Department of Energy
Golden Field Office
1617 Cole Boulevard
Golden, Colorado 80401-3393

DE-FOA-0000592
Modification: 000002

DATE: January 5, 2012
FROM: Stephanie N. Carabajal, Contracting Officer
TO: All Prospective Applicants

SUBJECT: Modification 000002 to Request for Information (RFI) No. DE-FOA-EE0000592, "Total Costs of Ownership of Future Light-Duty Vehicles"

The purpose of this modification is to extend the closing date for the RFI.

RFI responses must be received no later than 11:59 PM EDT on January 30, 2012.

All other terms and conditions of the RFI remain the same.

Request for Information
U.S Department of Energy (DOE)
Office of Energy Efficiency and Renewable Energy

Total Costs of Ownership of Future Light-Duty Vehicles
DE-FOA-EE0000592

Date: October 13, 2011

Subject: Request for Information (RFI) on assumptions and the general financial analysis approach used for estimating the total cost of ownership of advanced vehicle technologies.

Description:
The Department of Energy (DOE) seeks input from the public on the analysis methodology and assumptions used for estimating the total cost of ownership[1] (TCO) of various advanced vehicle technologies within DOE's portfolio that have the potential to significantly reduce greenhouse gas (GHG) emissions and petroleum consumption. The methodology and basis for assumptions are provided below and stakeholder input is requested on their validity and on the various levels (aggressive, moderate and conservative) of success assumed for the different advanced technologies presented.

Program Manager /Area:
Sunita Satyapal, Program Manager / Fuel Cell Technologies Program, Office of Energy Efficiency and Renewable Energy (for technical questions, contact Tien Nguyen, tien.nguyen@ee.doe.gov)
Patrick Davis, Program Manager / Vehicle Technologies Program, Office of Energy Efficiency and Renewable Energy (for technical questions, contact Jake Ward, jacob.ward@ee.doe.gov)
Paul Bryan, Program Manager/ Biomass Program, Office of Energy Efficiency and Renewable Energy (for technical questions, contact Zia Haq, zia.haq@ee.doe.gov)

Background:
The Vehicle Technologies Program (VTP), Fuel Cell Technologies Program (FCTP) and Biomass Program (OBP) within the Department of Energy's Office of Energy Efficiency and Renewable Energy (DOE-EERE) are leading the DOE's efforts to develop advanced transportation and alternative fuels technologies. To find more information about the programs, please visit http://www1.eere.energy.gov/vehiclesandfuels/, http://www1.eere.energy.gov/hydrogenandfuelcells/, and http://www1.eere.energy.gov/biomass/

[1] For this particular analysis, DOE uses manufactured costs of vehicles instead of prices, i.e., excluding manufacturer and dealer markups, distribution costs, sales tax, etc.

The information collected by this Request for Information will be used for internal DOE analysis, including assisting DOE in estimating the benefits of its Research, Development and Demonstration (RD&D) portfolio. Interested parties to this RFI might include, but are not limited to: automobile technology developers or manufacturers, components suppliers (e.g., suppliers of batteries, fuel cells, motors, power electronics, etc.), fuels suppliers, electric utilities, independent power producers, industrial gas companies, state and local government, research laboratories, academics, and other public, private, or non-profit entities.

Input is requested from the public on estimated total costs of ownership of advanced light-duty vehicles. A preliminary analysis was conducted for several fuel/vehicle pathways for present day (2011) and future (2016 and 2030) mid-size cars to examine the potential for technology improvement to reduce the total costs of ownership of advanced powertrain vehicles and fuels to levels comparable to conventional powertrain vehicles and fuels. The results are summarized graphically in Figure 1 for the vehicles (mid-size cars):

- Gasol 2010: A current gasoline (spark ignition engine) vehicle,
- Gasol 2016: A conventional gasoline vehicle that meets the 2016 corporate average fuel economy (CAFE) standard,
- Gasol ICEV: A gasoline vehicle in Year 2030 which includes significant improvements resulting from DOE's R&D portfolio, including vehicle lightweighting and advanced combustion engines (but without hybridization),
- Diesel ICEV: A diesel vehicle in Year 2030 which includes significant improvements resulting from DOE's R&D portfolio, including vehicle lightweighting and advanced combustion engines (but without hybridization),
- Gasol HEV: A "2030" hybrid electric vehicle (with a spark ignition gasoline engine),
- PHEV10: A "2030" plug-in hybrid electric vehicle with an all-electric range (AER) of 10 miles,
- EREV40: A "2030" extended range electric vehicle with an AER of 40 miles,
- FCHEV: A "2030" fuel cell hybrid electric vehicle, and
- BEV: Three "2030" battery electric vehicles with nominal ranges of 100, 200, and 400 miles, respectively.

