DEPARTMENT OF TRANSPORTATION

National Highway Traffic Safety Administration

49 CFR Parts 531 and 533

[Docket No. NHTSA-2010-0175]

Passenger Car and Light Truck Average Fuel Economy Standards

Request for Product Plan Information – Model Years 2010-2025

AGENCY: National Highway Traffic Safety Administration (NHTSA), Department of Transportation (DOT).

ACTION: Request for Comments.

SUMMARY: The purpose of this request for comments is to acquire updated information regarding vehicle manufacturers' future product plans to assist the agency in assessing what corporate average fuel economy (CAFE) standards should be established for passenger cars and light trucks manufactured in model years 2017 and beyond. NHTSA must establish CAFE standards pursuant to the Energy Policy and Conservation Act, Pub. L. 94-163, as amended by the Energy Independence and Security Act (EISA) of 2007, Pub. L. 110-140. This request is being issued in preparation for an upcoming Joint Notice of Proposed Rulemaking being undertaken by NHTSA and EPA regarding future CAFE and greenhouse gas (GHG) standards currently anticipated to be released by September 30, 2011.

DATES: Comments must be received on or before **[insert date 60 days after publication in the Federal Register].**

ADDRESSES: You may submit comments [identified by Docket No. NHTSA-2010-0175] by any of the following methods:

- Federal eRulemaking Portal: Go to http://www.regulations.gov. Follow the online instructions for submitting comments.
- Mail: Docket Management Facility, U.S. Department of Transportation, 1200 New Jersey Avenue, SE, West Building Ground Floor, Room W12-140, Washington, DC 20590.
- Hand Delivery or Courier: West Building Ground Floor, Room W12-140, 1200 New Jersey Avenue, SE, between 9 am and 5 pm ET, Monday through Friday, except Federal holidays. Telephone: 1-800-647-5527.
- Fax: 202-493-2251

Instructions: All submissions must include the agency name and docket number for this proposed collection of information. Note that all comments received will be posted without change to http://www.regulations.gov, including any personal information provided. Please see the Privacy Act heading below.

Privacy Act: Anyone is able to search the electronic form of all comments received into any of our dockets by the name of the individual submitting the comment (or signing the comment, if submitted on behalf of an association, business, labor union, etc.). You may review DOT's complete Privacy Act Statement in the **Federal Register** published on April 11, 2000 (65 FR 19477-78) or you may visit http://www.dot.gov/privacy.html.

Docket: For access to the docket to read background documents or comments received, go to http://www.regulations.gov and follow the online instructions, or visit the Docket Management Facility at the street address listed above.

FOR FURTHER INFORMATION CONTACT: Mr. Ken Katz, Fuel Economy Division, Office of International Policy, Fuel Economy and Consumer Programs, at (202) 366-0846, facsimile (202) 493-2290, electronic mail ken.katz@dot.gov. For legal issues, call Ms. Rebecca Yoon, Office of the Chief Counsel, at (202) 366-2992.

SUPPLEMENTARY INFORMATION:

I. Introduction

NHTSA has been issuing Corporate Average Fuel Economy (CAFE) standards for the last 30 years under the Energy Policy and Conservation Act (EPCA). The CAFE program requires manufacturers to improve the fuel economy of vehicles sold in the United States which helps the Nation conserve petroleum, saves consumers money at the pump, and promotes energy independence and security by reducing dependence on foreign oil. Additionally, since higher fuel economy means that less fuel needs to be combusted to move a vehicle down the road, and since the by-product of fuel consumption is carbon dioxide (CO_2) emissions, the CAFE program also reduces the effects of climate change by reducing those emissions from the tailpipes of new motor vehicles.

Congress amended EPCA in 2007 through the Energy Independence and Security Act (EISA). EISA added several requirements for NHTSA to fulfill in developing passenger car and light truck CAFE standards for each model year (MY). For example, besides the requirement to set standards at the maximum feasible level for each model

year, EISA added a requirement that MYs 2011-2020 standards must be set to ensure that the industry-wide average of all new passenger cars and light trucks, combined, is at least 35 miles per gallon (mpg) by MY 2020. EISA also required the CAFE standards to be based on one or more vehicle attributes related to fuel economy and to be expressed in the form of a mathematical function. The attribute that NHTSA chose for the MYs 2011-2016 standards was vehicle footprint (which is defined as a vehicle's wheelbase times its average track width), and the mathematical function defining those standards is a "target curve" which is more stringent for smaller vehicles and less stringent for larger vehicles. The fleet wide average fuel economy that a particular manufacturer must achieve thus depends on the size mix of its fleet. This approach ensures that all manufacturers will be required to incorporate fuel-saving technologies across a broad range of their passenger car and light truck fleets.

Also in 2007, the Supreme Court ruled in *Massachusetts v. EPA* that the Clean Air Act allows EPA to regulate emissions of greenhouse gas (GHG) emissions if the agency determines that these gases endanger public health and welfare. In 2009, EPA issued the requisite endangerment finding,[1] and began working toward the regulation of motor vehicle GHG emissions.

Since 2008, NHTSA has been working closely with EPA to develop harmonized CAFE and GHG standards for passenger cars and light trucks, in order to ensure coordinated federal policy and reduce the burden on manufacturers. Following the success of the joint MYs 2012-2016 CAFE and GHG standards,[2] on May 21, 2010, President Obama requested that the two agencies begin evaluating potential standards for

[1] Information about EPA's endangerment finding is available at http://www.epa.gov/climatechange/endangerment.html (last accessed November 22, 2010).
[2] Final rule establishing the MYs 2012-2016 CAFE and GHG standards, 75 Fed. Reg.25324 (May 7, 2010).

MYs 2017-2025.[3] NHTSA and EPA released a Notice of Intent regarding such standards on September 30, 2010,[4] along with an Interim Technical Assessment Report developed jointly by NHTSA, EPA, and the California Air Resources Board (CARB).[5] The agencies subsequently issued a Supplemental Notice of Intent on November 30, 2010,[6] and expect to release a Notice of Proposed Rulemaking (NPRM) by September 30, 2011.

To assist the agency in analyzing potential CAFE standards for MYs 2017 and beyond, NHTSA is requesting any updates to product plans previously provided by vehicle manufacturers, as well as production data through the recent past, including data about engines, transmissions, vehicle mass reduction technologies, and hybrid technologies for MY 2010 through MY 2025 passenger cars and light trucks and the assumptions underlying those plans. If manufacturers have not previously submitted product plan information to NHTSA and wish to do so (especially those who previously had their plans submitted as part of another manufacturer's submission), NHTSA also requests such information from them. NHTSA requests information for MYs 2010-2025 primarily as a basis for subsequent discussions with individual manufacturers regarding their capabilities for the MYs 2017-2025 time frame as we develop the upcoming NPRM. The information received will also supplement other information that will be used by NHTSA to develop a realistic forecast of the vehicle market in MY 2017 and beyond, and to evaluate what technologies may feasibly be applied by manufacturers to achieve compliance with potential future standards. Information regarding earlier model years may help the agency to better account for cumulative effects such as cost reductions due

[3] The Presidential Memorandum is available at http://www.whitehouse.gov/the-press-office/presidential-memorandum-regarding-fuel-efficiency-standards (last accessed November 22, 2010).
[4] Notice of Intent, 75 Fed. Reg. 62739 (Oct. 13, 2010).
[5] Available at http://www.nhtsa.gov/fuel-economy (last accessed November 22, 2010).
[6] Supplemental Notice of Intent, 75 Fed. Reg. 76337 (Dec. 8, 2010).

to learning. This information will help the agencies check the estimates they employed for rulemaking against manufacturer-reported technology costs and effectiveness, and also to help the agencies understand product mix and technology application trends during model years for which the agency is currently receiving CAFE compliance data. Information regarding later model years may help the agency gain a better understanding of how manufacturers' plans through MY 2025 relate to their longer-term expectations regarding foreseeable regulatory requirements, market trends, and prospects for more advanced technologies (such as HCCI engines, dual loop cooled EGR, plug-in hybrid, electric, and fuel cell vehicles, among others).

NHTSA will also consider information regarding the model years requested when considering manufacturers' planned schedules for redesigning and freshening their products, in order to examine how manufacturers anticipate tying technology introduction to product design schedules. In addition, the agency is requesting information regarding manufacturers' estimates of the future vehicle population, and fuel economy improvements and incremental costs attributed to technologies reflected in those plans. The request for information is detailed in appendices to this notice. NHTSA has also included a number of questions directed primarily toward vehicle manufacturers, whereas others may also be applicable for suppliers that are interested in supplying independent responses. They can be found in Appendix A to this notice. Answers to those questions will assist the agency in its analysis.

Given the importance that responses to this request for comment may have in informing NHTSA's proposed CAFE rulemaking, either as part of the basis for the standards or as an independent check on them, NHTSA intends to review carefully and

critically all data provided by commenters. It is therefore important that commenters fully respond to each question, particularly by providing information regarding the basis for technology costs and effectiveness estimates. Although NHTSA practice has typically been to request product plan information reaching several years beyond the end of the anticipated rulemaking time frame in order to provide this context, many manufacturers submitting comments in the past have provided relatively little detail in response for those later model years. Considering past responses to these requests, we expect that most manufacturers' product plans are currently well defined through approximately 2015, somewhat less defined through approximately 2020, and thereafter, increasingly fluid and open to change. As NHTSA and EPA are working jointly to consider standards that cover MYs 2017-2025, we request that manufacturers provide as much information as they can, spanning as many of these model years as feasible, and also summarize major sources of uncertainty. For example, if a manufacturer's plans depend significantly on fuel prices, we request that the manufacturer indicate which fuel prices they have assumed, as well as what general differences in product plans could be expected given significantly lower or higher future fuel prices. Also, as fuel economy regulations are not defined beyond MY 2016, and GHG regulations currently do not change after MY 2016, it is expected that product plan information may be based on requirements continuing to reflect MY 2016 levels through MY 2025. However, if other assumptions have been used, NHTSA requests those assumptions be provided.

To facilitate the submission of comments and to help ensure the conformity of data received regarding manufacturers' product plans from MY 2010 through MY 2025, NHTSA has developed spreadsheet templates for manufacturers' use. The uniformity

provided by these spreadsheets is intended to aid and expedite our review, integration, and analysis of the information provided. These templates are the agency's strongly preferred format for data submittal, and can be found on the CAFE webpage at http://www.nhtsa.gov/fuel-economy or can be requested from Mr. Ken Katz at ken.katz@dot.gov. The templates include an automated tool (*i.e.*, a macro) that performs some auditing to identify missing or potentially erroneous entries. The appendices to this document also include sample tables that manufacturers may refer to when submitting their data to the agency.

In addition, NHTSA would like to note that we will share the information submitted in response to this notice with the Environmental Protection Agency (EPA). This sharing will facilitate NHTSA's and EPA's consideration of the appropriate factors to be used in establishing fuel economy and GHG standards, respectively, for MY 2017 and beyond. Both agencies will ensure that confidential information that is shared is protected from disclosure in accordance with their regulations and practices in this area.

