Draft Technical Assessment Report:

Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025

Executive Summary

United States Environmental Protection Agency
California Environmental Protection Agency Air Resources Board
NHTSA National Highway Traffic Safety Administration

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Executive Summary

The Environmental Protection Agency (EPA) and the Department of Transportation's National Highway Traffic Safety Administration (NHTSA) have established a coordinated program for Federal standards for greenhouse gas (GHG) emissions and corporate average fuel economy (CAFE) for light-duty vehicles.[1] This program was developed in cooperation and alignment with the California Air Resources Board (CARB) to ensure a single National Program. The National Program established standards that increase in stringency year-over-year from model year (MY) 2012 through MY2025 for EPA and through MY2021 for NHTSA. California adopted the first in the nation GHG standards for light-duty vehicles in 2004 for MY2009-2016, and in 2012 for MY2017-2025, followed by amendments that allow compliance with the Federal GHG standards as compliance with the California GHG standards, in furtherance of a single National Program. Under the National Program, consumers continue to have a full range of vehicle choices that meet their needs, and, through coordination with the California standards, automakers can build a single fleet of vehicles across the U.S. that satisfies all GHG/CAFE requirements. In the agencies' 2012 final rules establishing the MY2017-2025 standards for EPA and 2017-2021 final and 2022-2025 augural standards for NHTSA, the National Program standards were projected by MY2025 to double fuel economy and cut GHG emissions in half, save 6 billion metric tons of carbon dioxide (CO_2) pollution and 12 billion barrels of oil over the lifetime of MY2012-2025 vehicles, and deliver significant savings for consumers at the gas pump.

The rulemaking establishing the National Program for MY 2017-2025 light-duty vehicles included a regulatory requirement for EPA to conduct a Midterm Evaluation (MTE) of the GHG standards established for MYs 2022-2025.[i] The 2012 final rule preamble also states that "[t]he mid-term evaluation reflects the rules' long time frame, and, for NHTSA, the agency's statutory obligation to conduct a de novo rulemaking in order to establish final standards for MYs 2022-2025." NHTSA will consider information gathered as part of the MTE record, including information submitted through public comments, in the comprehensive *de novo* rulemaking it must undertake to set CAFE standards for MYs 2022-2025.[ii] Through the MTE, EPA must determine no later than April 1, 2018 whether the MY2022-2025 GHG standards, established in 2012, are still appropriate under section 202 (a) of the Clean Air Act, in light of the record then before the Administrator, given the latest available data and information.[iii] EPA's decision could go one of three ways: the standards remain appropriate, the standards should be less stringent, or the standards should be more stringent. EPA and NHTSA also are closely coordinating with CARB in conducting the MTE to better ensure the continuation of the National Program. The MTE will be a collaborative, data-driven, and transparent process and must entail a holistic assessment of all the factors considered in the initial standards setting.[iv]

This Draft Technical Assessment Report (TAR), issued jointly by EPA, NHTSA, and CARB for public comment, is the first formal step in the MTE process.[v] In this Draft TAR, the agencies examine a wide range of technical issues relevant to GHG emissions and augural CAFE standards for MY2022-2025, and share with the public the initial technical analyses of those issues. This is a technical report, not a policy or decision document. The information in this

[1] The agencies finalized the first set of National Program standards covering model years (MYs) 2012-2016 in May 2010[1] and the second set of standards, covering MYs 2017-2025, in October 2012.

report, and in the comments we receive on it, will inform the agencies' subsequent determination and rulemaking actions. The agencies will fully consider public comments on this Draft TAR as they continue to update and refine the analyses for further steps in the MTE process.

In this Draft TAR, EPA provides its initial technical assessment of the technologies available to meet the MY2022-2025 GHG standards and one reasonable compliance pathway, and NHTSA provides its initial assessment of technologies available to meet the augural MY2022-2025 CAFE standards and a different reasonable compliance pathway. Given that there are multiple possible ways that new technologies can be added to the fleet, examining two compliance pathways provides valuable additional information about how compliance may occur. NHTSA and EPA also performed multiple sensitivity analyses which show additional possible compliance pathways. The agencies' independent analyses complement one another and reach similar conclusions:

- A wider range of technologies exist for manufacturers to use to meet the MY2022-2025 standards, and at costs that are similar or lower, than those projected in the 2012 rule;
- Advanced gasoline vehicle technologies will continue to be the predominant technologies, with modest levels of strong hybridization and very low levels of full electrification (plug-in vehicles) needed to meet the standards;
- The car/truck mix reflects updated consumer trends that are informed by a range of factors including economic growth, gasoline prices, and other macro-economic trends. However, as the standards were designed to yield improvements across the light duty vehicle fleet, irrespective of consumer choice, updated trends are fully accommodated by the footprint-based standards.