In Figure 1, the type of liquid fuel used is shown in parentheses next to the vehicle type. A gasoline ICEV can use gasoline or bio-gasoline; an E85 flexible-fuel vehicle (FFV) can use gasoline, bio-gasoline, or E85 (Figure 1 only shows E85 FFVs using E85); a diesel vehicle can use diesel or diesel from biomass pyrolysis, etc. The cost of the fueling infrastructure is reflected in the estimated fuel prices, e.g., biofuels prices and hydrogen prices include both the capital and O&M cost elements of the production and distribution infrastructure. For plug-in vehicles (PHEV, EREV and BEVs), retail electricity prices (projected by U.S. Energy Information Administration (EIA)) were the fuel costs. The cost of a Level 1 home charger was added to the manufactured cost of each plug-in vehicle. No public charging was assumed.

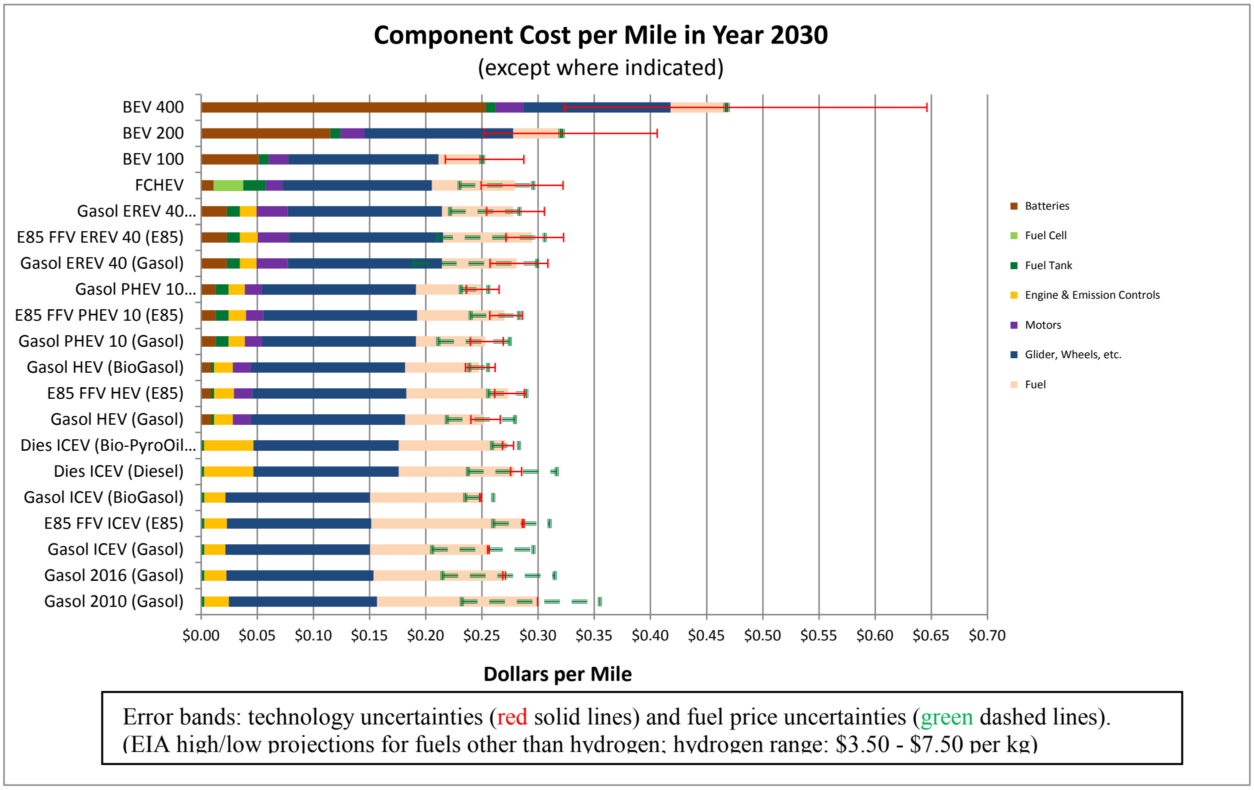

Figure 1. Ownership Costs for Future Mid-Size Car

Notes:
- Lifecycle costs estimated assuming 10,000 miles are driven each year over a 15-year vehicle life.
- Capital costs are amortized over the 15-year vehicle life, assuming a 7%/yr cost of money.
- Costs are expressed in constant 2010 dollars.
- Calculations do not include maintenance, insurance, or resale value.
- Vehicle costs and fuel economies were estimated using Argonne National Laboratory's (ANL) Autonomie Model for vehicle simulation.
- Capital costs include only factory production costs, and do not include items such as manufacturer and dealer markups, distribution costs, sales tax, etc.
- Costs are based on 500,000 units per year for fuel cells (the values are about 16% higher for 250,000 units/year), 250,000 units/year for batteries, motors and other electric machines, and 100,000 units per year for engines and other vehicle components.
- Prices of biofuels are based on biomass logistics systems and biorefineries that have progressed past the demonstration phase, i.e., have "Nth plant" status

The low/high error bars (sensitivity bands) illustrate uncertainties associated with projecting the performance of future vehicles and future fuel costs. The green sensitivity bands show the effects of variations in the fuel costs, and the red sensitivity bands show the effects of non-fuel related uncertainties (corresponding to aggressive and conservative levels of success), including manufactured component costs and ranges of fuel economy of the associated vehicles:

- The reference or "mid" case is based on medium fuel economy values and medium vehicle prices coupled with medium fuel prices (i.e., EIA reference oil prices and DOE's mid-range estimates of future biofuels and hydrogen prices).
- Vehicle technology sensitivity: The "low" vehicle sensitivity case includes optimistic vehicles with higher fuel economy values and lower prices; and the "high" vehicle sensitivity case includes less optimistic vehicles with lower fuel economy values and

higher prices. The fuel prices were kept at their medium values for the vehicle technology sensitivity cases.

- Fuel prices sensitivity: The fuel price sensitivity cases show the effect lower and higher fuel prices on the "mid" case. That is, the fuel economy values and prices of vehicles were kept at their medium values in the fuel price sensitivity cases.