II. Submission of Comments

How Do I Prepare and Submit Comments?

Comments should be prepared using the spreadsheet template described above. Please include the docket number of this document in your comments. Please submit two copies of your comments, including the attachments, to Docket Management at the address given above under ADDRESSES. Alternatively, comments may also be submitted to the docket electronically by logging onto http://www.regulations.gov. Click on the "Help" tab at the top of the page and follow the instructions for finding a

regulation and filing the comment electronically.

How Can I Be Sure That My Comments Were Received?

If you wish Docket Management to notify you upon its receipt of your comments, enclose a self-addressed, stamped postcard in the envelope containing your comments. Upon receiving your comments, Docket Management will return the postcard by mail.

How Do I Submit Confidential Business Information?

If you wish to submit any information under a claim of confidentiality, you should submit three copies of your complete submission, including the information you claim to be confidential business information, to the Chief Counsel, NHTSA, at the address given above under FOR FURTHER INFORMATION CONTACT. In addition, you should submit a copy from which you have deleted the claimed confidential business information to the docket. When you send a comment containing information claimed to be confidential business information, you should include a cover letter setting forth the information specified in our confidential business information regulation. (49 CFR Part 512.)

Will the Agency Consider Late Comments?

We will consider all comments that Docket Management receives before the close of business on the comment closing date indicated above under DATES. The agency retains discretion to consider late-filed comments, but emphasizes that comments will be most helpful and informative to the agency if submitted in a timely manner, so that the agency may begin reviewing submissions as soon as possible and return to commenters with follow-up questions as necessary.

How Can I Read the Comments Submitted by Other People?

You may read the comments received by Docket Management at the address given above under ADDRESSES. The hours of the Docket are indicated above in the same location. You may also see the comments on the Internet. To read the comments on the Internet, take the following steps:

1) Go to http://www.regulations.gov.
2) Check the box for "View results by docket folder."
3) In the field marked "Keyword," type in the docket number found at the beginning of this notice.
4) On the results page, click on the desired comments. You may download the comments. However, since the comments are imaged documents, instead of word processing documents, the downloaded comments may not be word searchable.

Please note that even after the comment closing date, we will continue to file relevant information in the Docket as it becomes available. Accordingly, we recommend that you periodically check the Docket for new material.

Anyone is able to search the electronic form of all comments received into any of our dockets by the name of the individual submitting the comment (or signing the comment, if submitted on behalf of an association, business, labor union, etc.). You may review DOT's complete Privacy Act Statement in the **Federal Register** published on April 11, 2000 (Volume 65, Number 70; Pages 19477-78) or you may visit http://www.dot.gov/privacy.html.

Authority: 49 U.S.C. 32902; delegation of authority at 49 CFR 1.50.

Issued on:

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Joseph S. Carra
Acting Associate Administrator for
Rulemaking

Billing Code: 4910-59-P

APPENDIX A

I. Definitions

As used in these appendices--

1. "Automobile," "fuel economy," "manufacturer," and "model year (MY)," have the meaning given them in Section 32901 of Chapter 329 of Title 49 of the United States Code, 49 U.S.C. 32901.
2. "Basic engine" has the meaning given in 40 CFR 600.002-93(a)(21).
3. "Cargo-carrying volume," "gross vehicle weight rating" (GVWR), and "passenger-carrying volume" are used as defined in 49 CFR 523.2.
4. "CARB" means California Air Resources Board
5. "Domestically manufactured" is used as defined in Section 32904(b)(2) of Chapter 329, 49 U.S.C. 32904(b)(2).
6. "ED&T" means Engineering, Design and Testing
7. "Footprint" means the product of average track width (measured in inches and rounded to the nearest tenth of an inch) times wheelbase (measured in inches and rounded to the nearest tenth of an inch) divided by 144 and then rounded to the nearest tenth of a square foot as described in 49 CFR 523.2.
8. "Light truck" means an automobile of the type described in 49 CFR 523.3 and 523.5.
9. A "model" of passenger car is a line, such as the Chevrolet Impala, Ford Fusion, Honda Accord, etc., which exists within a manufacturer's fleet.
10. "Model Type" is used as defined in 40 CFR 600.002-93(a)(19).
11. "MY" means model year

12. "Passenger car" means an automobile of the type described in 49 CFR 523.3 and 523.4.

13. "Percent fuel consumption improvements" means that percentage which corresponds to the amount by which respondent could improve the fuel consumption of vehicles in a given model or class through the application of a specified technology, averaged over all vehicles of that model or in that class which feasibly could use the technology. Projections of percent fuel consumption improvement should be based on the assumption of maximum efforts by respondent to achieve the highest possible fuel economy increase through the application of the technology while holding other performance characteristics constant (such as 0-60 miles-per-hour (mph) time, gradeability, towing capacity, NVH, etc.) relative to the respondent's 2010MY vehicles/fleet. The baseline for determination of percent fuel consumption improvement is the level of technology and vehicle performance for respondent's 2010 model year passenger cars or light trucks in the equivalent class.

14. "Percent production implementation rate" means that percentage which corresponds to the maximum number of passenger cars or light trucks of a specified class which could feasibly be produced with the technology if respondent made maximum efforts to apply the technology by a specified model year.

15. "Production" means production for the U.S. market.

16. “Production percentage” means the percent of respondent's passenger cars or light trucks of a specified model projected to be manufactured in a specified model year.
17. “Project” or “projection” refers to the best estimates made by respondent, whether or not based on less than certain information.
18. “R&D” means research and development
19. “Redesign” means any change, or combination of changes, to a vehicle that would change its weight by 50 pounds or more or change its frontal area or aerodynamic drag coefficient by 2 percent or the implementation of new engine.
20. “Refresh” means any change, or combination of changes, to a vehicle that would change its weight by less than 50 pounds and would not change its frontal area or aerodynamic drag coefficient.
21. “Relating to” means constituting, defining, containing, explaining, embodying, reflecting, identifying, stating, referring to, dealing with, or in any way pertaining to.
22. “Respondent” means each manufacturer (including all its divisions) providing answers to the questions set forth in this appendix, and its officers, employees, agents or servants.
23. “RPE” means retail price equivalent
24. “Test Weight” is used as defined in 40 CFR 86.082-2.
25. “Track Width” means the lateral distance between the centerlines of the base tires at ground, including the camber angle.

26. "Truckline" means the name assigned by the Environmental Protection Agency to a different group of vehicles within a make or car division in accordance with that agency's 2001 model year pickup, van (cargo vans and passenger vans are considered separate truck lines), and special purpose vehicle criteria.

27. "Variants of existing engines" means versions of an existing basic engine that differ from that engine in terms of displacement, method of aspiration, induction system or that weigh at least 25 pounds more or less than that engine.

28. "Wheelbase" means the longitudinal distance between front and rear wheel centerlines.

II. Assumptions

All assumptions concerning emission standards, damageability regulations, safety standards, etc., should be listed and described in detail by the respondent.

III. Specifications – Passenger Car and Light Truck Data

Go to http://www.nhtsa.gov/fuel-economy for spreadsheet templates.

1. Identify all passenger car and light truck models offered for sale in MY 2010 whose production each respondent projects discontinuing before MY 2017 and identify the last model year in which each will be offered.

2. Identify all basic engines offered by respondent in MY 2010 passenger cars and light trucks which respondent projects it will cease to offer for sale in passenger cars and light trucks before MY 2017, and identify the last model year in which each will be offered.

3. For each model year 2010-2025, list all known or projected car and truck lines and provide the information specified below for each model type. Model types that are essentially identical except for their nameplates (*e.g.*, Ford Fusion/ Lincoln MKZ) may be combined into one item. Engines having the same displacement but belonging to different engine families are to be grouped separately. Within the fleet, the vehicles are to be sorted first by car or truck line, second by basic engine, and third by transmission type. For each model type, a specific indexed engine and transmission are to be identified. As applicable, an indexed predecessor model type is also to be identified. Spreadsheet templates can be found athttp://www.nhtsa.gov/fuel-economy. These templates include codes and definitions for the data that the agency is seeking, including, but not limited to the following:

A. General Information

1. Vehicle Number – a unique number assigned to each model
2. Manufacturer – manufacturer's name (*e.g.*, Toyota)
3. Model – name of model (*e.g.*, Corolla)
4. Nameplate – vehicle nameplate (*e.g.*, Corolla Matrix)
5. Primary Fuel – classified as CNG = compressed natural gas; D = diesel; E = electricity; E-85 = ethanol; E100 = neat ethanol; G = gasoline; H = hydrogen; LNG = liquefied natural gas; LPG = propane; M85 = methanol; M100 = neat methanol
6. Fuel Economy on Primary Fuel – measured in miles per gallon; laboratory fuel economy (weighted FTP+highway gasoline-equivalent gallon (GEG), exclusive of any calculation under 49 U.S.C. 32905)

7. Secondary Fuel – classified as CNG = compressed natural gas; D = diesel; E = electricity; E-85 = ethanol; E100 = neat ethanol; G = gasoline; H = hydrogen; LNG = liquefied natural gas; LPG = propane; M85 = methanol; M100 = neat methanol
8. Fuel Economy on Secondary Fuel – measured in miles per gallon; laboratory fuel economy (weighted FTP + highway GEG, exclusive of any calculation under 49 U.S.C. 32905)
9. Tertiary Fuel – classified as CNG = compressed natural gas; D = diesel; E = electricity; E-85 = ethanol; E100 = neat ethanol; G = gasoline; H = hydrogen; LNG = liquefied natural gas; LPG = propane; M85 = methanol; M100 = neat methanol
10. Fuel Economy on Tertiary Fuel – measured in miles per gallon; laboratory fuel economy (weighted FTP + highway GEG, exclusive of any calculation under 49 U.S.C. 32905)
11. CAFE Fuel Economy – measured in miles per gallon; laboratory fuel economy (weighted FTP + highway GEG, inclusive of any calculation under 49 U.S.C. 32905)
12. Engine Code – unique number assigned to each engine
    a. Manufacturer – manufacturer's name (*e.g.*, General Motors, Ford, Toyota, Honda)
    b. Name – name of engine
    c. Configuration – classified as V = V-shaped; I = inline; R = rotary, H = horizontally opposed (boxer)

