

ACEEE's greenercars.org Life-Cycle Analysis Methodology

Presentation to IEA and the Global Fuel Economy Initiative

Shruti Vaidyanathan, American Council for an Energy-Efficient Economy (ACEEE)

ACEEE's greenercars.org

- Aims to help consumers purchase the greenest vehicle that meets their needs and fits their budget
- “Green Scores” for all vehicles available to subscribers
- “Highlights”, articles, methodology description available to all
- Model Year 2013 was 15th annual release



The screenshot shows the greenercars.org website. At the top left is a logo featuring a green leaf on a car wheel next to the text 'greenercars.org' and 'ACEEE'S GREEN BOOK'. To the right of the logo are three links: 'subscriber login', 'subscribe to greenercars.org', and 'donate to greenercars.org'. Below the logo is a vertical menu with links: 'ACEEE's Green Book®', 'ratings highlights', 'green driving tips', 'guide to green', 'technology', 'news & documents', 'resources', 'about us', 'contact us', and 'ACEEE'. The main content area has a green header that reads '2013 MODEL YEAR RANKINGS RELEASED'. To the right of this header is a large image of a car's dashboard. Below the header are three columns of text. The first column is titled '2013 METHODOLOGY UPDATES' and contains a paragraph about the Green Book methodology. The second column is titled 'LEED CERTIFIED VEHICLES' and contains a paragraph about a downloadable Excel spreadsheet. The third column is titled 'REVISED GREEN SCORES AVAILABLE FOR HYUNDAI AND KIA' and contains a paragraph about a USEPA finding and updates to Green Scores. At the bottom of the page is a green bar with the text 'About Us | Contact Us | ACEEE | copyright 2013 ACEEE'.

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2013 MODEL YEAR RANKINGS RELEASED

2013 METHODOLOGY UPDATES
For a summary of the Green Book methodology and for links to the methodology report and memo, click [here](#).

LEED CERTIFIED VEHICLES
A downloadable Excel spreadsheet of all model year 2000–2013 vehicles that meet the U.S. Green Building Council's LEED criteria can be found [here](#) under "Documents."

REVISED GREEN SCORES AVAILABLE FOR HYUNDAI AND KIA
The USEPA recent found that Hyundai and Kia had overstated the fuel economy for several of their vehicles in model years 2011, 2012, and 2013. For updates to their Green Scores, please click [here](#)

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Greenercars.org Rating System

