Octane's Potential Role In Raising CAFÉ Standards

EIA Energy Conference
June 26-27, 2017
Washington Hilton – Washington, DC

Max Pyziur
Energy Policy Research Foundation, Inc.
Washington, DC 20007

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Presentation Outline

- Recent Events - CAFE (Corporate Average Fuel Economy) Standards
- CAFE Standards, Inception to the Present
- History of Automotive Technology: [Displacement, Horsepower, Compression Ratio] vs. AKI Octane
- History of Automotive Technology: Fuel Delivery, Engine Size, Incremental Improvements, Computerization
- A Case Study: Bullitt's Ford Mustang - 1968, 1978, 2017
- A Convergence of themes: Octane & CAFE at the crossroads: more refinery-sourced octane? more fuel ethanol? more [P/H]EVs in order to comply with CAFE?

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Recent Dates - 1 - CAFE Standards

- **On July 19, 2016 EPA, NHTSA, and CARB jointly released the draft Technical Assessment Review (TAR), one month late, with a six-month comment period. It formed the basis for the determination of GHG and CAFÉ Standards for Model Years (MY) 2022-2025.**
- **On November 30, 2016, one month ahead of deadline, EPA issues its Proposed Determination deeming that the GHG portion of the CAFE standards as proposed in July 2016 remain appropriate, and that a rulemaking to change them is not warranted.**
- **On January 12, 2017, EPA issued its Final Determination to maintain the GHG portion of the CAFE Standards.**

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Recent Dates - 2 – Why Is This Controversial?

- **The original <u>Proposed Determination</u> date was set for the middle of 2017, not November 2016.**
- **The original <u>Final Determination</u> date was set for April 2018, giving automobile manufacturers the necessary time to fully review assessments well in advance of planning and manufacturing for Model Year 2022 to 2025.**
- **Only EPA, participated in the January 2017 <u>Final Determination</u>; NHTSA and CARB did not.**
- **So …**
- **On March 15, 2017, EPA and NHTSA jointly announced that EPA intends to reconsider its January 2017 <u>Final Determination.</u>**

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A.G. SCHNEIDERMAN – LEADING COALITION OF 13 AGS – PROMISES LEGAL FIGHT IF TRUMP ADMINISTRATION MOVES TO ROLL BACK KEY VEHICLE EMISSION STANDARDS

Air Pollution Standards Targeted By Trump EPA Would Slash Carbon Emissions By The Equivalent Of 422 Million Cars, While Improving Fuel Economy – Resulting In $1,650 Net Savings For Each Consumer

Coalition Warns EPA Administrator Pruitt To Expect "Vigorous" Legal Challenge If Agency Seeks To Weaken Pollution Standards For Cars And Light Duty Trucks

AG Schneiderman: We Stand Ready To Aggressively Challenge President Trump's Dangerous Anti-Environmental Agenda In Court

NEW YORK – New York Attorney General Eric T. Schneiderman, leading a coalition of 13 Attorneys General and the PA Department of Environmental Protection, today warned the Trump Administration that any effort to roll back key vehicle emission standards would be met by a "vigorous" court challenge. In a letter to Environmental Protection Agency (EPA) Administrator Scott Pruitt, the coalition makes clear that it will take legal action if the EPA attempts to weaken air pollution standards set for passenger cars and light-duty trucks for model years 2022 to 2025.

"Reducing pollution from cars and trucks is vital to New Yorkers' and all Americans' health and environment, as we protect the clean air we've worked so hard to achieve and fight climate change," **New York Attorney General Eric Schneiderman** said. "Any effort to roll back these affordable, achievable, and common-sense vehicle emission standards would be both irrational and irresponsible. We stand ready to vigorously and aggressively challenge President Trump's dangerous anti-environmental agenda in court – as we already have successfully done."

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CAFE Standards, History to the Present - 1

- **CAFE in its original form …**
  - **Introduced through the 1975 Energy Protection and Conservation Act (EPCA);**
  - **In reaction to the 1973 Arab Oil Embargo that cut supplies and raised prices;**
  - **Sought to reduce fuel consumption through the regulation of fuel-efficiency motor vehicle standards rather than a consumption tax;**
  - **Administered by the National Highway Traffic Safety Administration (NHTSA) (one agency, not three).**

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CAFE Standards, History to the Present - 2

- **In September 2004, CARB (California Air Resources Board) formulated GHG standards for motor vehicles to begin in MY 2009.**
- **On April 2, 2007, U.S. Supreme Court decided Mass. vs EPA; this ruling effectively required EPA to regulate CO2.**
- **On May 19, 2009, the CAFÉ "One National Program" was established setting both fuel-efficiency and GHG standards administered together by NHTSA, EPA, and CARB.**
  - **Phase 1 for Model Years 2012 to 2016**
  - **Phase 2 for Model Years 2017 to 2025**
  - **Phase 2 required the TAR in June 2016 and Final Determination in April 2018 for MY 2022 to 2025 for reassessment.**

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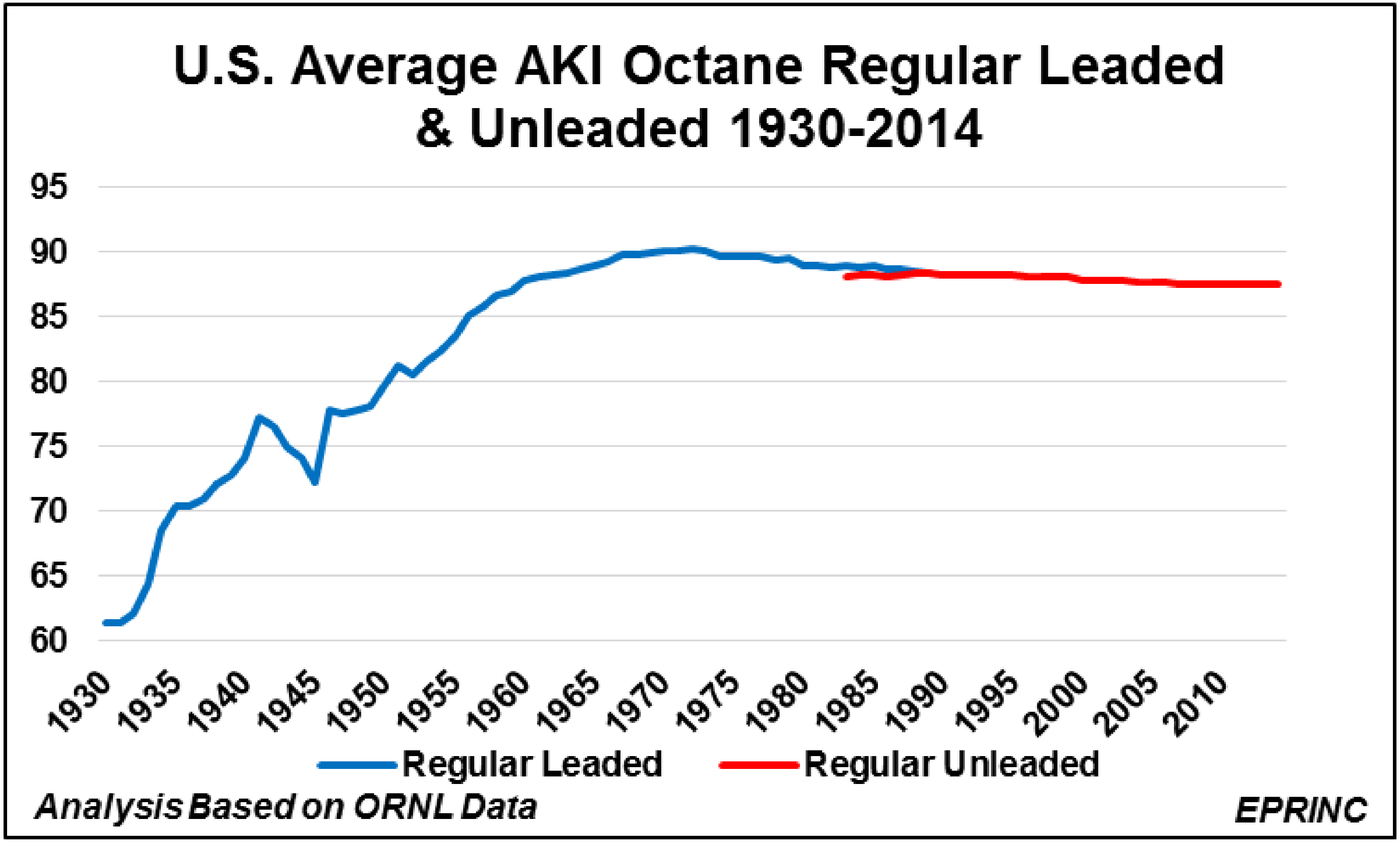