Additionally, while the Draft TAR analysis focuses on the MY2022-2025 standards, the agencies note that the auto industry, on average, is over-complying with the first several years of the National Program. This has occurred concurrently with a period during which the automotive industry successfully rebounded after a period of economic distress. The industry has now seen six consecutive years of increases and a new all-time sales record in 2015, reflecting positive consumer response to vehicles complying with the standards.

A summary of each chapter of the Draft TAR follows.

Chapter 1: Introduction. This chapter provides a broad discussion of the National Program, explains further the MTE process and timeline, and provides additional background on NHTSA's CAFE program, EPA's GHG program, and California's GHG program. This chapter also includes an update on what the latest science tells us about climate change impacts, and the U.S.'s and California's commitments on actions to address climate change. Chapter 1 also provides a discussion of petroleum consumption and energy security.

Chapter 2: Overview of Agencies' Approach to Draft TAR Analysis. The agencies are committed to conducting the MTE through a collaborative, data-driven, and transparent process. In gathering data and information for this Draft TAR, the agencies drew from a wide range of sources to evaluate how the automotive industry has responded into the early years of the National Program, how technology has developed, and how other factors affecting the light-duty vehicle fleet have changed since the final rule in 2012. The agencies found that there is a wealth of information since the 2012 final rule upon which to inform this Draft TAR, and this information is detailed throughout the document. Chapter 2 describes these sources, including extensive state-of-the-art research projects by experts at the EPA National Vehicle and Fuel Emissions Laboratory, as well as consultants to the agencies, data and input from stakeholders, and information from technical conferences, published literature, and studies published by various organizations. A significant study informing the agencies' analyses is the National Academy of Sciences 2015 report[vi] on fuel economy technologies, which the agencies highlight in Chapter 2, and discuss throughout this document.

The analyses presented in this Draft TAR reflect the new data and information gathered by the agencies thus far, and the agencies will continue to gather and evaluate more up-to-date information, including public comments on this Draft TAR, to inform our future analyses. The agencies have conducted extensive outreach with a wide range of stakeholders – including auto manufacturers, automotive suppliers, non-governmental organizations (NGOs), consumer groups, labor unions, automobile dealers, state and local governments, and others.

Chapter 3: Recent Trends in the Light-Duty Vehicle Fleet since the 2012 Final Rule. This chapter summarizes trends in the light-duty vehicle market in the four years since the 2012 final rule, including changes in fuel economy/GHG emissions, vehicle sales, gasoline prices, car/truck mix, technology penetrations, and vehicle power, weight and footprint. Since the 2012 final rule, vehicle sales have been strong, hitting an all-time high of 17.5 million vehicles in 2015, gas prices have dropped significantly, and truck share has grown. At the same time, fuel economy technologies are entering the market at rapid rates. The agencies provide the latest available projections for vehicle sales, gasoline prices, and fleet mix out to 2025, and compare those to projections made in the 2012 final rule. This chapter also highlights compliance to date with the GHG and CAFE standards, where, for the first three years of the program (MY2012-2014), auto manufacturers have over-complied with the program.

Chapter 4: Baseline and Reference Vehicle Fleets. This chapter describes the agencies' methodologies for developing a baseline fleet of vehicles and future fleet projections out to MY2025. The GHG analysis uses a baseline fleet based on the MY2014 fleet, the latest year available for which there are final GHG compliance data. The CAFE analysis uses a MY2015 baseline fleet based on MY2015 data and sales projections provided by manufacturers in the latter half of MY2015, when production was well underway. These data sets complement one another and each yield important perspective, with the MY2014 data having the benefit of validation through compliance data, and the MY2015 data providing more recent perspective. The GHG and CAFE analysis fleets utilized similar, but separate, purchased projections from IHS-Polk for the future vehicle fleet mix out to 2025, thereby representing some of the uncertainty inherent in all reference case projections. Both analyses used data from the Energy Information Administration's Annual Energy Outlook 2015 (AEO 2015) as the basis for total vehicle sales projections to 2025, as well as for the car and truck volume mix. Although the agencies have relied on different data sources in development of the baseline fleets, we believe this combination of approaches strengthens our results by showing robust results across a range of reference case projections.

