used. The difference in electric efficiency between the first generation of chargers, that are deployed in the field today, and the advanced, second-generation chargers can be as much as 10-20%. This becomes significant as electric vehicle penetration increases into the future.

***Advanced technology credit multipliers for PHEV, BEV and FCEV should end before MY 2027.***

Analyses by ICCT and researchers at Carnegie Mellon have shown that extended use of super credits in the light-duty sector has resulted in the unintended consequence of increased emissions from the non-ZEV fleet as it is allowed to emit more under a fleet average regulatory structure that includes averaging, banking and trading provisions.[42,43] Given the considerable incentives created by the Inflation Reduction Act (IRA) and Bipartisan Infrastructure Law (BIL) and other federal and state programs supporting the

[42] A. Jenn, I. L. Azevedo and J. J. Michalek, "Alternative-fuel-vehicle policy interactions increase U.S. greenhouse gas emissions," Transportation Research Part A: Policy and Practice, vol. 124, pp. 396-407, 2019.

[43] R. Minjares and J. Hannon, "Adapting US heavy-duty vehicle emission standards to support a zero-emission commercial truck and bus fleet," 2022.

production, sale and operation of medium-duty zero tailpipe emitting vehicles, MECA agrees that Advanced Technology Multipliers for PHEVs, BEVs and FCEVs are no longer needed for medium-duty vehicles beyond MY 2026. Similar to the light-duty sector, an over-incentivized credit scheme for medium-duty ZEVs is likely to result in market distortions that will reduce the broader deployment of electric and hydrogen fuel cell powertrains and thus decrease the benefits anticipated by the standards.

***Off-cycle credits provide real-world emission benefits and should continue to be offered.***

We continue to support EPA's off-cycle credit program for recognizing the breadth of engineering ingenuity to reduce real-world $CO_2$ through a verifiable credit process. This program has offered a method for vehicle manufacturers to apply for off-cycle $CO_2$ credits through three pathways with increasing levels of complexity. We agree that the five-cycle approval process is complex and thus has had limited subscribership. The program requires that off-cycle technologies be fully integrated into vehicles, and thus suppliers have had a difficult time generating enough evidence to convince their customers to commit resources to demonstrate the technology across a fleet of vehicles without any indication of the amount of credits the technology may deliver. Furthermore, suppliers have found it difficult to take advantage of the 5-cycle pathway to generating data toward demonstrating the $CO_2$ reduction benefits of a technology to their customers without access to the methodology the agency uses for calculating the final credit value.

However, light-duty super credits were recently sunset in 2022 and advanced technology multiplier credits for medium- and heavy-duty vehicles are phasing out by 2027, and we believe this could lead to increased interest and use of the current off-cycle credit program. While we understand EPA's rationale in its decision to simplify and eliminate the off-cycle credit process by removing the 5-cycle pathway and phasing out the credits, we request: (1) that the agency retain the five-cycle pathway; and (2) that the agency continue off-cycle menu credits at the 10 g/mile cap rather than phasing credit caps down to zero.

***Conclusion***

In conclusion, MECA appreciates EPA staff's dedicated effort in developing the proposed LDMDV regulation. We strongly support the proposal with modifications based on our comments. The proposal coupled with our suggested modifications would result in cost effective air quality benefits for millions of Americans. MECA believes that the standards are technically achievable while there remains uncertainty concerning the BEV penetration timelines proposed for implementation. Our industry is prepared to do its part and deliver cost-effective and durable advanced emission control and efficiency technologies to the light-duty sector to assist in simultaneously advancing electrification of new vehicles while reducing criteria and GHG emissions from, the last remaining engine-equipped vehicles.

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