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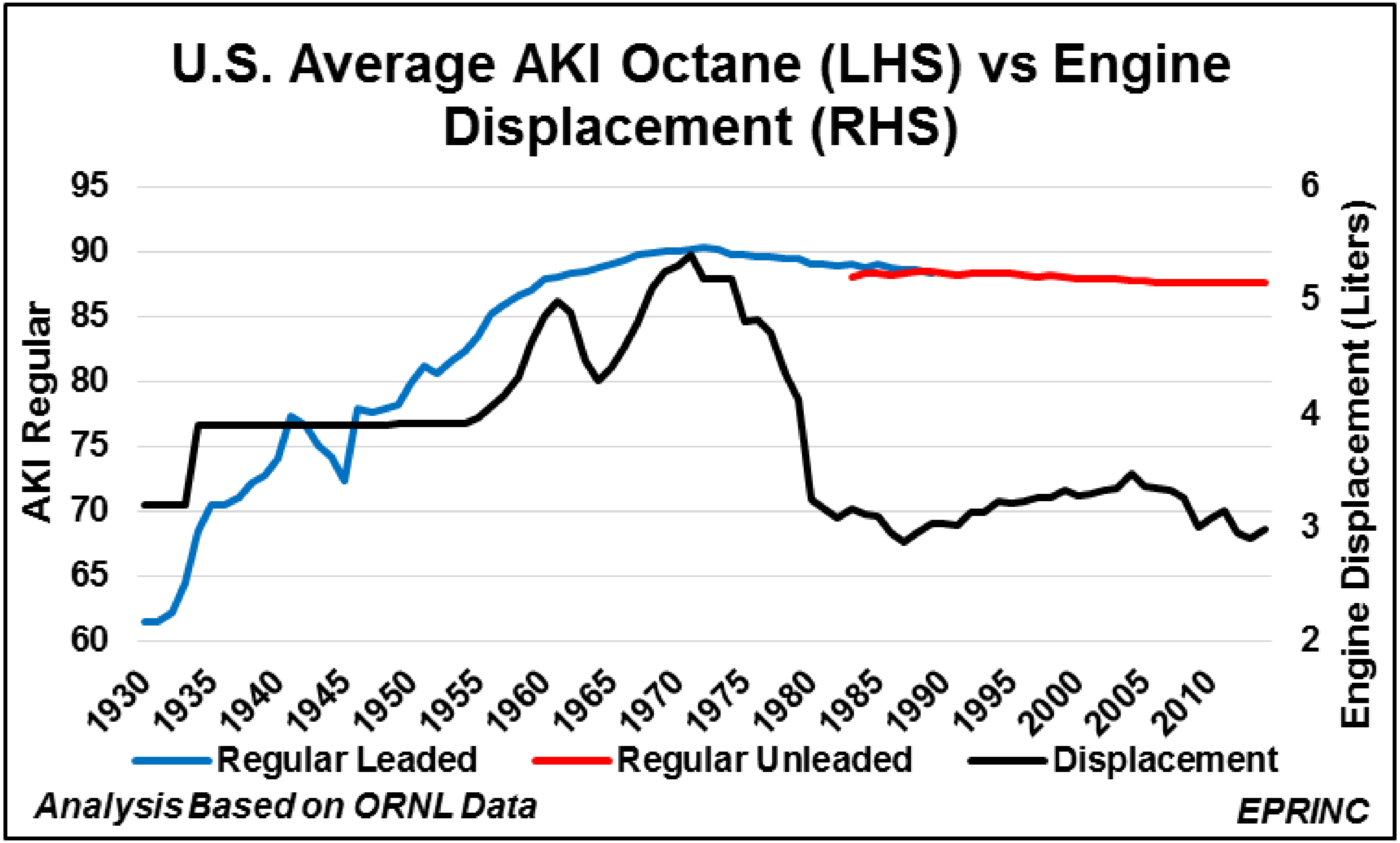

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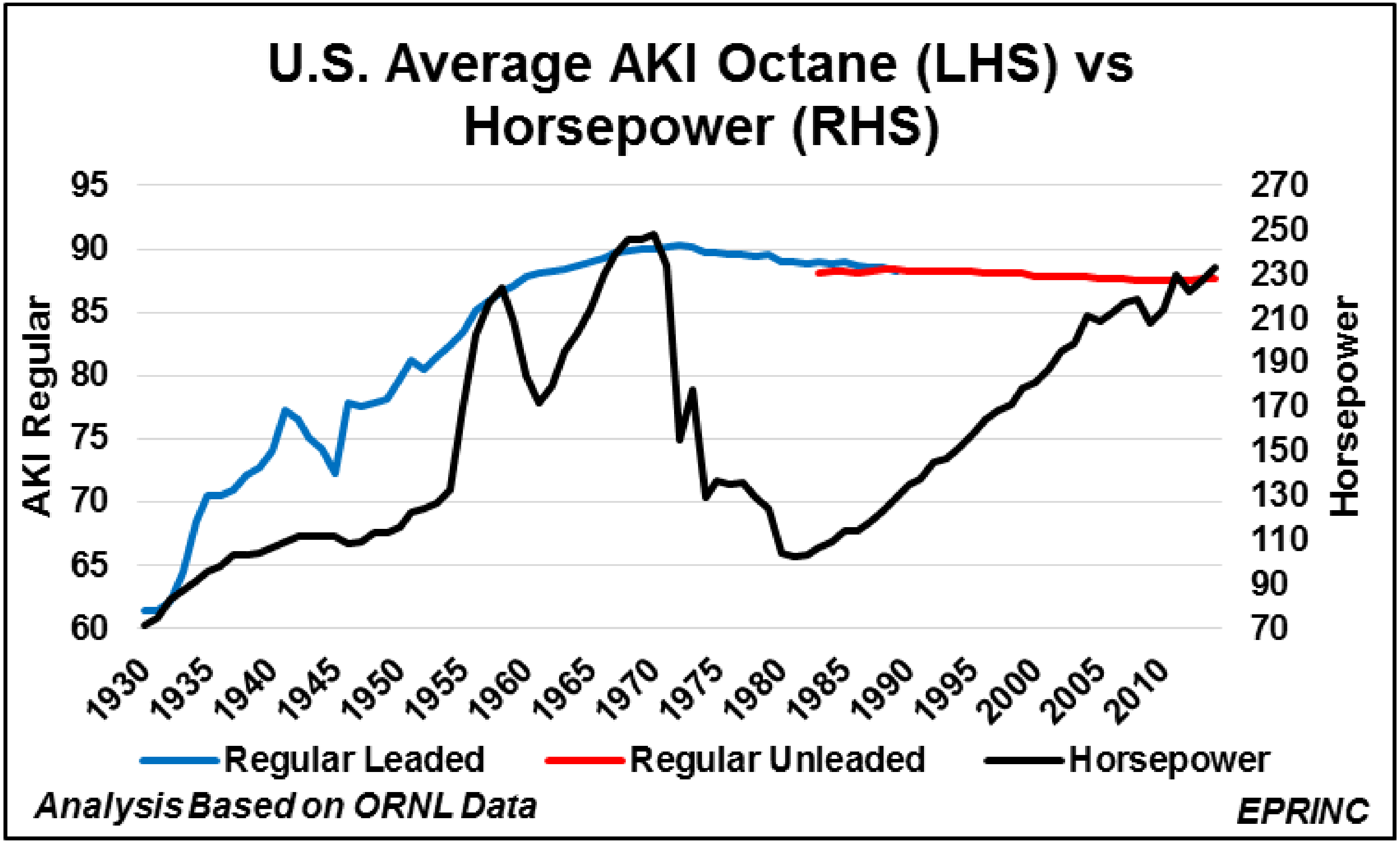