The "Data and Assumptions" section identified in this RFI provides a detailed explanation of the methodology and assumptions used to obtain the preliminary values given in Figure 1. Please refer to this material in formulating a response to any of the specific items requested below in the "Requested Information" section.

Requested Information:

This is a RFI and not a Funding Opportunity Announcement. Therefore, DOE is not accepting applications. Only responses to the items listed below are being solicited. Responses should provide any arguments, observations, references, or recommendations that respondents consider relevant to the items below:

1) Feedback is requested on the specific assumptions and on the range of values used to represent achieving aggressive, moderate or conservative levels of success for various technologies:
    a. Advanced internal combustion engine vehicles
    b. Hybrid electric vehicles
    c. Plug-in hybrid electric vehicles
    d. Battery electric vehicles
    e. Fuel cell hybrid electric vehicles
    f. Alternative fuels from biomass

    Respondents should comment on methodology to ensure a common ground for the various technologies and appropriate levels of success for comparison. For example, aggressive targets should not be assumed for one technology while less than aggressive targets are assumed for another, unless adequate justification is provided. The basis for any proposed changes to the assumptions (aggressive, moderate and conservative) should be provided (along with references where available).

2) Specific comments are requested on the projection of cost reduction rates for technologies that are not yet fully commercial (or for which substantial validation is not yet available). If respondents have information on learning curves (progress ratios, scale elasticities, etc.), please provide, along with validation, where available. Key components, such as batteries, fuel cells, motors, etc. are of particular interest.

3) Comments are requested on the general financial analysis approach used. Is it appropriate or is there a better approach (for example, is the discounting and amortization used appropriate)?

RFI Guidelines:

Parties interested in submitting a response to this RFI should review the RFI Guidelines in their entirety before developing and submitting a response. DOE will review and consider all responses. DOE will not reimburse costs associated with preparing any documents for this RFI, and there is no guarantee that future funding opportunities or other activities will be undertaken as a result of this RFI.

Comments in response to this RFI must be provided as an attachment to an e-mail message addressed to *TCORFI@go.doe.gov*. All responses to this RFI must be delivered electronically to the aforementioned e-mail address using Microsoft Word (.doc or .docx) format. Responses to this RFI should be no more than 5 pages in length, single spaced (minimum 11 point font, 1 inch margins). Although the RFI responses are intended for DOE internal review, **responses will not be considered confidential. Do not include any confidential or proprietary information in your response.** Respondents are requested to provide the following information at the start of their response to this RFI:

- Company/Institution Name,
- Company/Institution Contact,
- Address, phone number, and e-mail address,
- Brief description of the operations and mission of business or institution (several sentences will suffice).