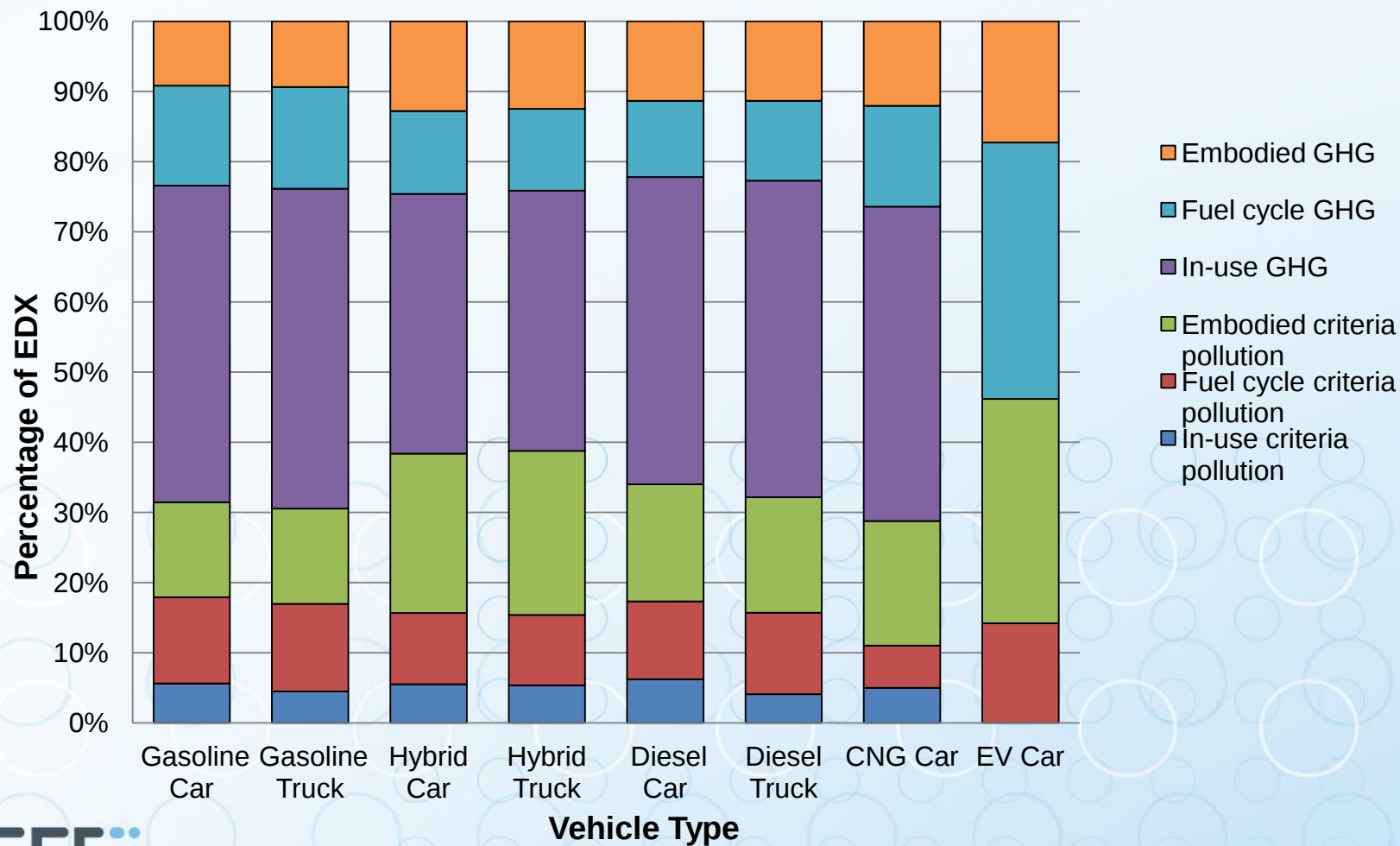
- Lifecycle analysis of each car and light truck in a given model year
- Evaluates:
 - In-use criteria and GHG emissions
 - Fuel-cycle emissions (production and distribution)
 - Vehicle-cycle emissions (manufacturing and disposal/recycling)
- Key inputs:
 - Fuel economy
 - Emission standard
 - Vehicle weight
 - Battery weight
- Model-specific data used (except battery weight) is from the EPA

Impacts Included in Greenercars.org Rating

Table 1. Life Cycle Assessment Matrix for Estimating Motor Vehicle Green Ratings

Environmental Concern	Phase of Product Life Cycle					
	Materials Production	Product Manufacture	Product Distribution	Fuel Upstream	Product Use	End of Life
Air Pollution	C	C		B	B	C
Energy Consumption	C	C		B	A	C
Greenhouse Gas Emissions	C	C		B	A	C
Land Contamination						
Noise						
Water Pollution						
Worker/Community Health						
Other Ecosystem Damage						
Status in the <i>ACEEE's Green Book</i>[®] methodology (blank cells indicate items not included): A—Included explicitly, with good data quality and relatively high accuracy for discriminating among vehicles. B—Included explicitly, but with lower level of data quality and relatively high uncertainties. C—Included only indirectly, with very aggregate or uncertain data.						

Emission Impacts by Phase and Technology for Select 2013 Vehicles



Emission Impacts by Phase and Technology

- US fuel economy and tailpipe emissions standards have become progressively more stringent over time
- Initial set of rankings (1998) assigned a damage cost for CO₂ equivalent GHG emissions by setting total GHG emissions damage cost for the average vehicle equal to total criteria pollutant damage cost for that vehicle
- Led to a damage cost for GHG of \$27 per ton CO₂ equivalent which we have kept constant in real dollars
- Breakdown of GHG vs criteria pollutants for the average vehicle now closer to 2/3 and 1/3
- Breakdown will change again with the new 2017-2025 stds, Tier 3 emission standards – vehicle cycle portion likely to grow

Fuel Consumption

- EPA adopted new methods to estimate fuel economy values for car and light truck labels in 2008 to better reflect varying real world driving conditions
- “Five-cycle” test
- These five-cycle testing results are then used to calculate adjusted (i.e. label) city and highway fuel economy values with 55%/45% weighting of city/highway fuel economy for a combined value
- Greenercars.org adopts EPA’s adjusted city and highway results from the 5-cycle testing but uses a weighting of 43%/57% to create a combined weighting