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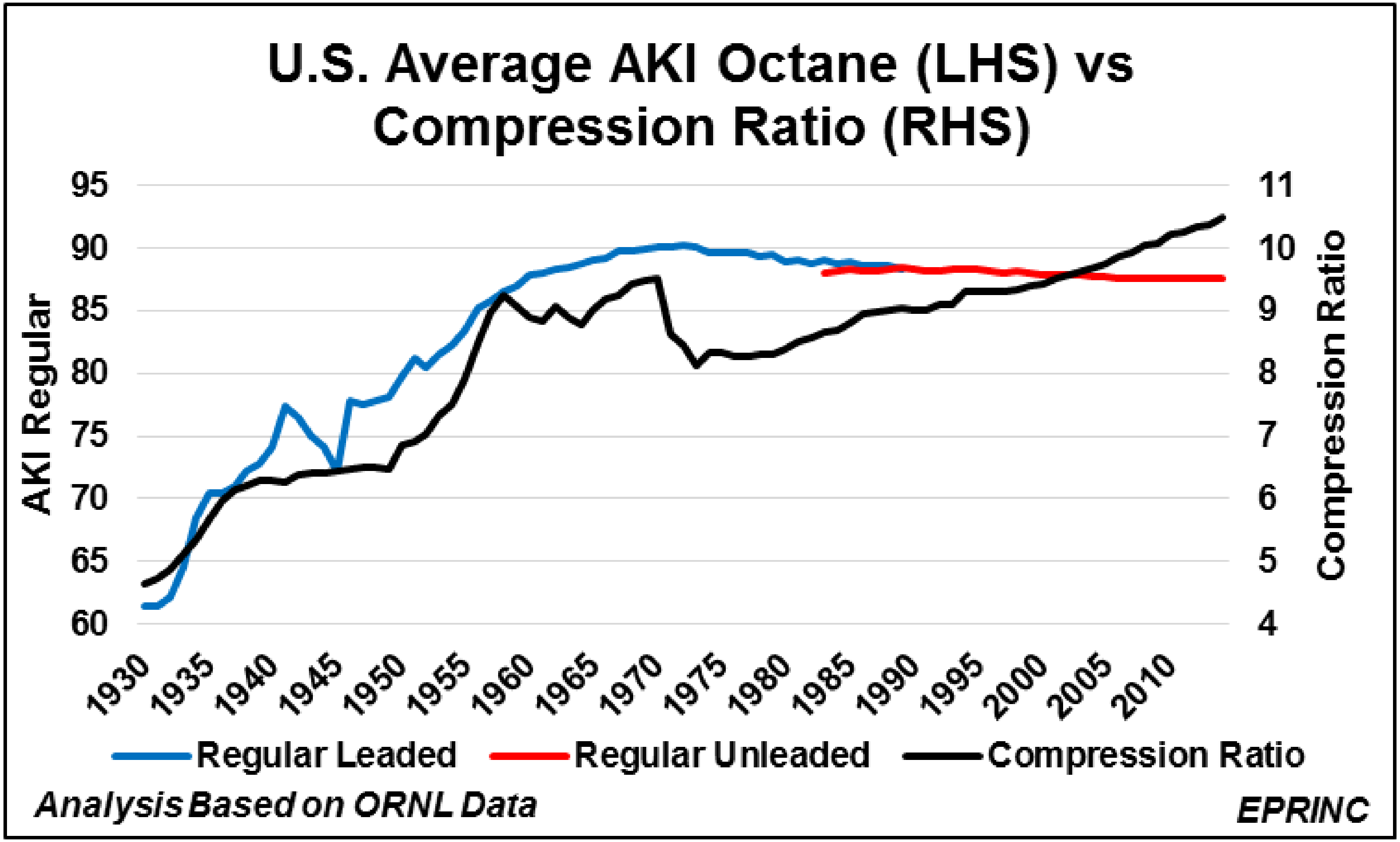

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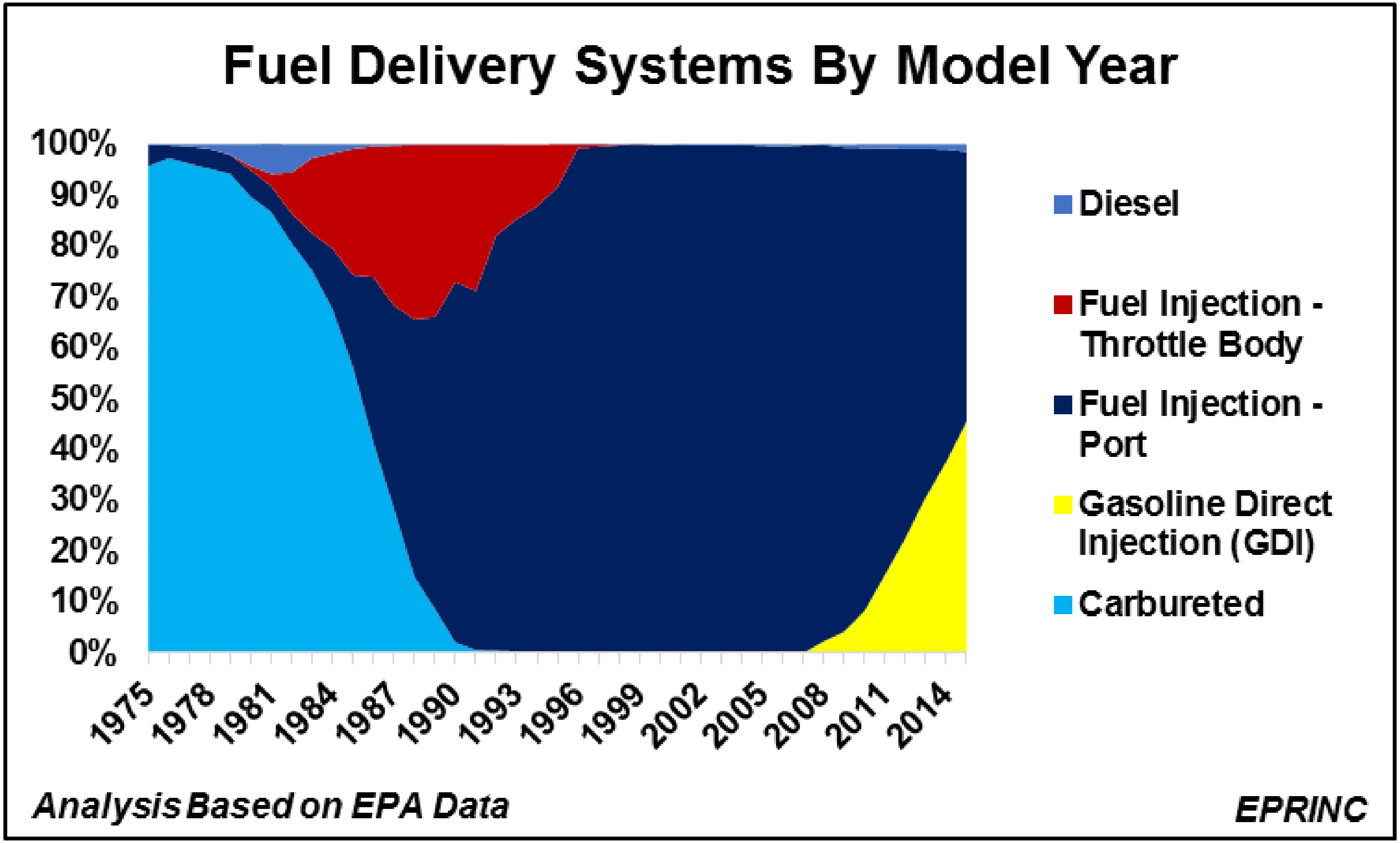

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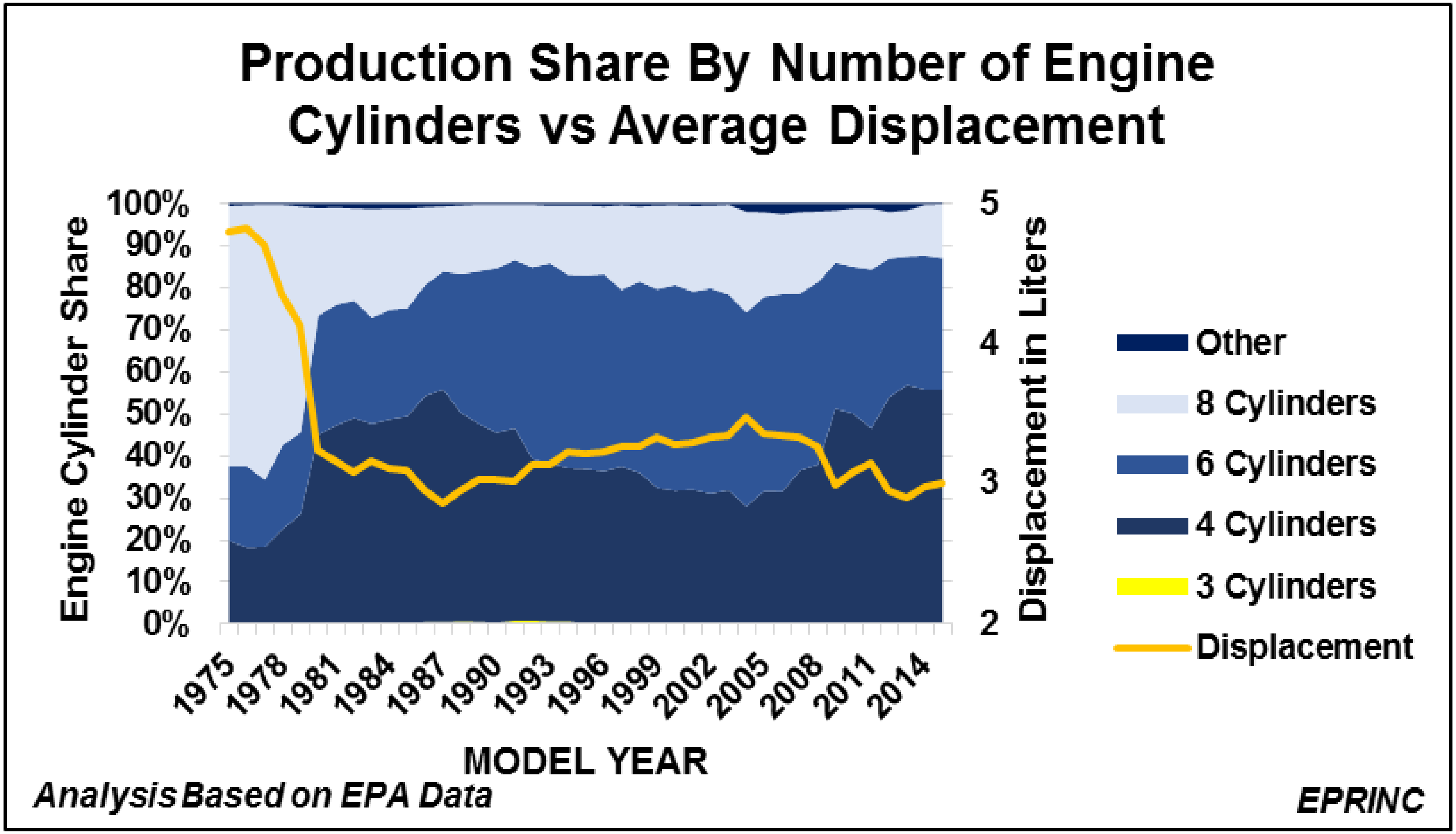