RFIs are one of several routine processes used to solicit information from stakeholders and DOE will not be providing individual responses to those who submit comments nor feedback on any decisions based on the comments received. Responses will be utilized by DOE to refine and update TCO analyses as needed.

RFI responses must be received no later than 11:59 PM EDT on January 30, 2012.
Questions may be addressed to TCORFI@go.doe.gov with the subject line "Question".

Data & Assumptions
The following bulleted items and tables provide details on the methodology and assumptions used by DOE to estimate the total cost of ownership of future light duty vehicles.

- Major inputs to the TCO calculation include the cost of vehicle manufacture (sum of subsystem costs) and annual fuel costs over the vehicle life (assumed to be 15 years).
- Results for all advanced vehicle pathways are based on a projected state of the technologies in 2030, and they incorporate fuel economy improvements based on the corporate average fuel economy (CAFE) standards adopted in the Energy Independence and Security Act of 2007.
- Year 2030 cost range for major vehicle subsystems:

- Batteries for PHEVs and BEVs: $125, $220 and $300 per kWh.
- Fuel cell: $25, $30 and $40 per kW.
- On-board hydrogen storage: $6, $11 and $16 per kWh.

- For 2030 advanced vehicles, major subsystems (batteries, fuel cells, hydrogen tanks) are assumed to last for 15 years.
- The high/low technology range is based on the high/low optimism sets of assumptions used by DOE-EERE. The vehicle factory production costs (not prices) and the total cost of ownership result in $ per mile shown in Table 1 below are for the average-optimism set of assumptions (e.g., battery at $220/kWh, fuel cell at $30/kW, etc.). Additional assumptions and details are shown in Table 2.

- A cost-of-capital factor is applied to initial vehicle cost using a 7% (net without inflation) cost of money to amortize said initial cost over the 15-year vehicle lifetime. The cost of a vehicle includes only factory production costs, not distribution and retail markups (i.e., the cost is less than the retail price).
- Fuel economies (as measured in the laboratory) for all fuel/vehicle systems were determined using Argonne National Laboratory's Autonomie Model, Summer 2011 version. For more information on the model, see: http://www.autonomie.net/.
- The U.S. Environmental Protection Agency's latest method was used in deriving on-road fuel economies from results of simulations of laboratory driving tests. For more information on EPA's method, see: http://edocket.access.gpo.gov/2006/pdf/06-9749.pdf.
- Assumed costs and conversion efficiencies of biofuels are shown in Table 3.

Fuel economy estimates for vehicles are expressed in terms of gasoline gallon-equivalents (gge) for each applicable fuel, using energy conversion factors where appropriate:

- Gasoline: approximately 114,000 Btu/gal (lower heating value or LHV).
- Diesel fuel: approximately 129,000 Btu/gal (LHV)
- Electricity: 3,412 Btu/kWh
- E85: approximately 83,700 Btu/gal (LHV), based on gasoline LHV (19% by volume) and ethanol LHV (81% by volume, 76,300 Btu/gal)
- Bio-gasoline : approximately 114,000 Btu/gal (LHV)
- Hydrogen: approximately 33.3 kWh per kg

- The cars were assumed to log 10,000 miles per year over a lifetime of 15 years.
- Baseline fuel prices: except for cellulosic E85, bio-gasoline, renewable diesel from bio-based pyrolytic oil, and hydrogen, all are from the Energy Information Administration's Annual Energy Outlook (AEO) 2011 for the year 2030, reference oil prices case: $3.60 per gallon gasoline equivalent (gge), $3.50 per gge diesel, and 10.6¢/kWh electricity ($3.50 per gge). Fuel prices were assumed to remain constant in real dollars over the life of the vehicles.
    - E85: $4.60 per gge, based on pure cellulosic ethanol price at $3.40 per gallon ($5.00 per gge) and gasoline at $3.60 per gallon.
    - Bio-gasoline: $3.40 per gge
    - Renewable diesel: $3.40 per gallon ($3.30 per gge)
    - Hydrogen price was assumed at $4.50 per kg (or gge) based on the DOE hydrogen analysis (H2A) modeling of natural gas reforming at a 1500 kg/day fueling station with AEO 2011 prices for industrial natural gas.
- Fuel sensitivity analysis involved:
    - Low/high prices from AEO 2011's low oil price and high oil price cases:
        - Gasoline at $2.20 and $5.30 per gallon
        - Diesel at $2.20 and $4.90 per gge
        - Electricity at 10.3¢ and 10.8¢/kWh

- E85 at $3.80 and $5.50 per gge, based on cellulosic ethanol prices at $4.30 and $5.60 per gge and low/high gasoline prices shown above
- Bio-gasoline at $3.00 and $3.80 per gge
- Renewable diesel at $2.80 and $3.60 per gge
- Hydrogen at $3.50 and $7.50 per gge

- Maximum economy-of-scale is achieved at 500,000 units per year for fuel cells (costs are about 16% higher at 250,000 units/year), 250,000 units/year for batteries, motors and other electric machines, and 100,000 units per year for engines and other vehicle components.