d. Primary Fuel – classified as CNG = compressed natural gas, D = diesel, E85 = ethanol, E100 = neat ethanol, G = gasoline, H = hydrogen, LNG = liquefied natural gas, LPG = propane, M85 = methanol, M100 = neat methanol
e. Secondary Fuel – classified as CNG = compressed natural gas, D = diesel, E85 = ethanol, E100 = neat ethanol, G = gasoline, H = hydrogen, LNG = liquefied natural gas, LPG = propane, M85 = methanol, M100 = neat methanol
f. Country of Origin – name of country where engine is manufactured
g. Engine Oil Viscosity – ratio between the applied shear stress and the rate of shear, which measures the resistance of flow of the engine oil (as per SAE Glossary of Automotive Terms); typical values as text include 0W20, 5W20, etc.
h. Cycle – combustion cycle of engine; classified as A = Atkinson, AM = Atkinson/Miller, D = Diesel, M = Miller, O = Otto, OA = Otto/Atkinson
i. Air/Fuel Ratio – the weighted (FTP + highway) air/fuel ratio (mass); a number generally around 14.7 for gasoline engines
j. Fuel Delivery System – mechanism that delivers fuel to engine; classified as SGDI = stoichiometric gasoline direct injection; LBGDI = lean-burn gasoline direct injection; SFI = sequential fuel injection; MPFI = multipoint fuel injection; TBI = throttle body

fuel injection; CRDI = common rail direct injection (diesel); UDI = unit injector direct injection (diesel)

k. Aspiration – breathing or induction process of engine (as per SAE Automotive Dictionary); classified as NA = naturally aspirated, S = supercharged, T = turbocharged, T2P = parallel twin turbocharged, T2S = sequential twin turbocharged, T2ST = staged twin turbocharged, T4 = quad-turbocharged, ST = supercharged and turbocharged

l. External Exhaust Gas Recirculation (EGR) –recirculation of some of the exhaust gases back into the engine; classified as SSSL = single stage - single loop, SSDL = single stage - dual loop, DSSL = dual stage - single loop, DSDL = dual stage - dual loop, NA = not applicable

m. EGR Pressure, measured in Pounds per Square Inch (PSI)

n. EGR Cooler Type – classified as AC = air cooled, LC = liquid cooled.

o. EGR Coolant Type – type of coolant used

p. Engine Brake Mean Effective Pressure (BMEP) – average engine effective pressure, measured as bar

q. Valvetrain Design – design of the total mechanism from camshaft to valve of an engine that actuates the lifting and closing of a valve (as per SAE Glossary of Automotive Terms); classified as CVA =

camless valve actuation, DOHC = dual overhead cam, OHV = overhead valve, SOHC = single overhead cam

r. Valve Actuation/Timing – valve opening and closing points in the operating cycle (as per SAE J604); classified as F = fixed, ICP = intake cam phasing, CCP = coupled cam phasing, DCP = dual cam phasing

s. Valve Lift – describes the manner in which the valve is raised during combustion (as per SAE Glossary of Automotive Terms); classified as F = fixed, DVVL = discrete variable valve lift, CVVL = continuously variable valve lift, IVC = intake valve control (*e.g.*, Fiat's MultiAir system)

t. Cylinders – the number of engine cylinders; an integer such as 2, 3, 4, 5, 6, 8, 10 or 12.

u. Valves/Cylinder – the number of valves per cylinder, an integer from 2 through 5

v. Deactivation – presence of cylinder deactivation mechanism; classified as Y = cylinder deactivation applied; N = cylinder deactivation not applied

w. Displacement – total volume displaced by a piston in a single stroke multiplied by the number of cylinders; measured in liters

x. Compression Ratio (min) – typically a number between 8 and 11; (for fixed CR engines, should be identical to maximum CR)

y. Compression Ratio (max) – typically a number between 8 and 20; (for fixed CR engines, should be identical to minimum CR)

z. Max. Horsepower – the maximum power of the engine, measured as horsepower

aa. Max. Horsepower RPM – rpm at which maximum horsepower is achieved

bb. Max. Torque – the maximum torque of the engine, measured as lb-ft.

cc. Max Torque RPM – rpm at which maximum torque is achieved

13. Transmission Code – unique number assigned to each transmission

a. Manufacturer – manufacturer's name (*e.g.*, General Motors, Ford, Toyota, Honda)

b. Name – name of transmission

c. Country of origin - where the transmission is manufactured

d. Type – type of transmission; classified as M = manual, A = automatic (torque converter), AMT = automated manual transmission (single clutch w/ torque interrupt), DCT = dual clutch transmission, CVT1 = belt or chain CVT, CVT2 = other CVT (*e.g.*, toroidal), HEVT = hybrid/electric vehicle transmission (for a BISG or CISG type hybrid, please define the actual transmission used, not HEVT)

e. Clutch Type – type of clutch used in AMT or DCT type transmission; D = dry, DA = damp , W = wet,

f. Number of Forward Gears – classified as an integer indicating the number of forward gears; “CVT” for a CVT type transmission; or “n/a”

g. Logic – indicates aggressiveness of automatic shifting; classified as A = aggressive bias toward improving fuel economy, C = conventional shifting. Provide rationale for selection in the transmission notes column.

14. Origin – classification (under CAFE program) as domestic or import, D = domestic, I = import

B. Production

1. Production – actual and projected U.S. production for MY 2010 to MY 2025 inclusive, measured in number of vehicles
2. Percent of Production Regulated by CARB Standards – percent of production volume that will be regulated under CARB standards in each of MYs 2010 to MY 2025.

C. MSRP – measured in 2009 dollars actual and projected average MSRP (sales-weighted, including options) for MY 2010 to MY 2025 inclusive

D. Vehicle Information

1. Subclass – for technology application purposes only and should not be confused with vehicle classification for regulatory purposes; classified as Subcompact, Subcompact Performance, Compact, Compact Performance, Midsize, Midsize Performance, Large, Large Performance, Minivan, Small LT, Midsize LT, Large LT; where LT = SUV/Pickup/Van; use

tables below, with example vehicles, to place vehicles into the most appropriate subclass

Subclass	**Example (MY 2010) vehicles**
Subcompact	Chevy Aveo, Honda Civic, Volkswagen New Beetle
Subcompact Performance	Audi TT, Mazda Miata, Subaru Impreza
Compact	Chevy Cruze, Ford Focus, Nissan Sentra
Compact Performance	Audi S4 Quattro, Mazda RX8, Mitsubishi Lancer Evolution
Midsize	Honda Accord, Hyundai Azera, Toyota Camry
Midsize Performance	Chevy Corvette, Ford Mustang GT, Nissan G37 Coupe
Large	Audi A8, Cadillac CTS, Ford Taurus
Large Performance	Bentley Arnage, BMW M5, Daimler CL600

Subclass	**Example (MY 2010) vehicles**
Minivans	Dodge Caravan, Toyota Sienna
Small SUV/Pickup/Van	Ford Ranger, Nissan Rogue, Toyota RAV4
Midsize SUV/Pickup/Van	Jeep Wrangler 4-door, Mazda CX-9, Toyota Tacoma
Large SUV/Pickup/Van	Chevy Silverado, Ford Econoline, Toyota Sequoia

2. Style – classified as Convertible, Coupe, Hatchback, Sedan, Minivan, Pickup, Sport Utility, Van, Wagon
3. Light Truck Indicator – a unique code(s) (*e.g.*, 2ii, 7i) assigned to each vehicle which represents the design feature(s) that classify it as a light truck, classified as:

(0) The vehicle neither has off-road design features (defined under 49 CFR 523.5(b) and described by numbers 1 and 2 below) nor has functional characteristics (defined under 49 CFR 523.5(a) and described by numbers 3 through 7 below) that would allow it to be properly classified as a light truck, thus the vehicle is properly classified as a passenger car.

An automobile capable of off-highway operation, as indicated by the fact that it:

(1) (i) Has 4-wheel drive; or

(ii) Is rated at more than 6,000 pounds gross vehicle weight; and

(2) Has at least four of the following characteristics calculated when the automobile is at curb weight, on a level surface, with the front wheels parallel to the automobile's longitudinal centerline, and the tires inflated to the manufacturer's recommended pressure—

(i) Approach angle of not less than 28 degrees.

(ii) Breakover angle of not less than 14 degrees.

(iii) Departure angle of not less than 20 degrees.

(iv) Running clearance of not less than 20 centimeters.

(v) Front and rear axle clearances of not less than 18 centimeters each.

An automobile designed to perform at least one of the following functions:

(3) Transport more than 10 persons;

(4) Provide temporary living quarters;

(5) Transport property on an open bed;

(6) Provide, as sold to the first retail purchaser, greater cargo-carrying than passenger-carrying volume, such as in a cargo van; if a vehicle is sold with a second-row seat, its cargo-carrying volume is determined with that seat installed, regardless of whether the manufacturer has described that seat as optional; or

(7) Permit expanded use of the automobile for cargo-carrying purposes or other non-passenger-carrying purposes through:

(i) For non-passenger automobiles manufactured prior to model year 2012, the

removal of seats by means installed for that purpose by the automobile's manufacturer or with simple tools, such as screwdrivers and wrenches, so as to create a flat, floor level, surface extending from the forward most point of installation of those seats to the rear of the automobile's interior; or

(ii) For non-passenger automobiles manufactured in model year 2008 and beyond, for vehicles equipped with at least 3 rows of designated seating positions as standard equipment, permit expanded use of the automobile for cargo-carrying purposes or other non-passenger-carrying purposes through the removal or stowing of foldable or pivoting seats so as to create a flat, leveled cargo surface extending from the forward most point of installation of those seats to the rear of the automobile's interior.

4. Structure – classified as either L = Ladder or U =Unibody
5. Drive – classified as A = all-wheel drive; F = front-wheel drive; R = rear-wheel-drive; 4 = 4-wheel drive[7]
6. Axle Ratio – ratio of the speed of the drive shaft to the speed of the driven wheels
7. Length – measured in inches; defined per SAE J1100, L103 (Sept. 2005)
8. Width – measured in inches; defined per SAE J1100, W116 (Sept. 2005)
9. Wheelbase – measured to the nearest tenth of an inch; defined per SAE J1100, L101 (Sept. 2005), and clarified above
10. Track Width (front) – measured to the nearest tenth of an inch; defined per SAE J1100, W101-1 (Sept. 2005), and clarified above

[7] NHTSA considers "4-wheel drive" to refer only to vehicles that have selectable 2- and 4-wheel drive settings, as opposed to all-wheel drive, which is not driver-selectable.