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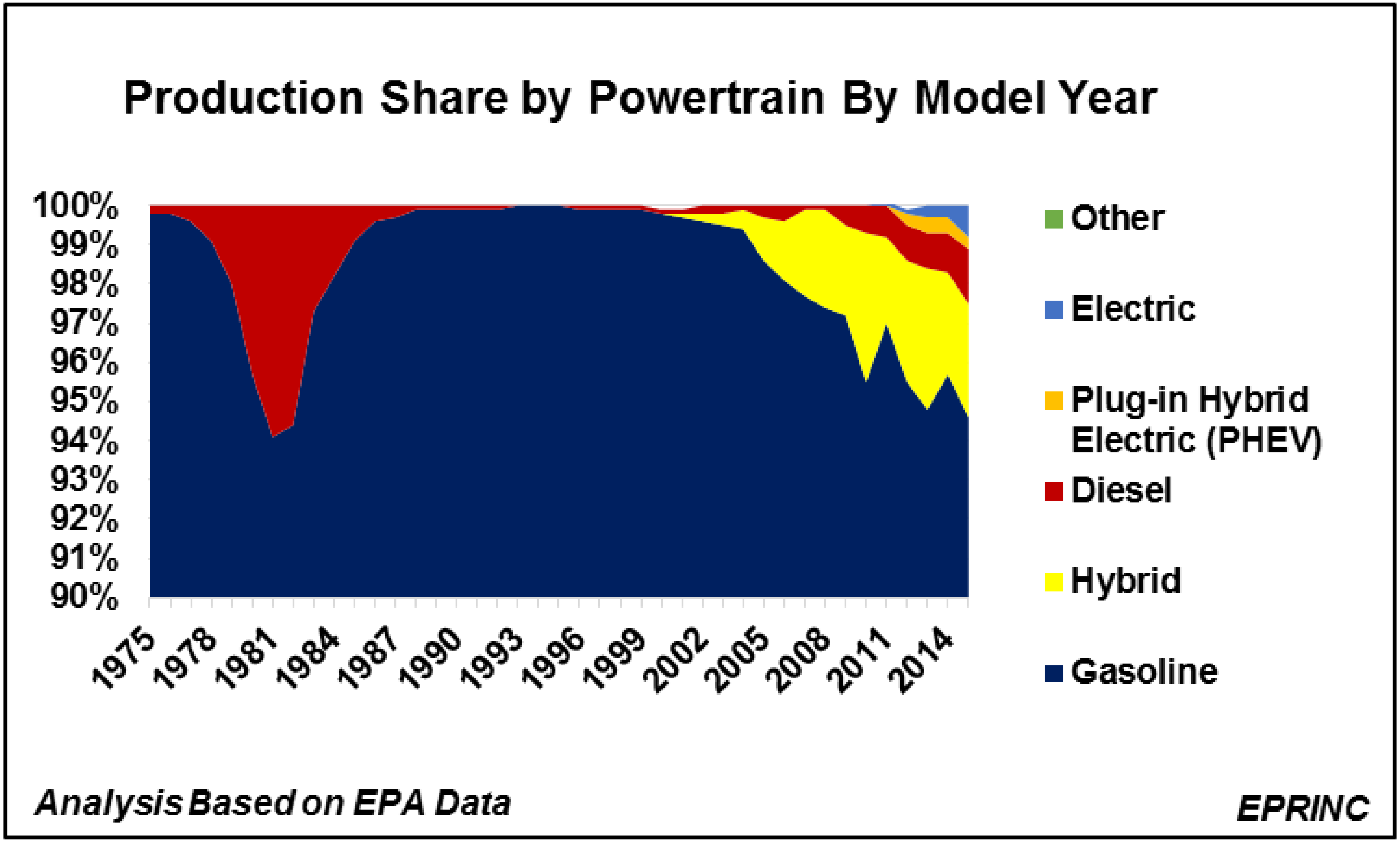

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Engine Technologies Compliance Costs For Fuel Economy, Horsepower Increase, GHG Mitigation	
Low-friction lubricants & Engine Friction Reduction	$0 - $168
Valve & Cylinder	
Variable Valve Timing (VVT)	$60 - $210
Cylinder Deactivation	$200 - $210
Variable Valve Lift & Timing (VVLT)	$245 - $1260
Fuel Delivery	
Gasoline Direct Injection (GDI)	$120 - $750
Optimised for E20-E30	$145 - $750
TurboCharge+Downsize	$720 - $750
Transmission	
Increase in gearing	$40 - $150
Hybrid & Electric Technologies	
Power-Split Hybrid (like Prius)	$3,754
Plug-in Hybrid	$4500 - $6750
Full electric vehicle	$12,000 - $15,000
Analysis and Estimate based on EPA & NAP Data	*EPRINC*

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Ford Mustang Frank Bullitt's 1968 Mustang vs 1978, 2017 GTs				
	1968	1978	2017	2017
Model	390 V8 GT Fastback	3dr Hatchback	GT	V6
Displacement	6.4L / 390ci	5.0L / 302ci	5.0L / 305ci	3.7L / 225ci
Fuel System	4bbl Carb	2bbl Carb	Fuel Injection	GDI
Compression Ratio	10.5 to 1	8.0 to 1	11.0 to 1	10.5 to 1
Power	325hp	134hp	435	300
Analysis based on Multiple Automotive Sources				***EPRINC***