Treatment of Plug-in Electric Vehicles

In-use Emissions

- Pure EVs – zero in-use emissions
- PHEVs - emissions rates for PHEVs rely on SAE “multi-day individual” utility factors (MDIUFs) to determine the percentage of miles driven on gasoline vs. electricity

Manufacturing or “Vehicle-Cycle” emissions

- Vehicle-cycle emissions are calculated based on vehicle weight and battery weight
- Emissions per pound of vehicle and per pound of battery are derived from the GREET 2 model

Treatment of Plug-in Electric Vehicles

Upstream Emissions

- Pure EVs
 - Emission calculated as the product of vehicle's average kWh per mile and grams per kWh emissions factors from power generation, transmission and distribution (includes feedstock-related emissions)
 - Emissions profile of power generation is evaluated over the lifetime of the electric vehicle to take into account changing grid mix
 - Does not reflect regional variations in grid mix (based on AEO)
 - Varies from EPA's treatment of EVs as zero-emission vehicles for labeling purposes
- PHEVs
 - Impacts of gasoline use AND electricity use are factored into the EDX for plug-in vehicles
 - Utility factor used to determine percentage of miles driven on gasoline vs electricity

Environmental Damage Index and Green Scores

Environmental Damage Index (EDX)

- Emissions impacts at each vehicle stage are multiplied by a **damage cost** and then summed to derive an EDX for each vehicle in cents per vehicle mile
- Represents the lifetime average external cost per mile for criteria pollutants (human health impacts)

Green Score

- Derived from a given vehicle's EDX
- Yields score from 0-100
- Transformation changes to reflect methodology updates: Green Scores are comparable across years
- Best vehicle in 2013 scored a 58