11. Track Width (rear) – measured to the nearest tenth of an inch; defined per SAE J1100, W101-2 (Sept. 2005), and clarified above
12. Footprint – the product of average track width (measured in inches and rounded to the nearest tenth of an inch) times wheelbase (measured in inches and rounded to the nearest tenth of an inch) divided by 144 and then rounded to the nearest tenth of a square foot: defined per 49 CFR 523.2.
13. Base Tire - the tire specified as standard equipment by a manufacturer on each vehicle configuration of a model type; (*e.g.*, 275/40R17)
14. Running Clearance – measured in centimeters; defined per 49 CFR 523.2
15. Front Axle Clearance - measured in centimeters; defined per 49 CFR 523.2
16. Rear Axle Clearance - measured in centimeters; defined per 49 CFR 523.2
17. Approach Angle – measured in degrees; defined per 49 CFR 523.2
18. Breakover Angle - measured in degrees; defined per 49 CFR 523.2
19. Departure Angle - measured in degrees; defined per 49 CFR 523.2
20. Curb Weight – total weight of vehicle including batteries, lubricants, and other expendable supplies but excluding the driver, passengers, and other payloads, measured in pounds; per SAE J1100 (Sept. 2005)
21. Test Weight – weight of vehicle as tested, including the driver, operator (if necessary), and all instrumentation (as per SAE J1263); measured in pounds

22. GCWR – Gross Combined Weight Rating, as defined per 49 CFR 571.3, means the value specified by the manufacturer as the loaded weight of a combination vehicle, which is determined by the procedures and requirements found in SAE J2807
23. GVWR – Gross Vehicle Weight Rating; as defined per 49 CFR 523.2 measured in pounds
24. Towing Capacity (Maximum) – measured in pounds
25. Payload – measured in pounds
26. Cargo volume behind the front row – measured in cubic feet, defined per Table 28 of SAE J1100 (Sept. 2005)
27. Cargo volume behind the second row – measured in cubic feet, defined per Table 28 of SAE J1100 (Sept. 2005)
28. Cargo volume behind the third row – measured in cubic feet, defined per Table 28 of SAE J1100 (Sept. 2005)
29. Enclosed Volume – measured in cubic feet
30. Passenger Volume – measured in cubic feet; the volume measured using SAE J1100 as per EPA Fuel Economy regulations (40 CFR 600.315-82, "Classes of Comparable Automobiles"). This is the number that manufacturers calculate and submit to EPA.
31. Cargo Volume Index – defined per Table 28 of SAE J1100 (Sept. 2005)
32. Luggage Capacity – measured in cubic feet; defined per SAE J1100, V1 (Sept. 2005)

33. Seating (max) – number of usable seat belts before folding and removal of seats (where accomplished without special tools); provided in integer form
34. Number of Standard Rows of Seating – number of rows of seats that each vehicle comes with as standard equipment; provided in integer form (*e.g.*, 1,2,3,4, or 5).
35. Frontal Area – a measure of the wind profile of the vehicle, typically calculated as the height times width of a vehicle body, *e.g.*, 25 square feet.
36. Aerodynamic Drag Coefficient, C_d – a dimensionless coefficient that relates the motion resistance force created by the air drag over the entire surface of a moving vehicle to the force of dynamic air pressure acting only over the vehicle's frontal area, *e.g.*, 0.25.
37. Base Tire Rolling Resistance, C_{rr} – a dimensionless coefficient that relates the motion resistance force due to tire energy losses (*e.g.*, deflection, scrubbing, slip, and air drag) to a vehicle's weight for the base tire (highest production volume tire) used in the laboratory fuel economy test (weighted FTP+highway), *e.g.*, 0.0012 Normalized on (pound force/1000 pound) basis.
38. Fuel Capacity – measured in gallons of diesel fuel or gasoline; MJ (LHV) of other fuels (or chemical battery energy)
39. Electrical System Voltage – measured in volts, *e.g.*, 12 volt, 42 volts
40. Power Steering – H = hydraulic; E = electric; EH = electro-hydraulic
41. Percent of Production Volume Equipped with air conditioning (A/C)
42. A/C Refrigerant Type – e.g. HFC-134a; HFC-152a; CO_2

43. A/C Refrigerant Quantity – measured in pounds
44. A/C Compressor Displacement – measured in cubic centimeters
45. A/C CARB or EPA credit – measured in grams per mile; g/mile CO_2 equivalent as reportable under California ARB's AB 1493 or EPA's GHG Regulation
46. N_2O Emission Rate – measured in grams per mile; as reportable under California ARB's AB 1493 Regulation
47. CH_4 Emission Rate – measured in grams per mile; as reportable under California ARB's AB 1493 Regulation
48. Estimated Total CARB Credits - measured in grams per mile; g/mile CO_2 equivalent as reportable under California ARB's AB 1493 Regulation

E. Hybridization/Electrification

1. Type of Hybrid/Electric vehicle - classified as MHEV = 12V micro hybrid, BISG = belt mounted integrated starter generator, CISG = crank mounted integrated starter generator, PSHEV = power-split hybrid, P2HEV = P2 hybrid, 2MHEV = 2-mode hybrid, PHEV = plug-in hybrid, EV = electric vehicle, H = hydraulic hybrid, P = pneumatic hybrid
2. Electrical Only Driving Range (for EV and Plug-in only) – driving range powered by electric drive only – measured in miles. Please specify the basis for the range (e.g., combined city/highway test cycle)
3. Petroleum Only Driving Range (for Plug-in only) – driving range powered by petroleum drivetrain only – measured in miles. Please specify the basis for the range (e.g., combined city/highway test cycle)

4. Blended Driving Range (for HEV, PHEV and EV) – driving range with both electrical and petroleum powertrain measured in miles. Please specify the basis for the range (e.g., combined city/highway test cycle)
5. Voltage (volts) or, for hydraulic hybrids, pressure (psi) of the vehicle
6. Battery Information –
    a. Battery Type – classification such as NiMH = Nickel Metal Hydride; Li-ion = Lithium Ion; Li-Air = Lithium Air
    b. Battery 100% Discharge Energy – battery energy when the battery is 100% discharged, measured as kWh
    c. Fraction of Useable Energy (%) – Percent of useable energy for the battery which should take into consideration of battery fade, temperature effect and other factors that have an effect on usage energy of the battery
    d. Battery Chemistry for Cathode – Chemistries such as $LiNi_{0.8}Co_{0.15}Al_{0.05}O_2$(NCA), $LiFePO_4$(LFP), $LiMn_2O_4$ (MS), etc
    e. Battery Chemistry for Anode – Chemistries such as Graphite, Amorphous carbon, Lithium titanate, Lithium alloys, Lithium Oxides, etc
    f. Nominal Voltage for battery, measured as volts
    g. Weight of All Battery Packs, measured as kg – Weight should include closure, cooling system, control system and ancillary systems.
    h. Battery Manufacturer
7. Power Electronics Information –

a. Primary Motor Size, measured as kW

b. Secondary Motor Size, measured as kW

c. Primary Inverter size, measured as kW

d. Secondary Inverter size, measured as kW

8. Battery Only Range (charge depleting PHEV or EV) – measured in miles
9. Maximum Battery Only Vehicle Speed – measured in miles per hour; maximum speed at which a HEV/PHEV/EV can still operate solely on battery power measured on a flat road using the vehicle's FTP weight
10. Percentage of braking energy recovered and stored over weighted FTP + highway drive cycle
11. Percentage of maximum motive power provided by stored energy system
12. Electrified Accessories – list of electrified accessories; classified as WP = water (coolant) pump; OP = oil pump; AC = air conditioner compressor

F. Energy Consumption[8] – of total fuel energy (higher heating value) consumed over FTP city and highway tests (each weighted as for items 5 and 6 above), shares attributable to the following loss mechanisms, such that the sum of the shares equals one

1. System irreversibility governed by the Second Law of Thermodynamics
2. Heat lost to the exhaust and coolant streams
3. Engine friction (*i.e.*, the part of mechanical efficiency lost to friction in such engine components as bearings and rods, as could be estimated from engine dynamometer test results)

[8] This information is sought in order to account for a given vehicle model's fuel economy as partitioned into nine energy loss mechanisms. The agency may use this information to inform our estimates of the extent to which a given technology reduces losses in each mechanism.

4. Pumping losses (*i.e.*, the part of mechanical efficiency lost to work done on gases inside the cylinder, as could be estimated from engine dynamometer test results)
5. Accessory losses (*i.e.*, the part of fuel efficiency lost to work done by engine-driven accessories, as could be estimated from bench test results for the individual components)
6. Transmission losses (*i.e.*, the part of driveline efficiency lost to friction in such transmission components as gears, bearings, and hydraulics, as could be estimated from chassis dynamometer test results)
7. Aerodynamic drag of the body, as could be estimated from coast-down test results
8. Rolling resistance in the tires, as could be estimated from coast-down test results
9. Work done on the vehicle itself, as could be estimated from the vehicle's inertia mass and the fuel economy driving cycles

G. Planning and Assembly

1. U.S. Content – overall percentage, by value, that originated in the U.S.
2. Canadian Content – overall percentage, by value, that originated in Canada
3. Mexican Content – overall percentage, by value, that originated in Mexico
4. Domestic Content - overall percentage, by value, that originated in the U.S, Canada and Mexico
5. Final Assembly City
6. Final Assembly State/Province (if applicable)

7. Final Assembly Country
8. Predecessor – number (or name) of model upon which current model is based, if any
9. Refresh Years – model years of most recent and future refreshes through the 2025 time period; *e.g.*, 2010, 2015, 2020, 2025.
10. Redesign Years – model years of most recent and future redesigns through the 2025 time period; *e.g.*, 2012, 2017, 2022; where redesign means any change or combination of changes to a vehicle that would change its weight by 50 pounds or more or change its frontal area or aerodynamic drag coefficient by 2 percent or more.
11. Employment Hours Per Vehicle – number of hours of U.S. labor applied per vehicle produced

H. The agency also requests that each manufacturer provide an estimate of its overall passenger car CAFE and light truck CAFE for each model year. This estimate should be included as an entry in the spreadsheets that are submitted to the agency.

4. As applicable, please explain the differences between the product plans submitted in response to the 2009 product plan requests and the product plans being submitted in response to this request.

5. Relative to MY 2009 levels, for MYs 2010-2025 please provide information, by carline and as an average effect on a manufacturer's entire passenger car fleet and by truckline and as an average effect on a manufacturer's entire light truck fleet, on the

weight (increases or decreases) and/or fuel economy impacts of the following standards or equipment:

A. FMVSS No. 214, Side Pole Impact
B. FMVSS No. 216, Roof Crush Resistance
C. FMVSS No. 226, Ejection Mitigation
D. FMVSS No. 111, Rear Detection System
E. Voluntary installation of safety equipment (*e.g.*, forward collision warning); please provide the specific item(s)/system(s)
F. Pedestrian Global Technical Regulation (GTR)
G. Environmental Protection Agency regulations
H. California Air Resources Board requirements
I. Other applicable motor vehicle regulations affecting fuel economy Please specify the regulations which affect the weight change

For the following questions, whenever RPE cost is requested, please also provide the RPE multiplier value assumed and whether the component is manufactured in-house or out-sourced.

6. For each specific model (and model year if applicable) of respondent's passenger car and light truck fleets projected to implement one or more of the following and/or any other weight reduction methods:

A. Substitution of materials;

B. Use of new vehicle structural, system or component designs;

C. “Downsizing” of existing vehicle design due to the downsizing of vehicle dimensions (interior and exterior) and/or footprint;

D. “Downsizing” of existing vehicle design due to the downsizing of vehicle powertrain or component, *i.e.*, secondary mass reduction.