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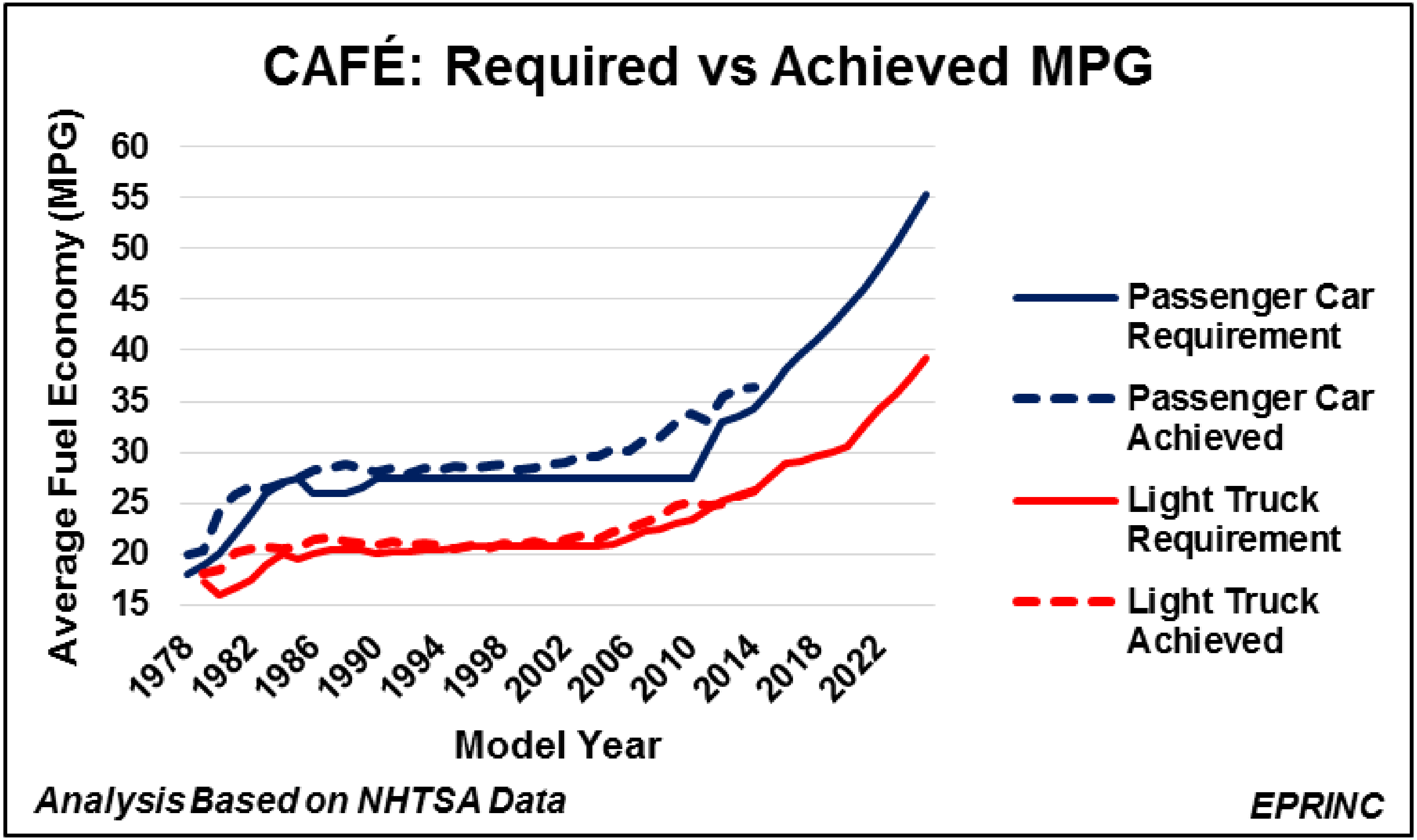

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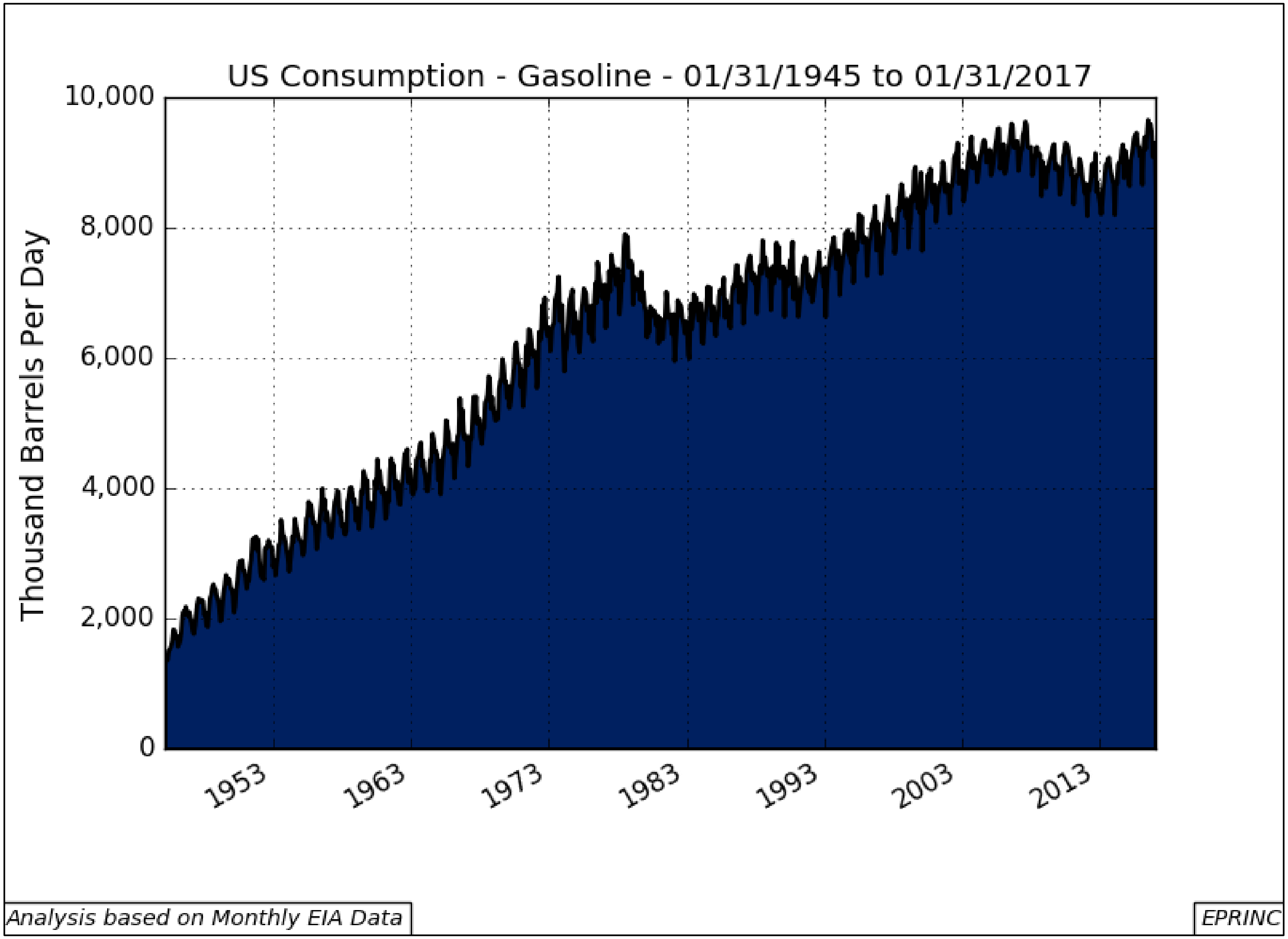

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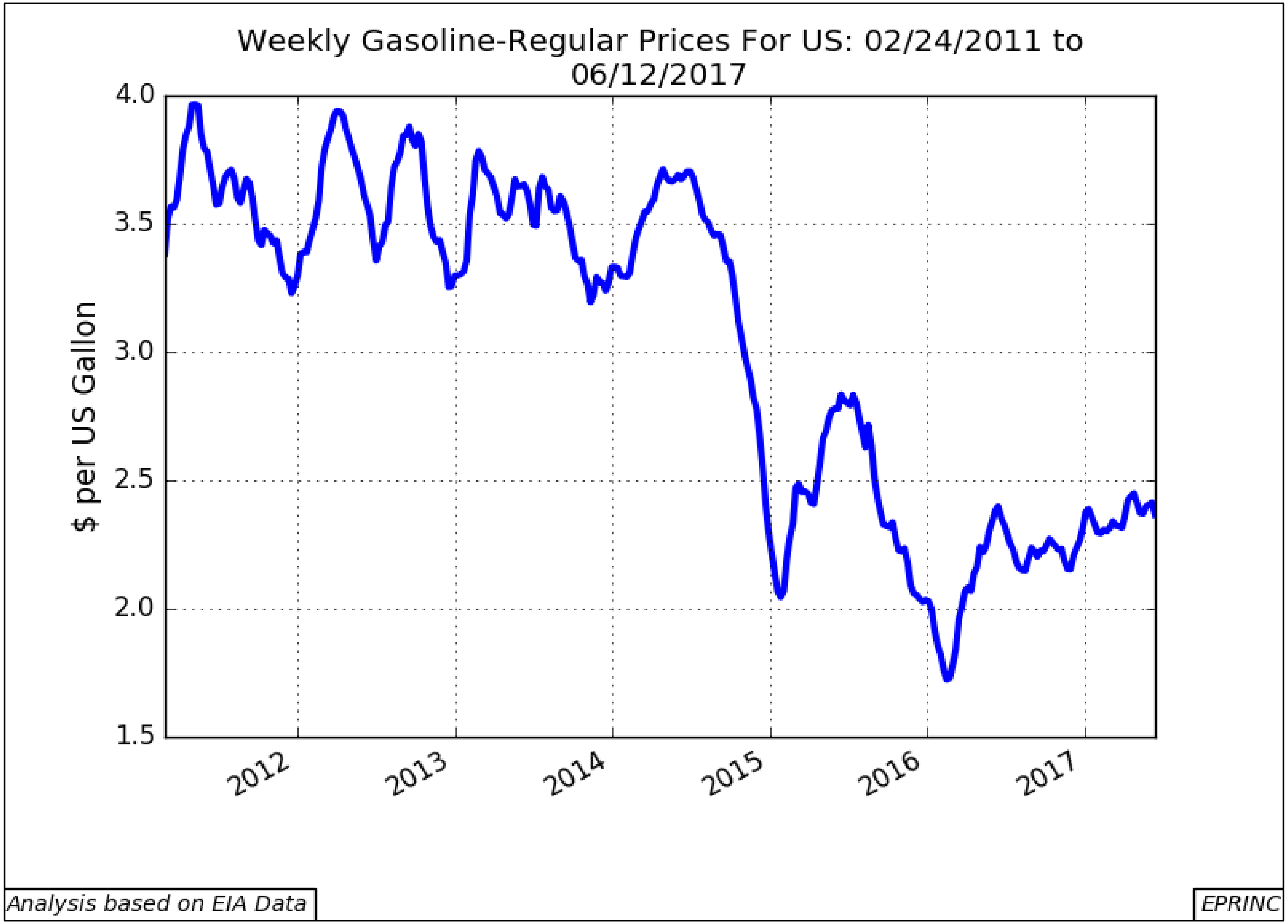