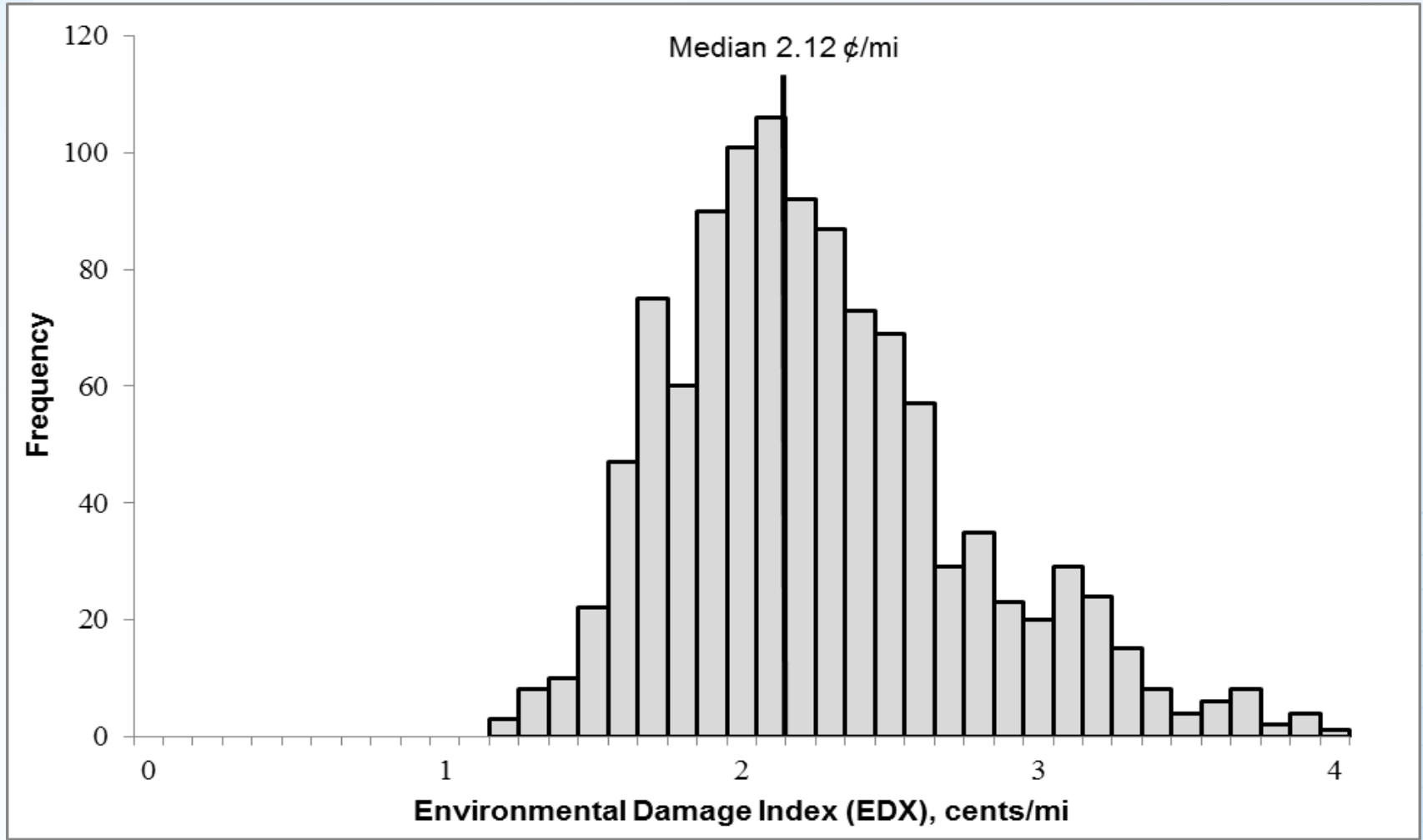
Damage Costs for Principal Pollutants

Pollutant	Marginal Cost by Location of Emissions (2004\$/kg)		
	Motor Vehicles ^a	Refineries and Factories ^b	Electric Power Plants ^c