Chapter 5: Technology Costs, Effectiveness, and Lead-Time Assessment. This chapter is an in-depth assessment of the state of vehicle technologies to improve fuel economy and reduce GHG emissions, as well as the agencies' assessment of expected future technology developments through MY2025. The technologies evaluated include all those considered for the 2012 final rule, as well as new technologies that have emerged since then. Every technology has been reconsidered with respect to its cost, effectiveness, application, and lead-time considerations, with emphasis on assessing the latest introductions of technologies to determine if and how they have changed since the agencies' assessment in the 2012 final rule. These efforts reflect the significant rate of progress made in automotive technologies over the past four years since the MY2017-2025 standards were established. Technologies considered in this Draft TAR include more efficient engines and transmissions, aerodynamics, light-weighting, improved accessories, low rolling resistance tires, improved air conditioning systems, and others. Beyond the technologies the agencies considered in the 2012 final rule, manufacturers are now employing several technologies, such as higher compression ratio, naturally aspirated gasoline engines, and greater penetration of continuously variable transmissions (CVTs); other new technologies are under active development and are expected to be in the fleet well before MY2025, such as 48-volt mild hybrid systems.

In Chapter 5, the agencies also provide details on the specific technology assumptions used respectively by EPA for the GHG assessment and by NHTSA for the CAFE assessment in this Draft TAR, including the specific assumptions that EPA and NHTSA each made for each technology's cost and effectiveness, and lead-time considerations. The agencies' estimates of technology effectiveness were informed by vehicle simulation modeling approaches; NHTSA utilized the Autonomie model developed by Argonne National Laboratories for the Department of Energy (DOE), and EPA used its Advanced Light-duty Powertrain and Hybrid Analysis (ALPHA) model. The agencies look forward to public comment in this and other areas to help advance collective forecasting of technology effectiveness in the out years of the program.

It is clear that the automotive industry is innovating and bringing new technology to market at a rapid pace and neither of the respective agency analyses reflects all of the latest and emerging technologies that may be available in the 2022-2025 time frame. For example, the agencies were not able for this Draft TAR to evaluate the potential for technologies such as electric turbo-charging, variable compression ratio, skip-fire cylinder deactivation, and P2-configuration mild-hybridization. These technologies may provide further cost-effective reductions in GHG emissions and fuel consumption. The agencies will continue to update their analyses throughout the MTE process as new information becomes available.

Chapter 6: Assessment of Consumer Acceptance of Technologies that Reduce Fuel Consumption and GHG Emissions. This chapter reviews issues surrounding consumer acceptance of the vehicle technologies expected to be used to meet the MY2022-2025 standards. Since the program has been in effect since MY2012, the agencies focus on the evidence to date related to consumer acceptance of vehicles subject to the National Program standards. This evidence includes an analysis of how professional auto reviewers assess fuel-saving technologies. For each technology, positive evaluations exceed negative evaluations, suggesting that it is possible to implement these technologies without significant hidden costs. To date, consumer response to vehicles subject to the standards is positive. Chapter 6 also discusses potential impacts of the standards on vehicle sales and affordability, which are closely interconnected with the effects of macroeconomic and other market forces. Based on the agencies' draft assessments, the reduced operating costs from fuel savings over time are expected to far exceed the increase in up-front vehicle costs, which should mitigate any potential adverse effects on vehicle sales and affordability.

Chapter 7: Employment Impacts. This chapter discusses the effects of employment in the automotive sector to date, and the projected effects of the MY 2022-2025 standards on employment. Employment in the automotive industry dropped sharply during the Great Recession, but has increased steadily since 2009. The primary employment effects of these standards are expected to be found in several key sectors: auto manufacturers, auto parts manufacturing, auto dealers, fuel production and supply, and consumers. The MY2025 standards are likely to have some effect on employment, due to both the effects of the standards on vehicle sales, and the need to produce new technologies to meet the standards. Nevertheless, the net effect of the standards on employment is likely to be small compared to macroeconomic and other factors affecting employment.