Please provide the following information:

(i) description of the method, for example:

- For material substitution, substituting a composite body panel for a steel panel;

- For downsizing, reducing front, rear, or side overhang (the dimensions of the vehicle outside the “footprint” area), or reducing track width or wheelbase;

- For use of new vehicle, structural, system or component designs, replacing a body-on-frame structure with a unibody structure, or replacing an existing fuel tank with a smaller fuel tank (*i.e.*, maintaining range).

(ii) the weight reduction, in pounds, averaged over the model;

(iii) the percent fuel economy improvement averaged over the model;

(iv) the basis for your answer to (iii), (*e.g.*, data from dynamometer tests conducted by respondent, engineering analysis, computer simulation, reports of test by others);

(v) the per vehicle incremental RPE cost (in 2009 dollars), averaged over the model, associated with the method;

(vi) the total capital cost, in constant 2009 dollars, required to implement the method, please subdivide the cost into product development (R&D/ED&T) and

capital investment (equipment, tolling plant/facilities, etc.) costs, indicate if these costs are included or amortized in the incremental RPE cost (v) above;

(vii) the maximum production capacity, expressed in units of capacity per year, associated with the capital expenditure in (vi) above.

(viii) the actual capacity and percent production implementation that is planned to be used each year and the reasons limiting the implementation of the method.

(ix) the actual capacity and percent production implementation that is planned for vehicles for sale in the United States.

7. For each specific model (and model year if applicable) of respondent's passenger car and light truck fleets projected to implement one or more of the following and/or any other aerodynamic drag reduction methods:

A. Revised exterior components (*e.g.*, front fascia or side view mirrors)

B. Addition of aerodynamic treatment, such as addition of underbody panels, usage of active grill shutter, etc

C. Vehicle design changes (*e.g.*, change in ride height or optimized cooling flow path)

Please provide the following information:

(i) description of the method/aerodynamic change

(ii) the percent reduction of the aerodynamic drag coefficient (C_d) and the C_d prior to the reduction, averaged over the model;

(iii) the percent fuel economy improvement averaged over the model;

(iv) the basis for your answer to (iii), (*e.g.*, data from dynamometer tests conducted by respondent, wind tunnel testing, engineering analysis, computer simulation, reports of test by others);

(v) the per vehicle incremental RPE cost (in 2009 dollars), averaged over the model, associated with the method;

(vi) the total capital cost, in constant 2009 dollars, required to implement the method, subdivide the cost into product development (R&D/ED&T) and capital investment (equipment, tolling plant/facilities, etc.) costs, indicate if these costs are included or amortized in the incremental RPE cost (v) above;

(vii) the maximum production capacity, expressed in units of capacity per year, associated with the capital expenditure in (vi) above.

(viii) the actual capacity and percent production implementation that is planned to be used each year and the reasons limiting the implementation of the method.

(ix) the actual capacity and percent production implementation that is planned for vehicles for sale in the United States.

8. For each specific model (and model year if applicable) of respondent's passenger car and light truck fleets projected to implement one or more of the following and/or any other A/C leakage reduction or A/C efficiency improvement methods:

A. Low permeation hoses

B. Improved system fittings, connections and seals (including compressor shaft seal)

C. Externally controlled fixed or variable displacement compressor

D. Automatic default to recirculated cabin air

E. Improved blower and fan motor controls

F. Electronic expansion valve

G. Improved-efficiency evaporators and condensers

H. Oil separator

Please provide the following information:

(i) description of the method, (*e.g.*, implementation of electronic control valve)

(ii) the g/mile CO_2 equivalent as reportable under California ARB's AB 1493 Regulation, averaged over the model;

(iii) the basis for your answer to (ii), (*e.g.*, data from dynamometer tests conducted by respondent, engineering analysis, computer simulation, reports of test by others);

(iv) the per vehicle incremental RPE cost (in 2009 dollars), averaged over the model, associated with the method;

(v) the percent production implementation rate and the reasons limiting the implementation rate.

9. Indicate any of your MYs 2010-2025 passenger car and light truck model types that have higher average test weights than comparable MY 2010 model types. Describe the reasons for any weight increases (*e.g.*, increased option content, less use of premium materials) and provide supporting justification.

10. Please provide your estimates of projected total industry U.S. passenger car sales and light truck sales, separately, for each model year from 2009 through 2025, inclusive.

11. Please provide your company's assumptions for U.S. gasoline and diesel fuel prices during 2009 through 2025.

12. Please provide projected production capacity available for the North American market (at standard production rates) for each of your company's passenger carline and light truckline designations during MYs 2010-2025.

13. Please provide your estimate of production lead-time for new models, your expected model life in years, and the number of years over which tooling costs are amortized. Additionally, the agency is requesting that manufactures provide vehicle or design changes that characterize a freshening and those changes that characterize a redesign.

IV. Technologies, Cost and Potential Fuel Economy Improvements

Spreadsheet templates for the tables mentioned in the following section can be found at http://www.nhtsa.gov/fuel-economy.

1. The agency requests that manufacturers, for each passenger car and light truck model projected to be manufactured for US sale by respondent between MYs 2010-2025,

provide the following information on new technology applications, including A/C technologies that will be eligible under EPA GHG standards.

(i) description of the nature of the technological improvement; including the vehicle's baseline technology that the technology replaces (*e.g.*, 6-speed automatic transmission replacing a 4-speed automatic transmission)

(ii) the percent fuel consumption improvement or the g/mile CO_2 equivalent reduction for A/C technologies, averaged over the model; please indicate if the weight saving (or increase), associated with the implementation of the technology, is accounted for in the fuel economy improvement estimate.

(iii) the basis for your answer to (ii), (*e.g.*, data from dynamometer tests conducted by respondent, engineering analysis, computer simulation, reports of test by others);

(iv) the per vehicle incremental RPE cost (in 2009 dollars), averaged over the model, associated with implementing the new technology in MY 2017 or the first MY of implementation;

(v) the total capital cost, in constant 2009 dollars, required to implement the new technology, subdivide the cost into product development (R&D/ED&T) and capital investment (equipment, tolling plant/facilities, etc.) costs, indicate if these costs are included or amortized in the incremental RPE cost (iv) above;

(vi) the maximum production capacity, expressed in units of capacity per year, associated with the capital expenditure in (v) above.

(vii) the actual capacity and percent production implementation that is planned to be used each year and the reasons limiting the implementation of the new technology.

(ix) the actual capacity and percent production implementation that is planned for vehicles for sale in the United States.

In regards to costs, the agency is requesting information on cost reductions available through learning effects that are anticipated, from MY 2017 to MY 2025, so information should be provided regarding what the cost reductions associated with learning effects are, when and at what production volumes they occur, and to what degrees such learning is expected to be available.[9] The agency is also asking that the indirect cost or retail price equivalent markup factor (used to determine the indirect cost estimates) is stated in the response.

2. Additionally, the agency requests that manufacturers and other interested parties provide the same information, as requested above, for the technologies listed in the following tables and any other potential technologies that may be implemented to improve fuel economy. These potential technologies can be inserted into additional rows at the end of each table. Examples of other potential technologies could include but are not limited to: Homogenous Charge Compression Ignition (HCCI), Electric Vehicle (EV)

[9] "Learning effects" describes the reduction in unit production costs as a function of accumulated production volume and small redesigns that reduce costs. Applying learning effects, or "curves," requires estimates of three parameters: (1) the initial production volume that must be reached before cost reductions begin to be realized (referred to as "threshold volume"); (2) the percent reduction in average unit cost that results from each successive doubling of cumulative production volume (usually referred to as the "learning rate"); and (3) the initial cost of the technology.

and Fuel Cell Vehicle specific technologies. In an effort to standardize the information received the agency requests that if possible respondents fill in the following tables:

Table IV-1 with estimates of the model year of availability for each technology listed and any other identified technology.

Table IV-2 with estimated phase-in rates[10] by year for each technology listed and any other additional technologies. Engineering, planning and financial constraints can prohibit many technologies from being applied across an entire fleet of vehicles within a year, so the agency requests information on possible constraints on the rates at which each technology can penetrate a manufacturer's fleet.

Tables IV-3a, b and IV-4a, b with estimates for incremental RPE costs (in 2009 dollars) and incremental fuel consumption reductions for each technology listed and any other additional technologies. These estimates, for the technologies already listed, should assume that the preceding technologies, as defined by the decision trees in Appendix B, have already been applied and/or will be superseded. The agency is requesting that respondents fill in incremental RPE costs and fuel consumption reductions estimates for all vehicle subclasses listed. If a respondent feels that the incremental RPE cost and fuel consumption reduction estimates are similar for different subclasses they may combine subclasses.

Table IV-5 with estimates for the percentage by which each technology reduces energy losses attributable to each of nine energy loss mechanisms.

[10] In NHTSA's 2006 rulemaking establishing CAFE standards for MY 2008-2011 light trucks, the agency considered phase-in caps by ceasing to add a given technology to a manufacturer's fleet in a specific model year once it has increased the corresponding penetration rate by at least the amount of the cap. Having done so, it applied other technologies in lieu of the "capped" technology.

Tables IV-6a, b with estimates for synergies[11] that can occur when multiple technologies are applied.

Table IV-7 with estimates of battery and power electronics information, listed below, for HEV, PHEV and EV technologies. For cost information the agency is requesting that respondents provide explicit MY 2017, MY 2020 and MY 2025 appropriate costs, in addition to the requested learning effects and mark-up factor assumptions discussed above, specific to HEVs, PHEVs and EVs.

(i) the 100% discharge energy battery pack RPE cost, measured as $/kWh (in 2009 dollars), which equals the total cost per kWh of the battery cell, battery pack closure, control system, cooling system and ancillary systems.

(ii) the usable energy battery pack RPE cost, measured as $/kWh (in 2009 dollars), which equals the total cost per kWh of the battery cell, battery pack closure, control system, cooling system and ancillary systems.

(iii) the battery cell RPE cost, measured as in $/kWh (in 2009 dollars), which equals the cost per kWh at the battery cell level before the cell is integrated into battery pack

(iv) the battery warranty (time), measured in number of years

(v) the battery warranty (mileage), measured in miles

(vi) the expected battery life (time), measured in number years

[11] When two or more technologies are added to a particular vehicle model to improve its fuel efficiency, the resultant fuel consumption reduction may sometimes be higher or lower than the product of the individual effectiveness values for those items. This may occur because one or more technologies applied to the same vehicle partially address the same source or sources of engine or vehicle losses. Alternately, this effect may be seen when one technology shifts the engine operating points, and therefore increases or reduces the fuel consumption reduction achieved by another technology or set of technologies. The difference between the observed fuel consumption reduction associated with a set of technologies and the product of the individual effectiveness values in that set is sometimes referred to as a "synergy." Synergies may be positive (increased fuel consumption reduction compared to the product of the individual effects) or negative (decreased fuel consumption reduction).