The mid-case data (reference oil prices, mid-range biofuels and hydrogen prices, and medium-optimism vehicles) used to generate Figure 1 are summarized in tabular form in the following tables:

Table 1. Vehicle/Fuel Costs (Mid-Case Estimates; High/Low Sensitivity not shown here)

Assumptions for Manufactured Costs (not Prices) – Year 2030 Technology Except as Noted

	Gasol 2010 (Gasol)	Gasol 2016 (Gasol)	Gasol ICEV (Gasol)	E85 FFV ICEV (E85)	Gasol ICEV (BioGasol)	Dies ICEV (Diesel)	Dies ICEV (Bio-PyroOil Dies)	Gasol HEV (Gasol)	E85 FFV HEV (E85)	Gasol HEV (BioGasol)
Vehicle Cost (medium Optimism)	14,263	13,982	13,696	13,796	13,796	16,015	16,020	16,506	16,606	16,561
Garage Charger (Level 1)										
Veh. Cost (mid-Optimism, with charger)	14,263	13,982	13,696	13,796	13,796	16,015	16,020	16,506	16,606	16,561
In the table below, ANL's Autonomie Model was used to simulate vehicle performance. It generated values such as battery energy, engine & motor power, fuel cell power, hydr										
Vehicle Life	15	15	15	15	15	15	15	15	15	15
Mid-Optimism Vehicle Costs										
Battery kWh (available energy)								*1.0*	*1.0*	*1.0*
$/Battery kWh								$800	$800	$800
Battery Cost								$800	$800	$800
Fuel Cell kW										
$/Fuel Cell KW										
Fuel Cell Cost										
Hydrogen Mass, kg										
Hydrogen kWh										
$/H2 kWh										
Fuel Tank Cost	$260	$260	$260	$260	$260	$230	$230	$260	$260	$260
Glider	9,900	10,250	10,700	10,700	10,700	10,700	$10,700	$10,700	$10,700	$10,700
Engine kW	133	122	118	118	118	109	109	79.0	79.0	79.0
$/Engine kW	$11	$11	$11	$11	$11	$28	$28	$14	$14	$14
Engine Cost	$1,463	$1,342	$1,296	$1,346	$1,346	$3,045	$3,045	$1,106	$1,156	$1,156
Emissions Control	$530	$450	$420	$470	$470	$950	$955	$360	$410	$365
Motors kW								105	105	105
$/Motors kW								$14	$14	$14
Motors Cost								$1,470	$1,470	$1,470
Transmission	$1,480	$1,050	$490	$490	$490	$580	$580	$870	$870	$870
Drive, Wheels, Tires	$630	$630	$530	$530	$530	$510	$510	$940	$940	$940

	Gasol PHEV 10 (Gasol)	E85 FFV PHEV 10 (E85)	Gasol PHEV 10 (BioGasol)	Gasol EREV 40 (Gasol)	E85 FFV EREV 40 (E85)	Gasol EREV 40 (BioGasol)
Vehicle Cost (medium Optimism)	16,615	16,715	16,720	18,707	18,807	18,812
Garage Charger (Level 1)	$800	$800	$800	$800	$800	$800
Veh. Cost (mid-Optimism, with charger)	17,415	17,515	17,520	19,507	19,607	19,612
In the table below, ANL's Autonomie Model was usedrogen mass, etc. Comments on these technical parameter values would l						
Vehicle Life	15	15	15	15	15	15
Mid-Optimism Vehicle Costs						
Battery kWh (available energy)	*2.0*	*2.0*	*2.0*	*9.5*	*9.5*	*9.5*
$/Battery kWh	*$600*	*$600*	*$600*	*$220*	*$220*	*$220*
Battery Cost	*$1,170*	*$1,170*	*$1,170*	*$2,079*	*$2,079*	*$2,079*
Fuel Cell kW						
$/Fuel Cell KW						
Fuel Cell Cost						
Hydrogen Mass, kg						
Hydrogen kWh						
$/H2 kWh						
Fuel Tank Cost	*$260*	*$260*	*$260*	*$260*	*$260*	*$260*
Glider	*$10,700*	*$10,700*	*$10,700*	*$10,700*	*$10,700*	*$10,700*
Engine kW	*57.0*	*57.0*	*57.0*	*63.0*	*63.0*	*63.0*
$/Engine kW	*$17*	*$17*	*$17*	*$16*	*$16*	*$16*
Engine Cost	*$969*	*$1,019*	*$1,019*	*$1,008*	*$1,058*	*$1,058*
Emissions Control	*$330*	*$380*	*$380*	*$340*	*$390*	*$390*
Motors kW	*99*	*99*	*99*	*180*	*180*	*180*
$/Motors kW	*$14*	*$14*	*$14*	*$14*	*$14*	*$14*
Motors Cost	*$1,386*	*$1,386*	*$1,386*	*$2,520*	*$2,520*	*$2,520*
Transmission	*$870*	*$870*	*$875*	*$870*	*$870*	*$875*
Drive, Wheels, Tires	*$930*	*$930*	*$930*	*$930*	*$930*	*$930*