Chapter 8: Assessment of Vehicle Safety Effects. This chapter assesses the estimated overall crash safety impacts of the MY 2022-2025 standards. In this chapter, the agencies first review the relationships between mass, size, and fatality risk based on the statistical analysis of historical crash data, which includes the new analysis performed by using the most recent crash data. The updated NHTSA analysis develops five parameters for use in both the NHTSA and EPA assessments to calculate the estimated safety impacts of the modeled mass reductions over the lifetimes of new vehicles in response to MY 2022-2025 GHG standards and augural CAFE standards. Second, to examine the impact of future lightweight vehicle designs on safety, the agencies also reviewed a fleet crash simulation study that examined frontal crashes using existing and future lightweight passenger car and cross-over utility vehicle designs. The study found a relationship between vehicle mass reduction and safety that is directionally consistent with the overall risk for passenger cars from the NHTSA 2016 statistical analysis of historical crash data. Next, the agencies investigate the amount of mass reduction that is affordable and feasible while maintaining overall fleet safety and as well as functionality such as durability, drivability, noise, vibration and handling (NVH), and acceleration performance. Based on those approaches, the agencies further discuss why the real world safety effects might be less than or greater than calculated safety impacts, and what new challenges these lighter vehicles might bring to vehicle safety and potential countermeasures available to manage those challenges effectively.

Chapter 9: Assessment of Alternative Fuel Infrastructure. This chapter assesses the status of infrastructure for alternative fueled vehicles, with emphasis on two technologies the agencies believe will be important for achieving longer-term climate and energy goals – plug-in electric vehicles (PEVs) and fuel cell electric vehicles (FCEVs). The agencies also discuss infrastructure for ethanol (E85) flex-fueled vehicles and natural gas vehicles. The agencies' assessment is that, as we concluded in the 2012 rule, high penetration levels of alternative fueled vehicles will not be needed to meet the MY2025 standards, with the exception of a very small percentage of PEVs, and that infrastructure is progressing sufficiently to support vehicles from those manufacturers choosing to produce alternative fueled vehicles to meet the MY2022-2025 standards. The majority of PEV charging occurs at home, and national PEV infrastructure in public and work locations is progressing appropriately. Hydrogen infrastructure developments are addressing many of the initial challenges of simultaneously launching new vehicle and fueling infrastructure markets, and current efforts in California and the northeast states will facilitate further vehicle and infrastructure rollout at the national level.

Chapter 10: Economic and Other Key Inputs Used in the Agencies' Analyses. This chapter describes many of the economic and other inputs used in the agencies' analyses. This chapter discusses the methodologies used to assess inputs such as the real-world fuel economy/GHG emissions gap, vehicle miles traveled (VMT), vehicle survival rates, the VMT rebound effect, energy security, the social cost of carbon and other GHGs, health benefits, consumer cost of vehicle ownership, and others.

Chapter 11: Credits, Incentives and Flexibilities. The National Program was designed with a wide range of optional compliance flexibilities to allow manufacturers to maintain consumer choice, spur technology development, and reduce compliance costs, while achieving significant GHG and oil reductions. Chapter 11 provides an informational overview of all of these compliance flexibilities, with particular emphasis on those flexibility options likely to be most important in the MY2022-2025 timeframe.

Chapter 12: Analysis of the MY2022-2025 GHG Standards; and **Chapter 13: Analysis of Augural CAFE Standards.** Chapters 12 and 13 provide results, respectively, of EPA's initial technical assessment of the technologies available to meet the MY2022-2025 GHG standards (i.e., the footprint-based standard curves) and their costs, and NHTSA's initial technical assessment of technologies capable of meeting CAFE standards corresponding to the augural standards for MY2022-2025, and these technologies' costs. CARB has not conducted an independent analysis, but has participated in both EPA's and NHTSA's analyses. Although all three agencies have been working collaboratively in an array of areas throughout the development of this Draft TAR, the EPA GHG and NHTSA CAFE assessments were done largely independently. These independent analyses were done in part to recognize differences in the agencies' statutory authorities and to reflect independent choices regarding some of the modeling inputs used at this initial stage of our evaluation. The agencies believe that independent and parallel analyses can provide complementary results. The agencies further believe that, for this Draft TAR which is the first step of the Midterm Evaluation process, it is both reasonable and advantageous to make use of different data sources and modeling tools, and to show multiple pathways for potential compliance with the MY 2022-2025 GHG standards and augural CAFE standards.

As noted above, although CARB did not perform its own modeling assessment of the costs and technologies to meet the 2022-2025 GHG and CAFE requirements, it was integrally involved in analyzing the underlying technology cost and effectiveness inputs to the EPA and NHTSA modeling. CARB believes that the analyses presented in this Draft TAR appropriately present a range of technologies that could be used to meet the requirements. However, as discussed above, there are, and will continue to be, emerging technologies that may well be available in the 2022-2025 timeframe and could perform appreciably better or be lower cost than the technologies modeled in this Draft TAR. Such technologies are exemplified by recent advancements already seen in the marketplace yet not anticipated by the agencies' rule four years ago (e.g., expanded use of higher compression ratio, naturally aspirated gasoline engines). Vehicle manufacturers have historically outpaced agency expectations and CARB believes it is likely that industry will continue to do so.