CO	0.04	0.008	0.004
HC or VOC	0.47	0.094	0.047
NO _x	6.24	1.25	0.62
SO ₂	29.42	5.88	2.94
PM ₁₀	50.09	10.02	5.01

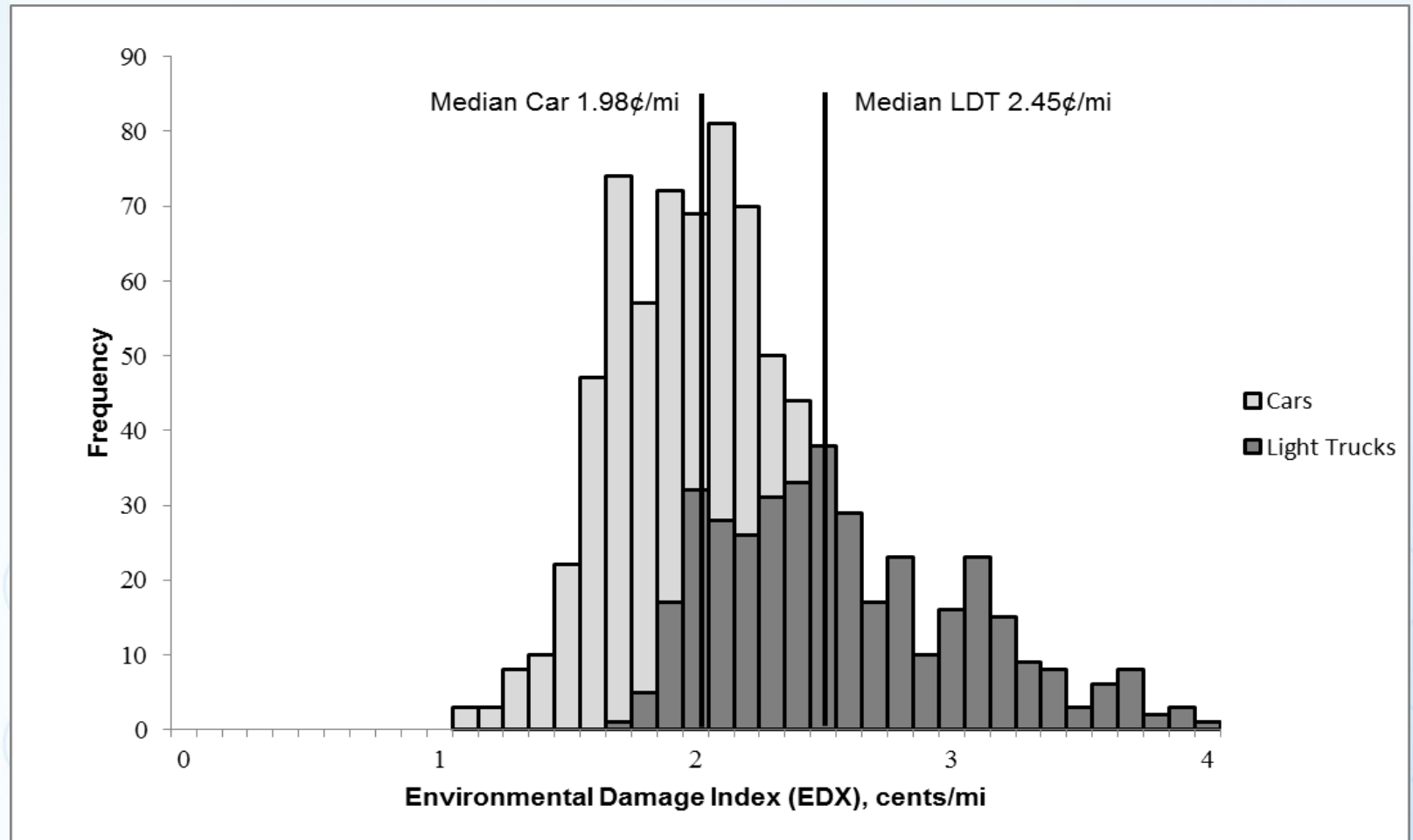
Notes:

- a. Geometric mean of low and high health cost estimates from Delucchi (2004), Table 1-A1.
- b. Values for motor vehicles (a) reduced by a factor of 5.
- c. Values for motor vehicles (a) reduced by a factor of 10.

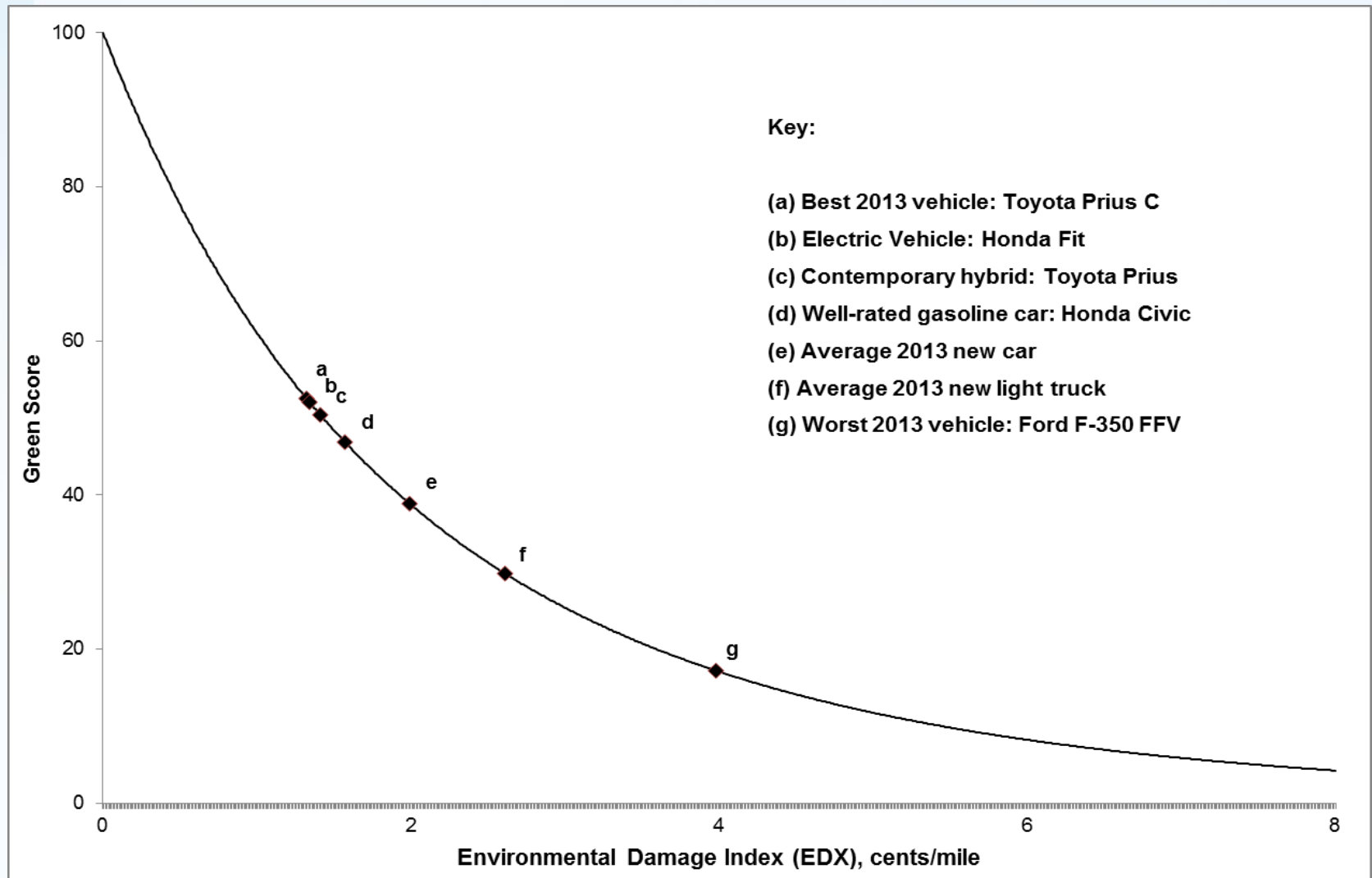
Distribution of 2013 EDX



Distribution of 2013 EDX – Cars vs. Trucks



Conversion of EDX to Green Score



Sample Green Scores

	Specs	Total EDX	In-Use Criteria EDX	Upstream Criteria EDX	Embodied Criteria EDX	In-Use GHG EDX	Upstream GHG EDX	Embodied GHG	Green Score
Toyota Prius	1.8L 4, auto	1.22	0.079	0.069	0.32	0.47	0.11	0.18	55
Chevrolet Volt	Electric (Li-ion bat.) / 1.4L 4, auto [P]	1.45	0.033	0.20	0.38	0.23	0.40	0.22	49
Ford F-150	3.5L 6, auto	2.52	0.149	0.18	0.42	1.23	0.28	0.28	31

Greenest Vehicles of 2013

Make and Model	Specifications	Emission Standard ^a	MPG: City	MPG: Hwy	Green Score
TOYOTA PRIUS C	1.5L 4, auto	SULEV II / Bin 3	53	46	58
HONDA FIT ^b	Electric (Li-ion battery)	ZEV	3.9	3.1	57
TOYOTA PRIUS	1.8L 4, auto	PZEV / Bin 3	51	48	55
TOYOTA PRIUS PLUG-IN HYBRID ^c	Electric (Li-ion bat.) / 1.8L 4, auto CVT	PZEV / Bin 3	3.9 / 51	3.0 / 49	55
HONDA CIVIC HYBRID	1.5L 4, auto	PZEV / Bin 2	44	44	55
HONDA INSIGHT	1.3L 4, auto	Bin 3	41	44	54
VOLKSWAGEN JETTA HYBRID	1.4L 4, auto	PZEV / Bin 3	42	48	53
MERCEDES-BENZ SMART FORTWO CONVERTIBLE / COUPE	1.0L 3, manual [P]	ULEV II / Bin 5	34	38	53
SCION IQ	1.3L 4, auto	ULEV II / Bin 5	36	37	53
FORD FOCUS ^b	Electric (Li-ion bat.)	ZEV / Bin 1	3.3	2.9	52
TOYOTA PRIUS V	1.8L 4, auto	SULEV II / Bin 3	44	40	52
FORD FUSION HYBRID / C-MAX HYBRID	2.0L 4, auto	Bin 3	47	47	51

[P] denotes premium gasoline.

"auto CVT" denotes continuously variable automatic transmission.

^a A listing with two emission standards (e.g., Tier 2 bin 2/ PZEV) denotes a single vehicle carrying both a Federal and a California emission certification. Green Scores for such listings reflect the cleaner of the two certifications.

^b Fuel economy for electric vehicles is provided in miles per kilowatt-hour.