(vii) the expected battery life (mileage), measured in number miles

(viii) the primary motor RPE cost, measured as $/kW (in 2009 dollars)

(ix) the secondary motor RPE cost, measured as $/kW (in 2009 dollars)

(x) the primary inverter RPE cost, measured as $/kW (in 2009 dollars)

(xi) the secondary inverter RPE cost, measured as $/kW (in 2009 dollars)

3. The agency also asks that manufacturers or other interested parties provide information on appropriate sequencing of technologies, so that accumulated cost and fuel consumption effects may be evaluated incrementally. As examples of possible technology sequences, "decision trees" are shown in Appendix B below.

4. For each new or redesigned vehicle identified in response to Question III-3 provide your best estimate of the following, in terms of constant 2009 dollars:

A. Total capital costs required to implement the new/redesigned model according to the implementation schedules specified in your response. Subdivide the capital costs into product development (R&D/ED&T), and investment (equipment, tooling, plant/facilities, etc.) costs.

B. The maximum production capacity, expressed in units of capacity per year, associated with the capital expenditure in (a) above. Specify the number of production shifts on which your response is based and define "maximum capacity" as used in your answer.

C. The actual capacity that is planned to be used each year for each new/redesigned model.

D. The increase in variable costs per affected unit, based on the production volume specified in (b) above.

E. The equivalent retail price increase per affected vehicle for each new/redesigned model. Provide an example describing methodology used to determine the equivalent retail price increase.

Table IV-1: List of Technologies and Year of Availability

TECHNOLOGY	Abrev.	Year of Availability
Low Friction Lubricants	LUB	
Engine Friction Reduction	EFR	
VVT - Coupled Cam Phasing (CCP) on SOHC	CCPS	
Discrete Variable Valve Lift (DVVL) on SOHC	DVVLS	
Cylinder Deactivation on SOHC	DEACS	
VVT - Intake Cam Phasing (ICP)	ICP	
VVT - Dual Cam Phasing (DCP)	DCP	
Discrete Variable Valve Lift (DVVL) on DOHC	DVVLD	
Continuously Variable Valve Lift (CVVL)	CVVL	
Cylinder Deactivation on DOHC	DEACD	
Stoichiometric Gasoline Direct Injection (GDI)	SGDI	
Cylinder Deactivation on OHV	DEACO	
Variable Valve Actuation - CCP and DVVL on OHV	VVA	
Stoichiometric Gasoline Direct Injection (GDI) on OHV	SGDIO	
Conversion to DOHC with DCP	CDOHC	
Turbocharging and Downsizing	TRBDS	
Exhaust Gas Recirculation (EGR) Boost, Level 1	EGRB	
Exhaust Gas Recirculation (EGR) Boost, Level 2	EGRB2	
Lean Burn Direct Injection with TRBDS	LBDI	
Advanced Diesel	ADSL	
6-Speed Manual/Improved Internals	6MAN	
Improved Auto. Trans. Controls/Externals	IATC	
6-Speed Auto Trans with Improved Internals	NAUTO	
Dual Clutch Transmission (Dry/Wet)	DCT	
New Transmission (7+ Speed Auto or 7+ Speed DCT)	NTRANS	
Electric Power Steering	EPS	
Improved Accessories	IACC	
12V Micro-Hybrid	MHEV	
Belt mounted Integrated Starter Generator	BISG	
Crank mounted Integrated Starter Generator	CISG	
Strong Hybrid (P2 or 2-mode hybrid)	SHEV1	
Strong Hybrid (P2 or 2-mode hybrid) with EGRB	SHEV2	
Plug-in Hybrid - 20 mi range	PHEV20	
Plug-in Hybrid - 40 mi range	PHEV40	
Electric Vehicle	EV	
Fuel Cell Vehicle	FCV	
Mass Reduction, Level 1 (5%)	MR1	
Mass Reduction, Level 2 (7.5%)	MR2	
Mass Reduction, Level 3 (10%)	MR3	
Mass Reduction, Level 4 (15%)	MR4	
Mass Reduction, Level 5 (20%)	MR5	
Low Rolling Resistance Tires, Level 1	ROLL1	
Low Rolling Resistance Tires, Level 2	ROLL2	
Low Drag Brakes	LDB	
Secondary Axle Disconnect	SAX	
Aero Drag Reduction, Level 1	AERO1	
Aero Drag Reduction, Level 2 (Active Reduction)	AERO2	

Table IV-2: Phase-In Caps

		Percent Phase-in Rate per Year															
TECHNOLOGY	Abrev.	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Low Friction Lubricants	LUB																
Engine Friction Reduction	EFR																
VVT - Coupled Cam Phasing (CCP) on SOHC	CCPS																
Discrete Variable Valve Lift (DVVL) on SOHC	DVVLS																
Cylinder Deactivation on SOHC	DEACS																
VVT - Intake Cam Phasing (ICP)	ICP																
VVT - Dual Cam Phasing (DCP)	DCP																
Discrete Variable Valve Lift (DVVL) on DOHC	DVVLD																
Continuously Variable Valve Lift (CVVL)	CVVL																
Cylinder Deactivation on DOHC	DEACD																
Stoichiometric Gasoline Direct Injection (GDI)	SGDI																
Cylinder Deactivation on OHV	DEACO																
Variable Valve Actuation - CCP and DVVL on OHV	VVA																
Stoichiometric Gasoline Direct Injection (GDI) on OH	SGDIO																
Conversion to DOHC with DCP	CDOHC																
Turbocharging and Downsizing	TRBDS																
Exhaust Gas Recirculation (EGR) Boost, Level 1	EGRB																
Exhaust Gas Recirculation (EGR) Boost, Level 2	EGRB2																
Lean Burn Direct Injection with TRBDS	LBDI																
Advanced Diesel	ADSL																
6-Speed Manual/Improved Internals	6MAN																
Improved Auto. Trans. Controls/Externals	IATC																
6-Speed Auto Trans with Improved Internals	NAUTO																
Dual Clutch Transmission (Dry/Wet)	DCT																
New Transmission (7+ Speed Auto or 7+ Speed DC	NTRANS																
Electric Power Steering	EPS																
Improved Accessories	IACC																
12V Micro-Hybrid	MHEV																
Belt mounted Integrated Starter Generator	BISG																
Crank mounted Integrated Starter Generator	CISG																
Strong Hybrid (P2 or 2-mode hybrid)	SHEV1																
Strong Hybrid (P2 or 2-mode hybrid) with EGRB	SHEV2																
Plug-in Hybrid - 20 mi range	PHEV20																
Plug-in Hybrid - 40 mi range	PHEV40																
Electric Vehicle	EV																
Fuel Cell Vehicle	FCV																
Mass Reduction, Level 1 (5%)	MR1																
Mass Reduction, Level 2 (7.5%)	MR2																
Mass Reduction, Level 3 (10%)	MR3																
Mass Reduction, Level 4 (15%)	MR4																
Mass Reduction, Level 5 (20%)	MR5																
Low Rolling Resistance Tires, Level 1	ROLL1																
Low Rolling Resistance Tires, Level 2	ROLL2																
Low Drag Brakes	LDB																
Secondary Axle Disconnect	SAX																
Aero Drag Reduction, Level 1	AERO1																
Aero Drag Reduction, Level 2 (Active Reduction)	AERO2																

Table IV-3a: Technology Cost Estimates

VEHICLE TECHNOLOGY RETAIL PRICE EQUIVALENT INCREMENTAL COSTS PER VEHICLE (2008$) BY VEHICLE SUBCLASS							
			Performance		Performance		Performance
		Subcompact	Subcompact	Compact	Compact	Midsize	Midsize
TECHNOLOGY	Abrev.	Car	Car	Car	Car	Car	Car
Low Friction Lubricants	LUB						
Engine Friction Reduction	EFR						
VVT - Coupled Cam Phasing (CCP) on SOHC	CCPS						
Discrete Variable Valve Lift (DVVL) on SOHC	DVVLS						
Cylinder Deactivation on SOHC	DEACS						
VVT - Intake Cam Phasing (ICP)	ICP						
VVT - Dual Cam Phasing (DCP)	DCP						
Discrete Variable Valve Lift (DVVL) on DOHC	DVVLD						
Continuously Variable Valve Lift (CVVL)	CVVL						
Cylinder Deactivation on DOHC	DEACD						
Stoichiometric Gasoline Direct Injection (GDI)	SGDI						
Cylinder Deactivation on OHV	DEACO						
Variable Valve Actuation - CCP and DVVL on OHV	VVA						
Stoichiometric Gasoline Direct Injection (GDI) on OH	SGDIO						
Conversion to DOHC with DCP	CDOHC						
Turbocharging and Downsizing	TRBDS						
Exhaust Gas Recirculation (EGR) Boost, Level 1	EGRB						
Exhaust Gas Recirculation (EGR) Boost, Level 2	EGRB2						
Lean Burn Direct Injection with TRBDS	LBDI						
Advanced Diesel	ADSL						
6-Speed Manual/Improved Internals	6MAN						
Improved Auto. Trans. Controls/Externals	IATC						
6-Speed Auto Trans with Improved Internals	NAUTO						
Dual Clutch Transmission (Dry/Wet)	DCT						
New Transmission (7+ Speed Auto or 7+ Speed DC	NTRANS						
Electric Power Steering	EPS						
Improved Accessories	IACC						
12V Micro-Hybrid	MHEV						
Belt mounted Integrated Starter Generator	BISG						
Crank mounted Integrated Starter Generator	CISG						
Strong Hybrid (P2 or 2-mode hybrid)	SHEV1						
Strong Hybrid (P2 or 2-mode hybrid) with EGRB	SHEV2						
Plug-in Hybrid - 20 mi range	PHEV20						
Plug-in Hybrid - 40 mi range	PHEV40						
Electric Vehicle	EV						
Fuel Cell Vehicle	FCV						
Mass Reduction, Level 1 (5%)	MR1						
Mass Reduction, Level 2 (7.5%)	MR2						
Mass Reduction, Level 3 (10%)	MR3						
Mass Reduction, Level 4 (15%)	MR4						
Mass Reduction, Level 5 (20%)	MR5						
Low Rolling Resistance Tires, Level 1	ROLL1						
Low Rolling Resistance Tires, Level 2	ROLL2						
Low Drag Brakes	LDB						
Secondary Axle Disconnect	SAX						
Aero Drag Reduction, Level 1	AERO1						
Aero Drag Reduction, Level 2 (Active Reduction)	AERO2						