In this Draft TAR, NHTSA does not present alternatives to the augural standards because, as the first stage of the Midterm Evaluation process, the TAR is principally an exploration of technical issues -- including assumptions about the effectiveness and cost of specific technologies, as well as other inputs, methodologies and approaches for accounting for these issues. The agencies seek comment from stakeholders to further inform the analyses, in advance of the NHTSA rulemaking and the EPA Proposed Determination. For the purposes of clearly reflecting the impacts of updated technology assumptions relative to a familiar point of comparison, both agencies have run their respective models using the stringency levels included in NHTSA's augural standards, and EPA's existing GHG standards through MY2025. However, the technology assumptions and other analyses presented in this Draft TAR, which will be informed by public comment, will support the development of a full range of stringency alternatives in the subsequent CAFE Notice of Proposed Rulemaking.

In this Draft TAR, the EPA GHG and NHTSA CAFE assessments both show that the MY2022-2025 standards can be achieved largely through the use of advanced gasoline vehicle technologies with modest penetrations of lower cost electrification (like 48 volt mild hybrids which include stop/start) and low penetrations of higher cost electrification (like strong hybrids, plug-in hybrid electric vehicles, and all electric vehicles). Given the rapid pace of automotive industry innovation, the agencies may consider effectiveness and cost of additional technologies as new information, including comments on this Draft TAR, becomes available for further steps of the Midterm Evaluation.

Based on various assumptions including the Annual Energy Outlook 2015 (AEO 2015) reference case projections of the car/truck mix out to 2025, the footprint-based GHG standards curves for MY2022-2025 are projected to achieve an industry-wide fleet average CO_2 target of 175 grams/mile (g/mi) in MY2025, and the augural CAFE standards are projected to result in average CAFE requirements increasing from 38.3 mpg in MY2021 to 46.3 mpg in MY2025. The projected fleet average CO_2 target represents a GHG emissions level equivalent to 50.8 mpg (if all reductions were achieved exclusively through fuel economy improvements).[2]

Table ES-1 below compares two additional AEO 2015 scenarios in addition to the AEO 2015 reference case: a low fuel price case and a high fuel price case. As shown, these fuel price cases translate into different projections for the car/truck fleet mix (e.g., with a higher truck share shown in the low fuel price case, and a lower truck share shown in the high fuel price case), which in turn leads to varying projections for the estimated fleet wide CAFE requirements and GHG CO_2 targets and MPG-e levels projected for MY2025, from 169 g/mi (52.6 mpg-e) under the high fuel price case to 178 g/mi (49.9 mpg-e) under the low fuel price case. These estimated GHG target levels and CAFE requirements reflect changes in the latest projections about the MY2025 fleet mix compared to the projections in 2012 when the agencies first established the standards. Under the footprint-based standards, the program is designed to ensure significant GHG reductions/fuel economy improvements across the fleet, and each automaker's standard automatically adjusts based on the mix (size and volume) of vehicles it produces each model year. In the agencies' current analyses for this Draft TAR, we are applying the same footprint-based standards established in the 2012 final rule to the updated fleet projections for MY2025. It is important to keep in mind that the updated MY2025 fleet wide projections reflected in this Draft TAR are still just projections (as were the fleet projections in the 2012 rule) -- based on the latest available information, which may continue to change with future projections -- and that the actual GHG emissions/fuel economy level achieved in MY2025 won't be determined until the

[2] The projected MY 2025 target of 175 g/mi represents an approximate 50% decrease in GHG emissions relative to the fuel economy standards that were in place in 2010. It is clear from current GHG manufacturer performance data that many automakers are earning air conditioner refrigerant GHG credits that reduce GHG emissions, but do not increase fuel economy. Accordingly, the projected MY 2025 target of 175 g/mi represents slightly less than a doubling of fuel economy relative to the standards that were in place in 2010.

manufacturers have completed their MY2025 production. The agencies will continue to assess the latest available projections as we continue the Midterm Evaluation process.