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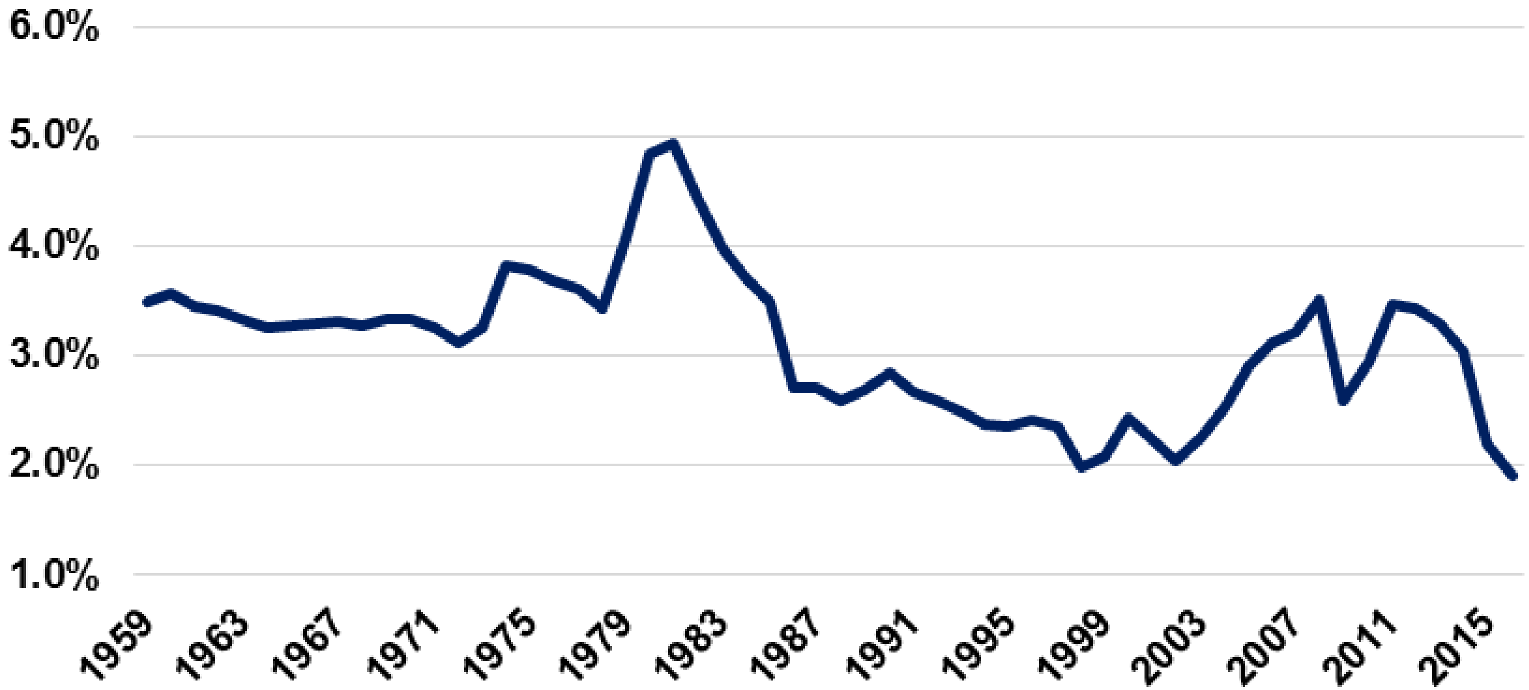
Consumer Expenditures on Motor Fuel As Percentage of Disposable Income



Analysis Based on BEA Data

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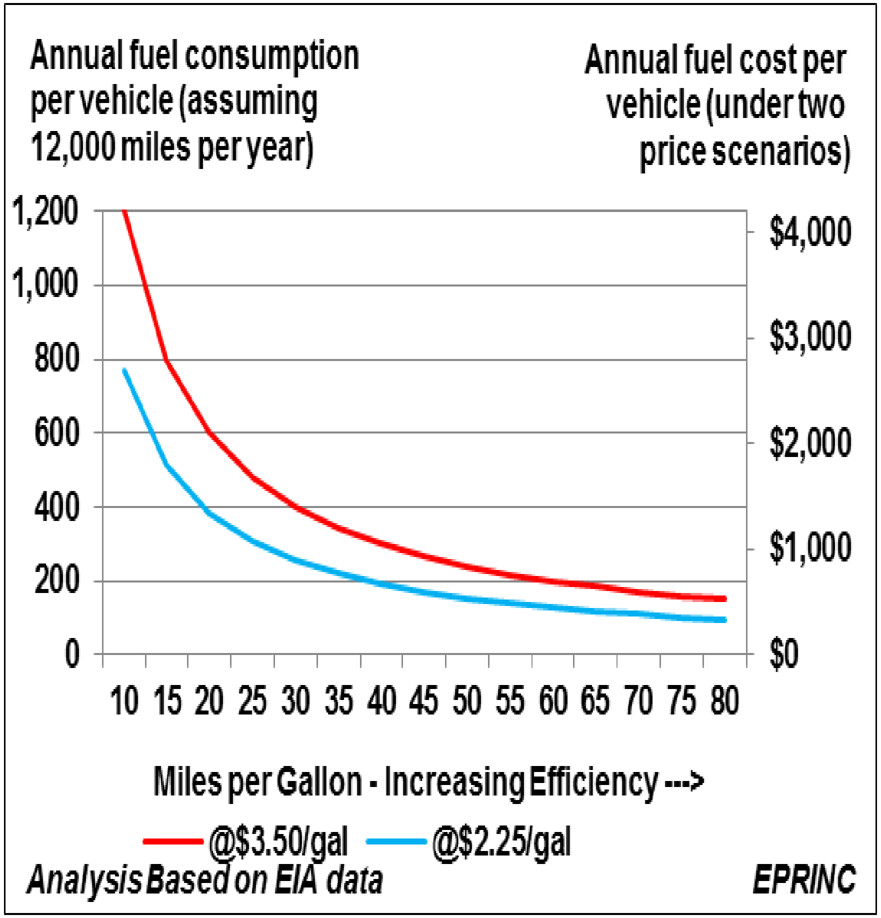