^c Fuel economy for plug-in hybrids is provided in miles per gallon for gasoline operation and in miles per kilowatt-hour for electric operation

Worst Vehicles of 2013

Make and Model	Specifications	Emission Standard ^a	MPG: City	MPG: Hwy	Green Score
FORD F-350 FFV ^b	6.2L 8, auto stk 4wd	Bin 8	11	16	17
FORD F-250 FFV ^c	6.2L 8, auto stk 4wd	Bin 8	11	16	17
FORD E-350 WAGON ^d	6.8L 10, auto	Bin 8	10	13	17
CHEVROLET G2500 EXPRESS (CARGO CONVERSION / GMC G2500 SAVANA (CARGO CONVERSION) (MDPV) ^e	6.0L 8, auto	Bin 8	10	15	18
CHEVROLET SUBURBAN K2500 / GMC K2500 YUKON XL ^f	6.0L 8, auto 4wd	Bin 5	10	15	19
BUGATT VEYRON	8.0L 16, manual Awd [P]	Bin 5 / LEV II	8	15	19
FORD E-150 WAGON FFV	5.4L 8, auto	Bin 8	12	16	21
MERCEDES-BENZ G63 AMG	5.5L 8, auto 4wd [P]	ULEV II / Bin 5	12	14	21
BENTLEY MULSANNE	6.8L 8, auto stk [P]	Bin 5 / LEV II	11	18	21
MERCEDES-BENZ G550	5.5L 8, auto 4wd [P]	ULEV II / Bin 5	12	15	22
FORD F-150 RAPTOR	6.2L 8, auto stk	Bin 4	11	16	22
FORD E-250 VAN FFV	5.4L 8, auto	Bin 8	12	16	22

[P] denotes premium gasoline.

"auto stk" denotes manually adjustable automatic transmission.

^a A listing with two emission standards (e.g., Tier 2 bin 5 / LEV II) denotes a single vehicle carrying both a federal and a California emission certification. Green Scores for such listings reflect the cleaner of the two certifications.

^b The 2wd version of this vehicle scores a 19

^c The 2wd version of this vehicle scores a 19

^d The E-250 Van earns a score of 18.

^e The passenger version of these vehicles score a 19

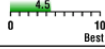
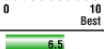
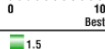
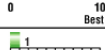
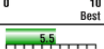
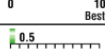
^f The 2wd version of these vehicles score a 20

Australia's Green Vehicle Guide (GVG)

- www.greenvehicleguide.gov.au
- The GVG provides an overall rating for all new light vehicles sold in Australia based on their combined greenhouse rating and air pollution rating for in-use vehicle emissions.

Greenhouse Rating

- All new vehicle models up to 3.5 tonnes gross vehicle mass sold in Australia are tested to determine both fuel consumption and the level of CO₂ emissions emitted. The combined CO₂ emissions value is used to derive the Greenhouse Rating of a vehicle (out of 10)

Greenhouse Rating	CO ₂ Emissions (combined g/km)	Greenhouse Rating	CO ₂ Emissions (combined g/km)
	<= 60		241 - 260
	61 - 80		261 - 280
	81 - 100		281 - 300
	101 - 120		301 - 320
	121 - 140		321 - 340
	141 - 160		341 - 360
	161 - 180		361 - 380
	181 - 200		381 - 400
	201 - 220		401 - 420
	221 - 240		421 - 440
			>440

Australia's Green Vehicle Guide (GVG)

Air pollution Rating

- Based on the air pollution emissions standard to which the vehicle is certified for sale in Australia
- Vehicles fuelled by petrol, LPG or NG are required to meet limits for the emission of carbon monoxide (CO), hydrocarbons (HC) and oxides of nitrogen (NO_x). In addition to these pollutants, diesel vehicles must also meet a limit for the emission of particulate matter (PM)

Star Rating

- Combined score of greenhouse rating and air pollution rating
- GHGs and criteria pollutants are weighted equally
- Translated into star rating

Overall Rating	Combined Air Pollution & Greenhouse Score
★★★★★	combined score ≥ 16
★★★★☆	$15 \leq$ combined score < 16
★★★★	$14 \leq$ combined score < 15
★★★☆☆	$11.5 \leq$ combined score < 14
★★★	$9.5 \leq$ combined score < 11.5
★★☆	$8 \leq$ combined score < 9.5
★★	$6.5 \leq$ combined score < 8
★☆	$5 \leq$ combined score < 6.5
★	combined score < 5

Australia's Green Vehicle Guide (GVG)

- Note that pure electric vehicles are treated as zero-emission vehicles
- PHEVs are rated according to their CO₂ emissions results for the Greenhouse Rating, and the ADR (Euro) standard to which they are certified for the air pollution rating.
- The GVG offers a separate evaluation of emissions from the production of various transportation fuels

Questions?

svaidyanathan@aceee.org