Table ES- 1 Projections for MY2025: Car/Truck Mix, CO2 Target Levels, and MPG-equivalent[1]

		AEO 2015 Fuel Price Case		
	2012 Final Rule	**AEO Low**	**AEO Reference**	**AEO High**
Car/truck mix	67/33%	48/52%	52/48%	62/38%
CAFE (mpg)[2]	48.7	45.7	46.3	47.7
CO_2 (g/mi)	163	178	175	169
MPG-e	54.5	50.0	50.8	52.6

Notes:
[1] The CAFE, CO_2 and MPG-e values shown here are 2-cycle compliance values. Projected real-world values are detailed in Chapter 10.1; for example, for the AEO reference fuel price case, real-world EPA CO_2 emissions performance would be 220 g/mi and real-world fuel economy would be 36 mpg.
[2] Average of estimated CAFE requirements.
[3] Mile per gallon equivalent (MPG-e) is the corresponding fleet average fuel economy value if the entire fleet were to meet the CO2 standard compliance level through tailpipe CO2 improvements that also improve fuel economy. This is provided for illustrative purposes only, as we do not expect the GHG standards to be met only with fuel efficiency technology.

The agencies' updated assessments provide projections for the MY2022-2025 standards for several key metrics, including modeled "low-cost pathway" technology penetrations, per-vehicle average costs (cars, trucks, and fleet, by manufacturer and total industry-wide), industry-wide average costs, GHG and oil reductions, consumer payback, consumer fuel savings, and benefits analysis.

Based on the extensive updated assessments provided in this Draft TAR, the projections for the average per-vehicle costs of meeting the MY2025 standards (incremental to the costs already incurred to meet the MY2021 standard) are, for EPA's analysis of the GHG program, $894 - $1,017, and, for NHTSA's analysis of the CAFE program, $1,245 in the primary analysis using Retail Price Equivalent (RPE), and $1,128 in a sensitivity case analysis using Indirect Cost Multipliers (ICM). In the 2012 final rule, the estimated costs for meeting the MY2022-2025 GHG standards (incremental to the costs for meeting the MY2021 standard in MY2021) was $1,070.[3,vii]

[3] This cost estimate from the 2012 final rule was based on the use of Indirect Cost Multipliers (ICMs) in 2010$.

Table ES- 2 Per-Vehicle Average Costs to Meet MY2025 Standards: Draft TAR Analysis Costs Shown are Incremental to the Costs to Meet the MY2021 Standards

	GHG[1] in MY2025		CAFE in MY 2028	
	Primary Analysis	RPE Sensitivity Case[3]	Primary Analysis[2]	ICM Sensitivity Case[3]
Car	$707	$789	$1,207	$1,156
Truck	$1,099	$1,267	$1,289	$1,096
Combined	$894	$1,017	$1,245	$1,128

Notes:
[1] The values reported for the GHG analysis to account for indirect costs reflect the use of Indirect Cost Multipliers for the primary analysis, and Retail Price Equivalent for the sensitivity case.
[2] The values reported for CAFE primary analysis reflect the use of RPE and include civil penalties estimated to be incurred by some OEMs as provided by EPCA/EISA. Estimated technology costs (without civil penalties) average $1,111, $1,246, and $1,174, respectively for MY2028 passenger cars, light trucks, and the overall light-duty fleet.
[3] Note that Chapter 12 (GHG) and Chapter 13 (CAFE) include a wide range of additional sensitivity cases.

In Table ES-2, NHTSA's estimates are provided for MY2028 because NHTSA's analysis, which is conducted on a year-by-year basis, indicates that manufacturers could make use of EPCA/EISA's provisions allowing credits to be earned and carried forward to be applied toward ensuing model years. Therefore, NHTSA's analysis indicates that a "stabilized" response to the augural standards might not be achieved until approximately 2028 (see Chapter 13 for additional detail). EPA estimates are provided for MY2025 because EPA's analysis projects that each manufacturer would comply in MY2025 with that year's standards (see Chapter 12 for additional details).

Table ES-3 shows fleet-wide penetration rates for a subset of the technologies the agencies' project could be utilized to comply with the MY2025 standards. While all three agencies have been working collaboratively on an array of issues throughout this initial phase of the Midterm Evaluation, much of the EPA GHG and NHTSA CAFE assessments were done largely independently, as reflected in the different technology pathways shown in Table ES-3 (see Chapter 2.3 for additional detail). The agencies' analyses each project that the MY2022-2025 standards can be met largely through improvements in gasoline vehicle technologies, such as improvements in engines, transmissions, light-weighting, aerodynamics, and accessories. The analyses further indicate that only modest amounts of hybridization, and very little full electrification (plug-in hybrid electric vehicles (PHEV) or electric vehicles (EV)) technology will be needed to meet the standards. This initial assessment of potential technology paths is similar to the agencies' projections made in the 2012 final rule, and is consistent with the findings of the National Academy of Sciences report from June 2015 (discussed in Chapter 2).