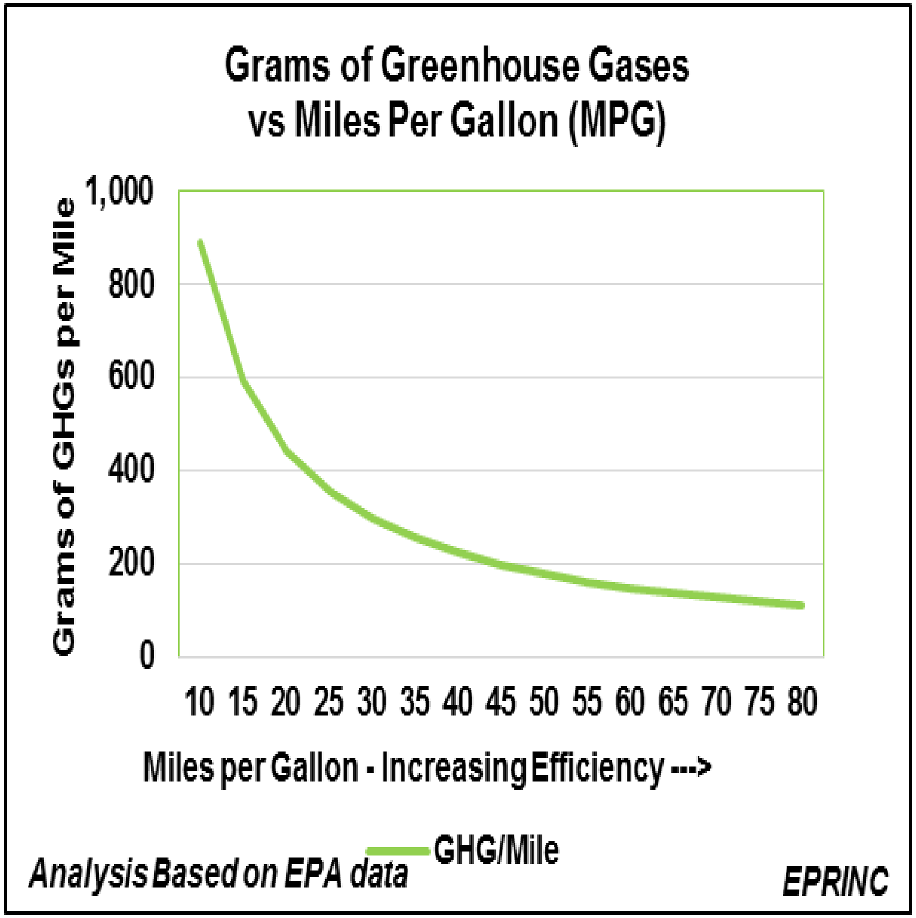

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Paths to CAFE MY 2022-2025 Compliance

- **More Octane**
  - **Refining Processes**
  - **Ethanol**
- **More [P/H] EVs (Electric Vehicles)**

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Paths to CAFE MY 2022-2025 Compliance

- **Refining Processes requiring more Octane-Producing capacity.**
  - **Note Blake Eskew & Tom Kloza's cost & pricing assessments; also IHS OPIS will be having its Octane Summit in the fall.**
- **EPRINC's Estimate on Additional Reforming Capacity (taken from EPRINC's yet-to-be-published Octane Paper):**
- **- $8,250 per barrel capital costs.**
- **- $4.87 per barrel || $0.12 per gallon operating costs.**

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Paths to CAFE MY 2022-2025 Compliance

Corn Ethanol Acreage

	Alcohol for fuel use - MM Bushels	Total US Corn Crop – MM Bushels	Total US Corn Crop – Harvested MM Acres	%tage of bushels for ethanol
2008	3,709	12,043	79	30.8%
2009	4,591	13,067	79	35.1%
2010	5,019	12,425	81	40.4%
2011	5,000	12,314	84	40.6%
2012	4,641	10,755	87	43.2%
2013	5,134	13,829	87	37.1%
2014	5,200	14,216	83	36.6%
2015	5,206	13,601	81	38.3%
2016	5,275	15,057	87	35.0%

Analysis based on USDA Data — *EPRINC*

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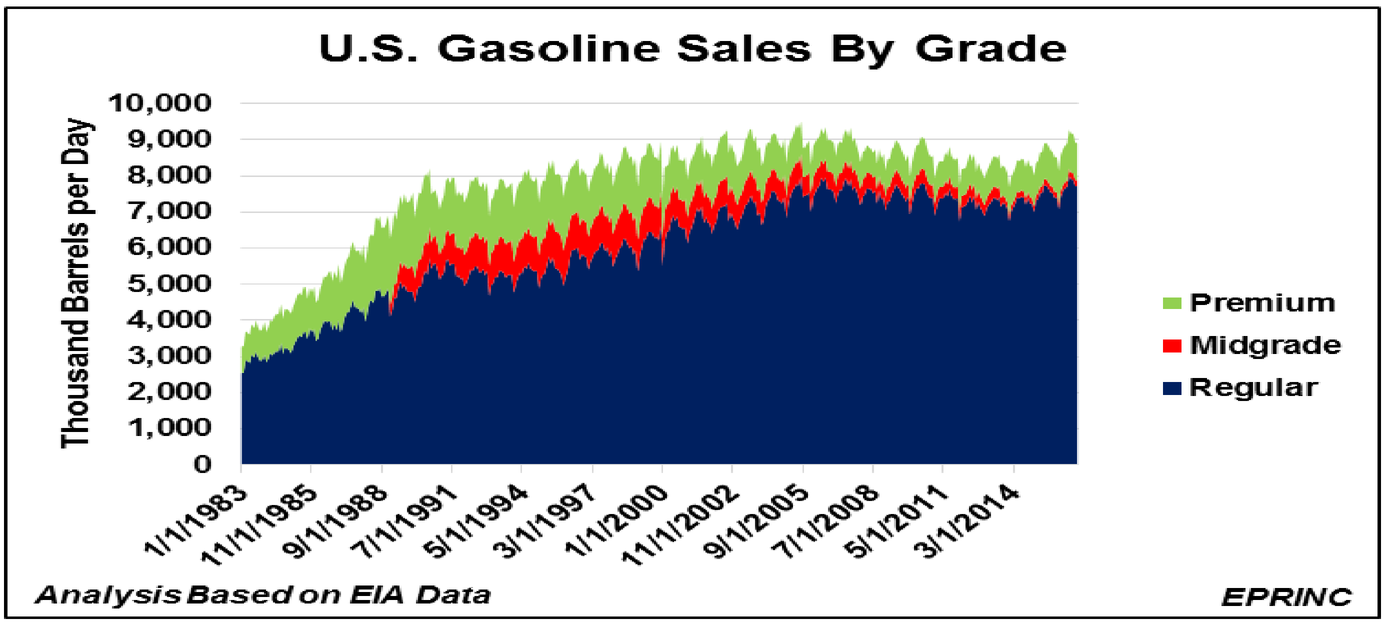
Paths to CAFE MY 2022-2025 Compliance



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Paths to CAFE MY 2022-2025 Compliance

Hypothetical Composition of MY 2025 Fleet		
	Qualifying Vehicles (millions)	**Target MPG**
	17.5	54.5
Non-EVs	16.5	51.7
EVs (Tesla)	1	100.0
Non-EVs	15.5	48.6
EVs (Tesla)	2	100.0
Analysis based on AFDC		***EPRINC***

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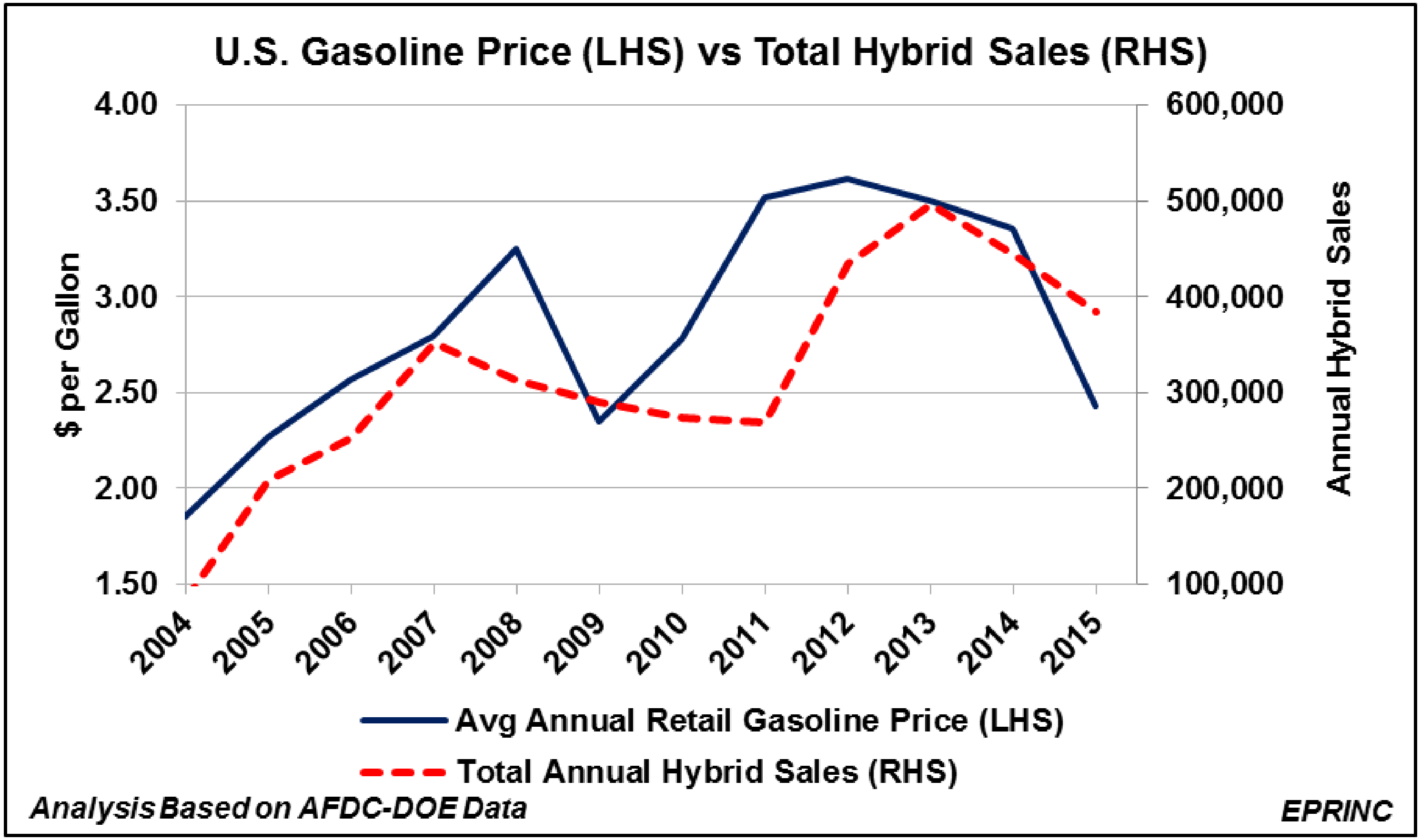
Paths to CAFE MY 2022-2025 Compliance