Table IV-3b: Technology Cost Estimates

VEHICLE TECHNOLOGY RETAIL PRICE EQUIVALENT INCREMENTAL COSTS PER VEHICLE (2008$) BY VEHICLE SUBCLASS							
			Performance				
		Large	Large	Minivan	Small	Midsize	Large
TECHNOLOGY	Abrev.	Car	Car	LT	LT	LT	LT
Low Friction Lubricants	LUB						
Engine Friction Reduction	EFR						
VVT - Coupled Cam Phasing (CCP) on SOHC	CCPS						
Discrete Variable Valve Lift (DVVL) on SOHC	DVVLS						
Cylinder Deactivation on SOHC	DEACS						
VVT - Intake Cam Phasing (ICP)	ICP						
VVT - Dual Cam Phasing (DCP)	DCP						
Discrete Variable Valve Lift (DVVL) on DOHC	DVVLD						
Continuously Variable Valve Lift (CVVL)	CVVL						
Cylinder Deactivation on DOHC	DEACD						
Stoichiometric Gasoline Direct Injection (GDI)	SGDI						
Cylinder Deactivation on OHV	DEACO						
Variable Valve Actuation - CCP and DVVL on OHV	VVA						
Stoichiometric Gasoline Direct Injection (GDI) on OH	SGDIO						
Conversion to DOHC with DCP	CDOHC						
Turbocharging and Downsizing	TRBDS						
Exhaust Gas Recirculation (EGR) Boost, Level 1	EGRB						
Exhaust Gas Recirculation (EGR) Boost, Level 2	EGRB2						
Lean Burn Direct Injection with TRBDS	LBDI						
Advanced Diesel	ADSL						
6-Speed Manual/Improved Internals	6MAN						
Improved Auto. Trans. Controls/Externals	IATC						
6-Speed Auto Trans with Improved Internals	NAUTO						
Dual Clutch Transmission (Dry/Wet)	DCT						
New Transmission (7+ Speed Auto or 7+ Speed DC	NTRANS						
Electric Power Steering	EPS						
Improved Accessories	IACC						
12V Micro-Hybrid	MHEV						
Belt mounted Integrated Starter Generator	BISG						
Crank mounted Integrated Starter Generator	CISG						
Strong Hybrid (P2 or 2-mode hybrid)	SHEV1						
Strong Hybrid (P2 or 2-mode hybrid) with EGRB	SHEV2						
Plug-in Hybrid - 20 mi range	PHEV20						
Plug-in Hybrid - 40 mi range	PHEV40						
Electric Vehicle	EV						
Fuel Cell Vehicle	FCV						
Mass Reduction, Level 1 (5%)	MR1						
Mass Reduction, Level 2 (7.5%)	MR2						
Mass Reduction, Level 3 (10%)	MR3						
Mass Reduction, Level 4 (15%)	MR4						
Mass Reduction, Level 5 (20%)	MR5						
Low Rolling Resistance Tires, Level 1	ROLL1						
Low Rolling Resistance Tires, Level 2	ROLL2						
Low Drag Brakes	LDB						
Secondary Axle Disconnect	SAX						
Aero Drag Reduction, Level 1	AERO1						
Aero Drag Reduction, Level 2 (Active Reduction)	AERO2						

Table IV-4a: Technology Effectiveness Estimates

VEHICLE TECHNOLOGY INCREMENTAL FUEL CONSUMPTION REDUCTION (-%) BY VEHICLE SUBCLASS							
			Performance		Performance		Performance
		Subcompact	Subcompact	Compact	Compact	Midsize	Midsize
TECHNOLOGY	Abrev.	Car	Car	Car	Car	Car	Car
Low Friction Lubricants	LUB						
Engine Friction Reduction	EFR						
VVT - Coupled Cam Phasing (CCP) on SOHC	CCPS						
Discrete Variable Valve Lift (DVVL) on SOHC	DVVLS						
Cylinder Deactivation on SOHC	DEACS						
VVT - Intake Cam Phasing (ICP)	ICP						
VVT - Dual Cam Phasing (DCP)	DCP						
Discrete Variable Valve Lift (DVVL) on DOHC	DVVLD						
Continuously Variable Valve Lift (CVVL)	CVVL						
Cylinder Deactivation on DOHC	DEACD						
Stoichiometric Gasoline Direct Injection (GDI)	SGDI						
Cylinder Deactivation on OHV	DEACO						
Variable Valve Actuation - CCP and DVVL on OHV	VVA						
Stoichiometric Gasoline Direct Injection (GDI) on OHV	SGDIO						
Conversion to DOHC with DCP	CDOHC						
Turbocharging and Downsizing	TRBDS						
Exhaust Gas Recirculation (EGR) Boost, Level 1	EGRB						
Exhaust Gas Recirculation (EGR) Boost, Level 2	EGRB2						
Lean Burn Direct Injection with TRBDS	LBDI						
Advanced Diesel	ADSL						
6-Speed Manual/Improved Internals	6MAN						
Improved Auto. Trans. Controls/Externals	IATC						
6-Speed Auto Trans with Improved Internals	NAUTO						
Dual Clutch Transmission (Dry/Wet)	DCT						
New Transmission (7+ Speed Auto or 7+ Speed DCT	NTRANS						
Electric Power Steering	EPS						
Improved Accessories	IACC						
12V Micro-Hybrid	MHEV						
Belt mounted Integrated Starter Generator	BISG						
Crank mounted Integrated Starter Generator	CISG						
Strong Hybrid (P2 or 2-mode hybrid)	SHEV1						
Strong Hybrid (P2 or 2-mode hybrid) with EGRB	SHEV2						
Plug-in Hybrid - 20 mi range	PHEV20						
Plug-in Hybrid - 40 mi range	PHEV40						
Electric Vehicle	EV						
Fuel Cell Vehicle	FCV						
Mass Reduction, Level 1 (5%)	MR1						
Mass Reduction, Level 2 (7.5%)	MR2						
Mass Reduction, Level 3 (10%)	MR3						
Mass Reduction, Level 4 (15%)	MR4						
Mass Reduction, Level 5 (20%)	MR5						
Low Rolling Resistance Tires, Level 1	ROLL1						
Low Rolling Resistance Tires, Level 2	ROLL2						
Low Drag Brakes	LDB						
Secondary Axle Disconnect	SAX						
Aero Drag Reduction, Level 1	AERO1						
Aero Drag Reduction, Level 2 (Active Reduction)	AERO2						

Table IV-4b: Technology Effectiveness Estimates

VEHICLE TECHNOLOGY INCREMENTAL FUEL CONSUMPTION REDUCTION (-%) BY VEHICLE SUBCLASS							
			Performance				
		Large	Large	Minivan	Small	Midsize	Large
TECHNOLOGY	Abrev.	Car	Car	LT	LT	LT	LT
Low Friction Lubricants	LUB						
Engine Friction Reduction	EFR						
VVT - Coupled Cam Phasing (CCP) on SOHC	CCPS						
Discrete Variable Valve Lift (DVVL) on SOHC	DVVLS						
Cylinder Deactivation on SOHC	DEACS						
VVT - Intake Cam Phasing (ICP)	ICP						
VVT - Dual Cam Phasing (DCP)	DCP						
Discrete Variable Valve Lift (DVVL) on DOHC	DVVLD						
Continuously Variable Valve Lift (CVVL)	CVVL						
Cylinder Deactivation on DOHC	DEACD						
Stoichiometric Gasoline Direct Injection (GDI)	SGDI						
Cylinder Deactivation on OHV	DEACO						
Variable Valve Actuation - CCP and DVVL on OHV	VVA						
Stoichiometric Gasoline Direct Injection (GDI) on OH	SGDIO						
Conversion to DOHC with DCP	CDOHC						
Turbocharging and Downsizing	TRBDS						
Exhaust Gas Recirculation (EGR) Boost, Level 1	EGRB						
Exhaust Gas Recirculation (EGR) Boost, Level 2	EGRB2						
Lean Burn Direct Injection with TRBDS	LBDI						
Advanced Diesel	ADSL						
6-Speed Manual/Improved Internals	6MAN						
Improved Auto. Trans. Controls/Externals	IATC						
6-Speed Auto Trans with Improved Internals	NAUTO						
Dual Clutch Transmission (Dry/Wet)	DCT						
New Transmission (7+ Speed Auto or 7+ Speed DCT	NTRANS						
Electric Power Steering	EPS						
Improved Accessories	IACC						
12V Micro-Hybrid	MHEV						
Belt mounted Integrated Starter Generator	BISG						
Crank mounted Integrated Starter Generator	CISG						
Strong Hybrid (P2 or 2-mode hybrid)	SHEV1						
Strong Hybrid (P2 or 2-mode hybrid) with EGRB	SHEV2						
Plug-in Hybrid - 20 mi range	PHEV20						
Plug-in Hybrid - 40 mi range	PHEV40						
Electric Vehicle	EV						
Fuel Cell Vehicle	FCV						
Mass Reduction, Level 1 (5%)	MR1						
Mass Reduction, Level 2 (7.5%)	MR2						
Mass Reduction, Level 3 (10%)	MR3						
Mass Reduction, Level 4 (15%)	MR4						
Mass Reduction, Level 5 (20%)	MR5						
Low Rolling Resistance Tires, Level 1	ROLL1						
Low Rolling Resistance Tires, Level 2	ROLL2						
Low Drag Brakes	LDB						
Secondary Axle Disconnect	SAX						
Aero Drag Reduction, Level 1	AERO1						
Aero Drag Reduction, Level 2 (Active Reduction)	AERO2						

Table IV-5: Energy Loss Mechanism Estimates

Percent Reduction of Energy Loss by Loss Mechanism										
TECHNOLOGY	Abrev.	System Irreversibility	Exhaust and Coolant Heat Loss	Engine Friction	Pumping Loss	Accessory Losses	Transmission Losses	Aerodynamic Drag	Tire Rolling Resistance	Vehicle Work
Low Friction Lubricants	LUB									
Engine Friction Reduction	EFR									
VVT - Coupled Cam Phasing (CCP) on SOHC	CCPS									
Discrete Variable Valve Lift (DVVL) on SOHC	DVVLS									
Cylinder Deactivation on SOHC	DEACS									
VVT - Intake Cam Phasing (ICP)	ICP									
VVT - Dual Cam Phasing (DCP)	DCP									
Discrete Variable Valve Lift (DVVL) on DOHC	DVVLD									
Continuously Variable Valve Lift (CVVL)	CVVL									
Cylinder Deactivation on DOHC	DEACD									
Stoichiometric Gasoline Direct Injection (GDI)	SGDI									
Cylinder Deactivation on OHV	DEACO									
Variable Valve Actuation - CCP and DVVL on OHV	VVA									
Stoichiometric Gasoline Direct Injection (GDI) on OHV	SGDIO									
Conversion to DOHC with DCP	CDOHC									
Turbocharging and Downsizing	TRBDS									
Exhaust Gas Recirculation (EGR) Boost, Level 1	EGRB									
Exhaust Gas Recirculation (EGR) Boost, Level 2	EGRB2									
Lean Burn Direct Injection with TRBDS	LBDI									
Advanced Diesel	ADSL									
6-Speed Manual/Improved Internals	6MAN									
Improved Auto. Trans. Controls/Externals	IATC									
6-Speed Auto Trans with Improved Internals	NAUTO									
Dual Clutch Transmission (Dry/Wet)	DCT									
New Transmission (7+ Speed Auto or 7+ Speed DCT)	NTRANS									
Electric Power Steering	EPS									
Improved Accessories	IACC									
12V Micro-Hybrid	MHEV									
Belt mounted Integrated Starter Generator	BISG									
Crank mounted Integrated Starter Generator	CISG									
Strong Hybrid (P2 or 2-mode hybrid)	SHEV1									
Strong Hybrid (P2 or 2-mode hybrid) with EGRB	SHEV2									
Plug-in Hybrid - 20 mi range	PHEV20									
Plug-in Hybrid - 40 mi range	PHEV40									
Electric Vehicle	EV									
Fuel Cell Vehicle	FCV									
Mass Reduction, Level 1 (5%)	MR1									
Mass Reduction, Level 2 (7.5%)	MR2									
Mass Reduction, Level 3 (10%)	MR3									
Mass Reduction, Level 4 (15%)	MR4									
Mass Reduction, Level 5 (20%)	MR5									
Low Rolling Resistance Tires, Level 1	ROLL1									
Low Rolling Resistance Tires, Level 2	ROLL2									
Low Drag Brakes	LDB									
Secondary Axle Disconnect	SAX									
Aero Drag Reduction, Level 1	AERO1									
Aero Drag Reduction, Level 2 (Active Reduction)	AERO2									