Table ES- 3 Selected Technology Penetrations to Meet MY2025 Standards[1]

	GHG	CAFE
Turbocharged and downsized gasoline engines	33%	54%
Higher compression ratio, naturally aspirated gasoline engines	44%	<1%
8 speed and other advanced transmissions[2]	90%	70%
Mass reduction	7%	6%
Stop-start	20%	38%
Mild Hybrid	18%	14%
Full Hybrid	<3%	14%
Plug-in hybrid electric vehicle[3]	<2%	<1%
Electric vehicle[3]	<3%	<2%

Notes:
[1] Percentages shown are absolute rather than incremental. These values reflect both EPA and NHTSA's primary analyses; both agencies present additional sensitivity analyses in Chapter 12 (GHG) and Chapter 13 (CAFE). For EPA this includes a pathway where higher compression ratio naturally aspirated gasoline engines are held at a 10% penetration, and the major changes are turbocharged and downsized gasoline engines increase to 47% and mild hybrids increase to 38% (See Chapter 12.1.2)
[2] Including continuously variable transmissions (CVT)
[3] In EPA's modeling, the California Zero Emission Vehicles (ZEV) program is considered in the reference case fleet; therefore, 3.5% of the fleet is projected to be full EV or PHEV in the 2022-2025 timeframe due to the ZEV program and the adoption of that program by nine additional states.

Although some of the differences in costs are expected as EPA and NHTSA conducted two independent analyses, the consideration of CARB's program also led to one important difference. As noted in the footnote for Table ES-3, EPA's analysis included consideration for compliance with other related state regulations including CARB's ZEV regulation that has also been adopted by nine other states under Section 177 of the Federal Clean Air Act. CARB's ZEV program requires a portion of new light-duty vehicle sales to be ZEVs and collectively, CA and these states represent nearly 30 percent of nationwide sales of light-duty vehicles. CARB worked with EPA to include ZEVs reflecting compliance with California's ZEV program within the reference fleet used by EPA. NHTSA's analysis did not. This accounts for at least part of the cost differences in the two agencies' analyses as well as for some of the difference in technology penetration rates for full hybrids.

EPA's analysis indicates that, compared to the MY2021 standards, the MY2025 standards will result in a net lifetime consumer savings of $1,460 - $1,620 and a payback of about 5 to 5 ½ years.[4] NHTSA's primary analysis indicates that net lifetime consumer savings could average $680 per vehicle, such that increased vehicle purchase costs are paid back within about 6 ½ years, and $800 with payback within about 6 years in a sensitivity case analysis using ICMs.

[4] Based on the AEO 2015 reference case gasoline price projections, 3 percent discount rate, and ICMs.

Table ES- 4 Payback Period and Lifetime Net Consumer Savings for an Average Vehicle Compared to the MY2021 Standards

	GHG MY2025 Vehicle		CAFE MY2028 Vehicle	
	Primary Analysis	**RPE Sensitivity Case**	**Primary Analysis**	**ICM Sensitivity Case**
Payback period (years)	5	5 ½	6 ½	6
Net Lifetime Consumer Savings ($, discounted at 3%)	$1,620	$1,460	$680	$800

* Note that Chapter 12 (GHG) and Chapter 13 (CAFE) include a wide range of additional sensitivity cases.

Over the lifetimes of MY2021-2025 vehicles, EPA estimates that under the GHG standards, GHG emissions would be reduced by about 540 million metric tons (MMT) and oil consumption would be reduced by 1.2 billion barrels. Over the lifetimes of MY2016-2028 vehicles, NHTSA estimates that under the augural MY2022-2025 CAFE standards, GHG emissions would be reduced by about 748 MMT and oil consumption would be reduced by about 1.6 billion barrels. NHTSA's estimates span a wider range of model years for two reasons, as discussed in Chapter 13: first, the NHTSA analysis projects that manufacturers may take some "early action" prior to MY2022; second, as discussed above, the response to the augural standards might not be "stabilized" until after MY2025. Differences in these values also result from differences in the agencies' estimates of annual mileage accumulation by light-duty vehicles.[5]

Table ES- 5 Cumulative GHG and Oil Reductions for Meeting the MY2022-2025 Standards