	FCHEV	BEV 100	BEV 200	BEV 400
Vehicle Cost (medium Optimism)	18,706	18,445	24,513	37,273
Garage Charger (Level 1)		$800	$800	$800
Veh. Cost (mid-Optimism, with charger)	18,706	19,245	25,313	38,073
Vehicle Life	15	15	15	15
Mid-Optimism Vehicle Costs				
Battery kWh (available energy)	*1.3*	*21*	*48*	*105*
$/Battery kWh	*$800*	*$220*	*$220*	*$220*
Battery Cost	*$1,020*	*$4,675*	*$10,483*	*$23,063*
Fuel Cell kW	*80*			
$/Fuel Cell KW	*$30*			
Fuel Cell Cost	*$2,400*			
Hydrogen Mass, kg	*5.0*			
Hydrogen kWh	*167*			
$/H2 kWh	*$11*			
Fuel Tank Cost	*$1,832*			
Glider	*$10,700*	*$10,700*	*$10,700*	*$10,700*
Engine kW				
$/Engine kW				
Engine Cost				
Emissions Control				
Motors kW	*96*	*115*	*140*	*160*
$/Motors kW	*$14*	*$14*	*$14*	*$14*
Motors Cost	*$1,344*	*$1,610*	*$1,960*	*$2,240*
Transmission	*$500*	*$550*	*$460*	*$360*
Drive, Wheels, Tires	*$910*	*$910*	*$910*	*$910*

Notes:

1. Table 1 entitled "Vehicle/Fuel Costs (Mid-Case Estimates)" shows total vehicle costs, as manufactured, broken down by vehicle subsystem.
2. Table 2 entitled "Results with High/Low Bounds and Key Assumptions" shows estimated costs per mile, consisting of the sum of vehicle and fuel costs. Vehicle costs are amortized at a 7% cost of money over 15 years, assuming 10,000 annual vehicle-miles traveled. The cost of ownership is expressed in annual dollars (using a capital recovery factor for initial costs and adding the annual fuel costs). Neither future cost payments nor miles driven are discounted. However, when the annual costs, i.e., costs of fuels and amortized capital costs, are constant from year to year as assumed in this analysis, the relative rankings are the same whether future cost streams are discounted or not. The spreadsheet used to estimate costs is being provided under this RFI in order to facilitate the review of DOE-EERE's analysis (see end of this RFI document for additional details). The first two results worksheets of the spreadsheet are for the reference oil prices, mid-range biofuels and hydrogen prices and medium-optimism vehicle technologies. The low/high cost-per-mile results are in the last two worksheets of the spreadsheet.

Table 2. Results with High/Low Bounds and Key Assumptions

TCO in Cents/Mile: Average Optimism (Low, High)[2]	Technical Parameters: Average (Low, High)	Cost Parameters: Average (Low, High)	Assumptions for Mid-Size Car (On-Road Fuel Economy and Other Parameters)
Current Gasoline ICEV 30 (24-37)¢/mile - gasoline	Engine Power 130 kW		• 25 mpg
2016 Gasoline ICEV 27 (22-33) ¢/mile - gasoline	Engine Power 125 kW (115 - 130)		• 31 mpg (31 – 36)
2030 Gasoline ICEV 26 (20-32) ¢/mile - gasoline 29 (23-33) ¢/mile - E85 25 (22-27) ¢/mile - bio-gasoline:	Engine Power 120 kW (105 - 130)		• 35 mpg (31 – 45)
2030 Diesel ICEV 28 (23-34) ¢/mile - diesel 27 (24-30) ¢/mile - renewable diesel	Engine Power 110 kW (100 - 120)		• 33 mpgge (31 – 42)
2030 Hybrid-Electric Vehicle 25 (20-32) ¢/mile - gasoline 27 (23-33) ¢/mile - E85 25 (21-28) ¢/mile - bio-gasoline	Battery Energy[3]: 1.0 kWh (0.9 – 1.1) Battery Power 25 kW (20 - 30) Motors: 105 kW (91 - 120)	Battery $/kWh: 800 (600 - 1,000)	• 51 mpgge (43 – 69)