Table IV-6a: Technology Synergy Estimates

Synergies		Fuel Consumption Improvement Synergy values by Subclass Positive values are [positive] synergies, negative values are dissynergies.					
Technology A	Technology B	Subcompact PC	Subcompact Perf. PC	Compact PC	Compact Perf. PC	Midsize PC	Midsize Perf. PC
ICP	NAUTO						

Table IV-6b: Technology Synergy Estimates

Synergies		Fuel Consumption Improvement Synergy values by Subclass Positive values are [positive] synergies, negative values are dissynergies.					
Technology A	**Technology B**	**Large PC**	**Large Perf. PC**	**Minivan LT**	**Small LT**	**Midsize LT**	**Large LT**
ICP	NAUTO						

Table IV-7: Battery and Power Electronics Estimates

Battery and Power Electronics Estimates										
		HEV			PHEV			EV		
	Units	MY2017	MY2020	MY2025	MY2017	MY2020	MY2025	MY2017	MY2020	MY2025
Battery Pack RPE Cost (100% Discharge Energy)	$/kWh									
Battery Pack RPE Cost (Usable Energy)	$/kWh									
Battery Cell RPE Cost	$/kWh									
Battery Warranty (Time)	years									
Battery Warranty (Mileage)	miles									
Expected Battery Life (Time)	years									
Expected Battery Life (Mileage)	miles									
Primary Motor RPE Cost	$/kW									
Secondary Motor RPE Cost	$/kW									
Primary Inverter RPE Cost	$/kW									
Secondary Inverter RPE Cost	$/kW									

Appendix B. Technology Decision Trees

Figure 1. Engine Technology Decision Tree

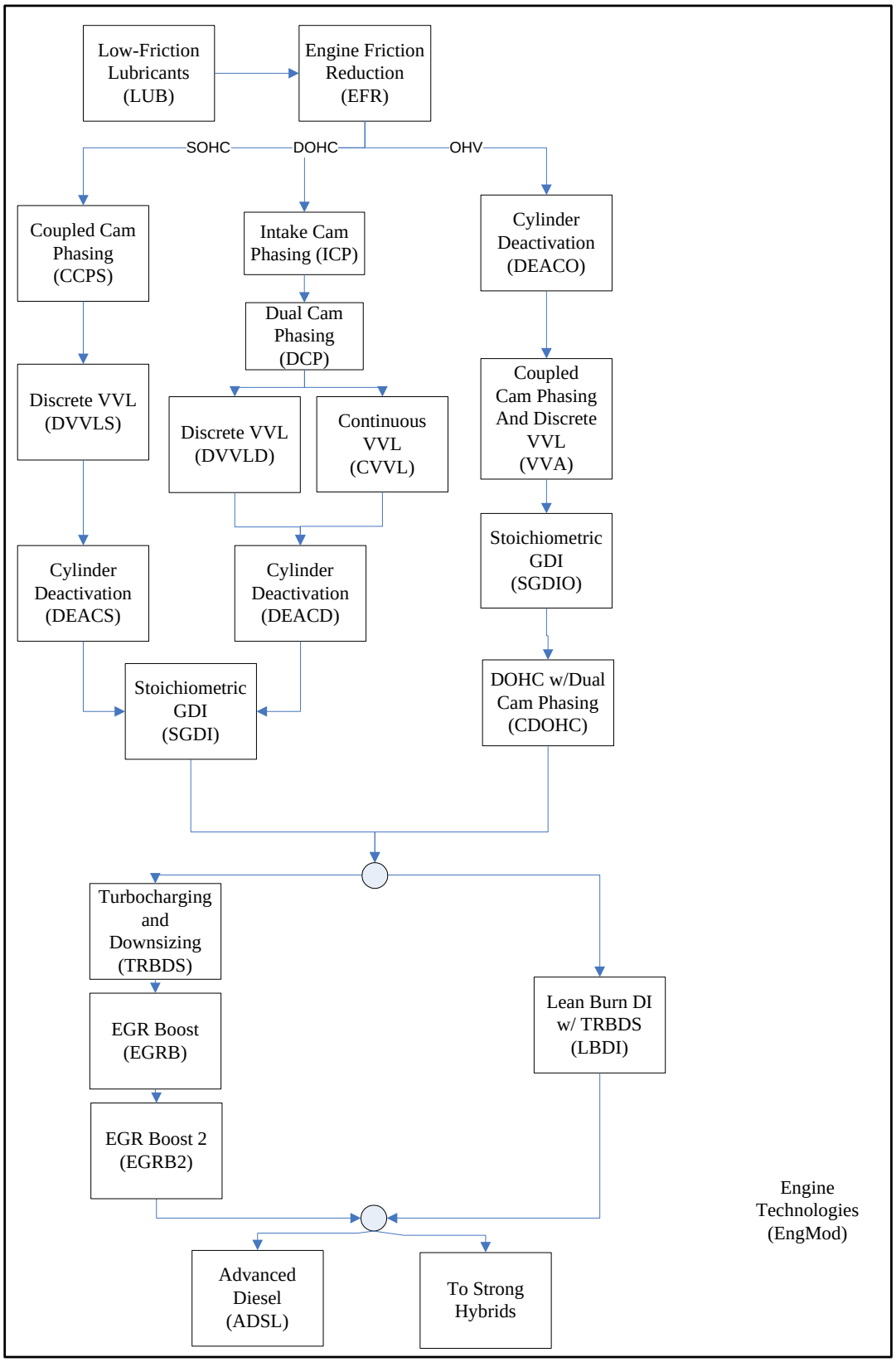

Figure 2. Electrification/Accessory, Transmission and Hybrid Technology Decision Tree

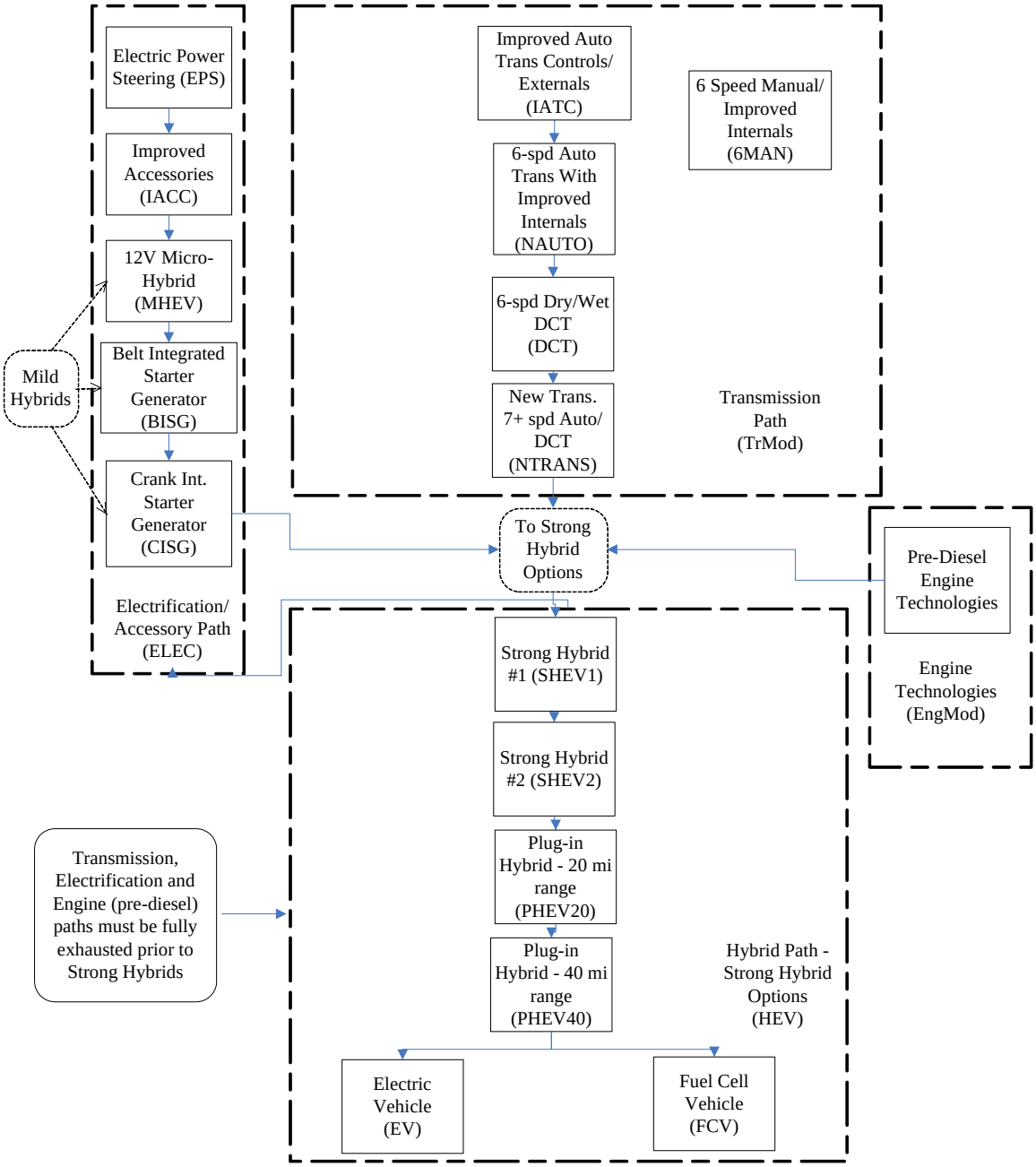

Figure 3. Vehicle Technology Decision Tree