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Conclusions and Thank you

- Any path towards MY2022-2025 CAFE Compliance presents considerable costs.
- These costs increase in a low-price transportation fuels environment that is set to continue for an extended period of time.
- Higher octane fuels will have higher production costs whether the octane is sourced from either refinery processes or corn ethanol, or both.
- Alternatively, more hybrid/plugIn electric vehicles cost more than equivalent gasoline-powered ones, and multiple automobile production lines balkanize manufacturing.
- Given that justification for the new CAFE standards relies substantially on a calculation of economic benefits to consumers from fuel savings, perhaps the Final Determination should consider some modest adjustment to the program's requirements to reduce costs so that they are closer to benefits.

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Extra Slides After This

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REGULAR
MINIMUM OCTANE RATING
(R + M) / 2 METHOD
87
PRESS
PLUS
MINIMUM OCTANE RATING
(R + M) / 2 METHOD
89
PRESS
PREMIUM
MINIMUM OCTANE RATING
(R + M) / 2 METHOD
93
PRESS
?
SUPER PREMIUM
MINIMUM OCTANE RATING
(R + M) / 2 METHOD
95
PRESS

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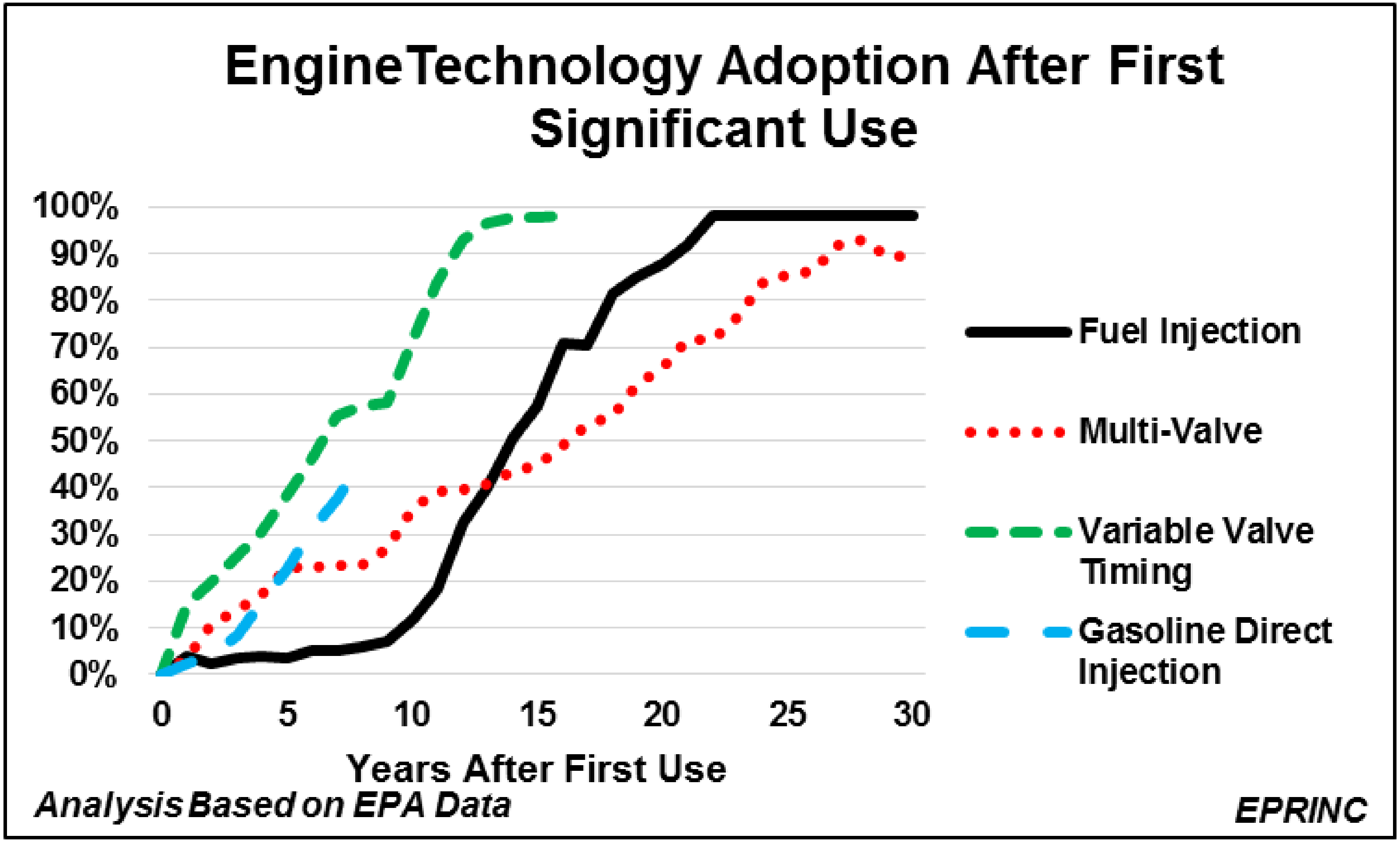

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Primary Gasoline Blendstocks

Source	Blending Component	RON*	MON*	AKI (R+M)/2	RVP, psi	Aromatics, vol%	Benzene, vol%	Sulfur, ppmw	Heating Value, BTU/gal (net)
Refining: Distillation									
	Light St Run Naphtha	63.7	61.2	62.4	10.8	2.2	0.73	325	101,550
Refining: Conversion									
	Full Range Reformate	97.3	86.7	92.0	3.2	61.1	1.17	9	112,879
	Mid Cut Reformate	109.3	100.4	104.9	1.0	94.2	0.00	10	104,145
	Heavy Reformate	104.3	92.4	98.4	0.3	93.8	0.00	8	116,239
	FCC Naphtha	92.6	82.1	87.4	4.6	35.9	1.23	522	111,706
	Light Alkylate	93.2	91.2	92.2	4.6	0.5	0.00	15	106,554
	C6 Isomerate	78.6	80.5	79.5	8.0	1.6	0.00	10	101,639
Oxygenates									
	Ethanol	132.0	106.0	119.0	11.0	0	0	<5	76,330
	MTBE	118.0	101.0	109.5	9.0	0	0	<5	93,540
	ETBE	118.0	102.0	110.0	4.0	0	0	<5	96,720
	TAME	111.0	98.0	104.5	1.5	0	0	<5	100,480
Metallic Additives									
	TEL-Lead	10,000.0	13,000.0	11,500.0	11.0	0	0	<5	N/A

* Octane numbers - RON & MON do not necessarily behave linearly when blended. These values are provided for illustration.

Analysis based on EIA, IEA, U of CO Data — *EPRINC*

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Gasoline Blending With Five Refinery FeedStocks & Ethanol = E20							
Blendstock	Blend vol%	RON*	MON*	AKI (R+M)/2	RVP, PSI	Aromatics, vol%	Heating Value, BTU/gal (net)
Light St Run Naphtha	5%	63.7	61.2	62.4	10.8	2.2	101,550
Full Range Reformate	36%	97.3	86.7	92.0	3.2	61.1	112,879
FCC Naphtha	20%	92.6	82.1	87.4	4.6	35.9	111,706
Light Alkylate	18%	93.2	91.2	92.2	4.6	0.5	106,554
C6 Isomerate	1%	78.6	80.5	79.5	8.0	1.6	101,639
Ethanol	20%	132.0	106.0	119.0	11.0	0.0	76,330
Volume Average Blending	100%	100.8	89.1	95.0	5.7	29.6	103,562

* Octane numbers - RON & MON do not necessarily behave linearly when blended. These values are provided for illustration.

Analysis based on U of CO and Iowa State-CARD Data

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