[2] For TCO results: Average: middle values for vehicle fuel economy and prices, and medium fuel prices (EIA reference oil prices, etc.); Low: optimistic values for vehicle fuel economy and prices, and optimistic fuel prices (EIA low oil prices, etc.); High: less optimistic values for vehicle fuel economy and fuel prices, and less optimistic fuel prices (EIA high oil prices, etc.)

[3] Useable (not total) battery energy is shown for plug-in vehicles.

<u>2030 PHEV10</u> (10-mile electric range; no noticeable change in electric range after on-road adjustment) 25 (21-31) ¢/mile - gasoline 27 (23-31) ¢/mile - E85 25 (22-28) ¢/mile - bio-gasoline	Battery Energy 2.0 kWh (1.7 – 2.3) Battery Power 60 kW (50 - 70) Motors: 100 kW (87 - 110)	Battery $/kWh: 600 (400 - 800)	• Charge-depleting blended mode: 145 mpgge (119-177) for liquid fuel (gasoline, E85 or bio-gasoline) and 178 Wh/mile (156 - 194) for electricity Charge-sustaining mode: 54 mpg (46 - 72) • Electricity consumption shown above does not include charging and battery losses (approximately 15%), and was increased by 18% % (1/0.85) in the estimation of actual on-road consumption to reflect these losses. • Share of distance traveled in the blended mode was assumed to be 25% based on 10-miles on-road AER
<u>2030 EREV40</u> (40-mile electric range became approximately 28 miles after on-road adjustment) 28 (23-34) ¢/mile - gasoline 29 (24-34) ¢/mile - E85 28 (24-32) ¢/mile - bio-gasoline	Battery Energy 15 kWh (10 - 20) Battery Power 150 kW (130 - 160) Motors: 180 kW (160 - 200)	Battery $/kWh: 220 (125 - 300)	• Charge-depleting mode: 327 Wh/mile (285 – 369) (no liquid fuel used in this mode). Charge-sustaining mode: 39 mpg (34 – 51) • Electricity consumption shown above does not include charging and battery losses (approximately 15%), and was increased by 18% in the estimation of actual on-road consumption. • Share of distance traveled in CD mode was 51% based on 28-mile on-road AER (28 miles = rated 40 miles times EPA's 0.7 adjustment factor)
<u>2030 BEV100</u> (100-mile electric range became approximately 70 miles after on-road adjustment) 25 (21-29) ¢/mile	Battery Energy 21 kWh (18 - 25) Battery Power 130 kW (110 - 150) Motors: 115 kW (100 - 130)	Battery $/kWh: 220 (125 - 300)	• 310 Wh per mile (362- 263) or 108 mpgge (92 – 127) • Electricity consumption shown above does not include charging and battery losses (approximately 15%), and was increased by 18% in the estimation of actual on-road consumption. • On-road (more realistic driving conditions) electric range is 70 miles for the BEV 100.
<u>2030 BEV200</u> (200-mile electric range became approximately 140 miles after on-road adjustment) 31 (24-42) ¢/mile	Battery Energy 48 kWh (40 - 60) Battery Power 150 kW (120 - 170) Motors: 130 kW (100 - 150)	Battery $/kWh: 220 (125 - 300)	• 343 Wh per mile (411- 283) or 97 mpgge (81 – 118) • Electricity consumption shown above does not include charging and battery losses (approximately 15%), and was increased by 18% in the estimation of actual on-road consumption. • On-road (more realistic driving conditions) electric range is 140 miles for the BEV 200. • Actual modeling of this vehicle was not performed; rather, interpolation between a BEV150 and a BEV 300 was used.
<u>2030 BEV400</u> (400-mile electric range became approximately 280 miles after on-road adjustment) 44 (31-66) ¢/mile	Battery Energy 105 kWh (86 - 130) Battery Power 190 kW (140 - 230) Motors: 160 kW (135 - 190)	Battery $/kWh: 220 (125 - 300)	• 397 Wh per mile (476 - 327) or 84 mpgge (70 – 102) • Electricity consumption shown above does not include charging and battery losses (approximately 15%), and was increased by 18% in the estimation of actual on-road consumption. • On-road (more realistic driving conditions) electric range is 280 miles for the BEV 400. • Actual modeling of this vehicle was not performed; rather, extrapolation based on a BEV 300 was used.
<u>2030 FCHEV</u> 28 (22-40) ¢/mile	Fuel Cell Power: 80 kW (60 - 100) H2 on-board: 170 kWh (130 - 200) Battery Energy: 1.3 kWh (1.1 – 1.4) Battery Power 34 kW (30 - 38) Motors: 96 kW (80 - 115)	Fuel Cell $/kW: 30 (25 - 40) H2 Tank $/kWh: 11 (6 - 16) Battery $/kWh: 800 (600 - 1,000)	• 61 mpgge (50 – 74)