Lifetime Reductions	GHG (MYs 2021-2025 vehicles)	CAFE (MYs 2016-2028 vehicles)
CO_2e reduction (million metric tons, MMT)	540	748
Oil reduction (billion barrels)	1.2	1.6

For the EPA GHG analysis, total industry-wide costs of meeting the MY2022-2025 GHG standards are estimated at $34 to $38 billion. Societal monetized benefits of the MY2022-2025 standards (exclusive of fuel savings to consumers) range from $40 to $41 billion. Consumer pre-tax fuel savings are estimated to be $89 billion over the lifetime of vehicles meeting the MY2022-2025 standards. Net benefits (inclusive of fuel savings) are estimated at $90 to $94 billion. These values are all at a 3 percent discount rate; values at a 7 percent discount rate are shown in Table ES-6 below.

[5] The agencies' methods for assessing vehicle mileage accumulation are discussed in Chapter 10.3 for EPA, and Chapter 13 for NHTSA.

Table ES- 6 GHG Analysis of Lifetime Costs & Benefits to Meet the MY2022-2025 Standards (for Vehicles Produced in MY2021-2025)* (Billions of 2013$)

	3 Percent Discount Rate		7 Percent Discount Rate	
	Primary Analysis	RPE Sensitivity Case	Primary Analysis	RPE Sensitivity Case
Vehicle Program	- $34	-$38	-$24	-$27
Maintenance	-$2	-$2	-$1	-$1
Fuel	$89	$89	$49	$49
Benefits*	$41	$40	$30	$30
Net Benefits	$94	$90	$54	$51

Note:
*These values reflect AEO 2015 reference fuel price case. The Primary Analysis reflects ICMs and the Sensitivity Case reflects RPEs. All values are discounted back to 2015; see Chapter 12.3 for details on discounting social cost of GHG and non-GHG benefits. Note that Chapter 12 also includes a number of additional sensitivity cases.

NHTSA's primary analysis shows that compared to the No Action alternative, the augural CAFE standards could entail additional costs totaling $87 billion during MYs 2016-2028 (reasons for this span of MYs are discussed above), and a sensitivity case using ICM shows total costs of $79 billion. The primary analysis shows benefits totaling $175 billion, and the ICM sensitivity case shows $178 billion. Consumer fuel savings are estimated to be $67 billion to $122 billion over the lifetime of vehicles meeting the MY2022-2025 standards. Thus, net benefits (inclusive of fuel savings) could total $88 billion based on the primary analysis and $99 billion for the ICM sensitivity case. These are estimates of the present value (in 2015) of costs and benefits, based on a 3 percent discount rate. NHTSA has also conducted analysis using a 7 percent discount rate, and a broader sensitivity analysis to examine the impact of other key analysis inputs, as discussed in Chapter 13. Below, Table ES-7 provides an overall summary of costs and benefits observed in NHTSA's analysis.

Table ES- 7 CAFE Analysis of Lifetime Costs & Benefits to Meet the MY2022-2025 Standards (for Vehicles Produced in MY2016-2028) (Billions of 2013$)

	3 Percent Discount Rate		7 Percent Discount Rate
	Primary Analysis[2]	ICM Sensitivity Case[3]	Primary Analysis
Vehicle Program[1]*	-$87	-$79	-$60
Benefits (Fuel)	$120	$122	$67
Benefits (Other)	$55	$56	$43
Net Benefits	$88	$99	$50

Notes:
[1] Includes changes in maintenance costs (small relative to cost of additional technology).
[2] The Primary Analysis reflects RPE.
[3] Note that Chapter 13 includes a wide range of additional sensitivity cases.

As noted above, because EPA and NHTSA developed independent assessments of technology cost, effectiveness, and reference case projections, the compliance pathways and associated costs that result are also different. Consideration of these two results provides greater confidence that compliance can be achieved through a number of different technology pathways.

References

[i] See 40 CFR 86.1818-12(h).
[ii] See 40 CFR 86.1818-12(h).
[iii] See 40 CFR section 86.181-12(h).
[iv] See 77 FR 62784 (Oct. 12, 2012).
[v] See 40 CFR 86.1818-12(h)(2)(i).
[vi] National Academy of Sciences, National Research Council to the National Academies, "Cost, Effectiveness and Deployment of Fuel Economy Technologies for Light-Duty Vehicles," June 2015.
[vii] Regulatory Impact Analysis: Final Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emissions Standards and Corporate Average Fuel Economy Standards, EPA-420-R-12-016, Table 5.1-8, page 5-8.