Each vehicle's driving range is 320 miles, except where noted for the electric range of the PHEV 10, EREV 40 and BEVs (the PHEV and EREV have a gasoline-only range of 320 miles in addition to their stated electric ranges; the BEVs have ranges as stated).

Derivation of Biofuel Costs

Biofuel production costs were derived from estimates of feedstock costs (delivered to a biorefinery), feedstock conversion efficiencies and biorefinery processing costs:

Production costs per gallon = Feedstock costs per dry ton / Gallons per dry ton + Processing cost per gallon.

Distribution costs, dealer markups, and federal and state taxes are added to biofuel production costs to estimate retail fuel prices for (undenatured) ethanol, bio-gasoline and biopyrolysis diesel. The retail price of E85 is calculated by using the costs of undenatured ethanol and the EIA gasoline price, assuming a 5% denaturant (by volume). This works out to be 81% undenatured ethanol and 21% gasoline (by volume). The federal and average state taxes are the taxes in effect as of July 2011. Finally, the price per gallon for each biofuel is converted to price per gge. Table 3 displays these calculations for the Average Optimism case.

Table 3. Costs and Prices of Biofuels

	Average Optimism		
	Cellulosic Ethanol in 2030	**Bio-gasoline in 2030**	**Bio Pyro Oil Diesel in 2030**
Feedstock Price per dry Ton (2010 dollars)	**$80**	**$96**	**$96**
Gallons per dry ton	**79**	**106**	**106**
Feedstock cost per gallon	$1.09	$0.98	$0.98
Production Cost, no feedstock (2010 dollars)	**$1.51**	**$1.68**	**$1.68**
Production Cost, incl feedstock (2010 dollars)	$2.60	$2.65	$2.65
Shipping/Distribution Cost per gallon	$0.14	$0.06	$0.06
Marketer's Profit, Retail Markups, Credit Card Fees, etc.	$0.16	$0.16	$0.16
Price before Federal/State Fuels Excise Taxes and Sales Tax	$2.90	$2.87	$2.87
Federal Fuels Excise Tax	$0.184	$0.184	$0.244
State Fuels Excise Tax	$0.208	$0.208	$0.189
State Other Taxes	$0.097	$0.097	$0.107

Final Price per Gallon (2010 dollars)	**$3.39**	**$3.36**	**$3.41**
Higher Heating Value (Btus)	84,530	124,230	130,030
Lower Heating Value (Btus)	76,330	115,983	123,670
Price per Gasoline-Equivalent Gallon	**$4.98**	**$3.36**	**$3.26**
Gasoline Price in AEO11	$3.60		
E85 Price per Gallon	$3.43		
E85 Price per gge	**$4.63**		

Note: After rounding, biofuels prices used in the calculation were $3.30 instead of $3.26 per gge, etc.

As Note #2 under Table 1 mentioned, a supporting spreadsheet is also available to further assist in responding to this RFI. It can be found on the same web page from which respondents downloaded this RFI. The spreadsheet includes all the input and key cost calculations that were used to create the mid-range bars (medium-optimism vehicles and fuel prices) in Figure 1, Ownership Costs for Future Mid-Size Car. Two financial analysis approaches were used (one in each worksheet that contains costs-per-mile calculations). Comments on both calculation approaches are welcome. The spreadsheet contains two additional worksheets, a less optimistic vehicle technology scenario combined with higher fuel prices, and a more optimistic vehicle technology scenario combined with lower fuel prices. For these additional worksheets, only one financial approach was used because the other financial approach can be easily applied through changing a few financial parameter inputs.

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