BRIEFING

AUGUST 2020

Summary of the Trump Administration's fatally flawed U.S. light-duty vehicle efficiency standards

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This briefing reviews the benefit-cost analysis developed by the National Highway Traffic Safety Administration (NHTSA) and the Environmental Protection Agency (EPA) to justify the Trump Administration's April 2020 final rule rolling back the 2021–2026 U.S. light-duty vehicle efficiency standards. It assesses changes in the final 2020 rule[1] as compared to the Trump administration's August 2018 proposed rule, [2] and details of the benefit-cost analysis that remain flawed.[3]

A benefit-cost analysis is required for any significant federal regulation. The agencies' rule, in this instance, would reduce the need to improve vehicle fuel efficiency after 2020. This rule reverses a regulation finalized in 2012 and confirmed in 2017 by the Obama administration (termed "original" standards in this briefing), by the same agencies, with the same expertise, data, research, and tools at their disposal. Justifying the reversal depends on changing dozens of underlying assumptions, data sources, and models to reverse the conclusions of the original benefit-cost analysis.

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[1] For the final rule, see The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, 85 Fed. Reg. 84 (April 30, 2020), https://www.govinfo.gov/content/pkg/FR-2020-04-30/pdf/2020-06967.pdf. For documents related to the impact analysis, see "The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule," National Highway Traffic Safety Administration, https://www.nhtsa.gov/corporate-average-fuel-economy/safe.

[2] For the proposed rule, see The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, 83 Fed. Reg. 165 (August 24, 2018), https://www.govinfo.gov/content/pkg/FR-2018-08-24/pdf/2018-16820.pdf.

[3] For a summary of that initial proposal, see Aaron Isenstadt and Nic Lutsey, *The flawed benefit-cost analysis behind proposed rollback of the U.S. light-duty vehicle efficiency standards* (ICCT: Washington, D.C., 2019), https://theicct.org/publications/cost-analysis-proposed-rollback-US-LDV-standards-201906.

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The United States has two separate but harmonized light-duty vehicle standards that regulate corporate average fuel economy (CAFE), under the purview of NHTSA, and greenhouse gas emissions, under the EPA. To meet their statutory requirements, each agency historically performed its own separate benefit-cost assessment of technology availability, costs, consumer fuel savings, and other factors influencing the effects of the regulation. The EPA uses the Optimization Model for reducing Emissions of Greenhouse gases from Automobiles (OMEGA) for that purpose; NHTSA uses the CAFE Compliance and Effects Modeling System. Until the 2018 rollback proposal the results of both models were made known, and they produced closely aligned results. Because the 2018 and 2020 benefit-cost analyses rely only on the NHTSA CAFE model, it is the focus here.

This briefing first summarizes the new standards and the major changes in the benefit-cost assessment. This is followed by a description of remaining technical flaws in the final rule's assessment and an analysis of the effect of correcting those factors.

THE TRUMP ADMINISTRATION 2020 REGULATION

MAJOR REGULATORY CHANGES

The final regulation is changed in numerous ways from the 2018 proposal. Figure 1 contrasts the overall effects on fuel efficiency, in terms of reduced CO_2 emissions, of the original 2017 standards, which required a 5% per year reduction in CO_2 emissions from 2020 to 2025; the proposed 2018 standards, with effectively no change beyond 2020; and the final 2020 standards, which reduce CO_2 emissions by 1.5% per year from 2020 to 2026. The regulation includes separate standards for passenger cars and light trucks, indexed to vehicle size, that require technical improvements across vehicle types. Figure 1 shows the overall average CO_2 values relative to the model year 2018 average of 252 grams CO_2 per mile (g/mi). The resulting regulatory emission levels reach 175 g/mi by 2025 in the original 2017 standards and 223 g/mi by 2026 in the 2018 proposal. The final standards reach 205 g/mi by 2026.

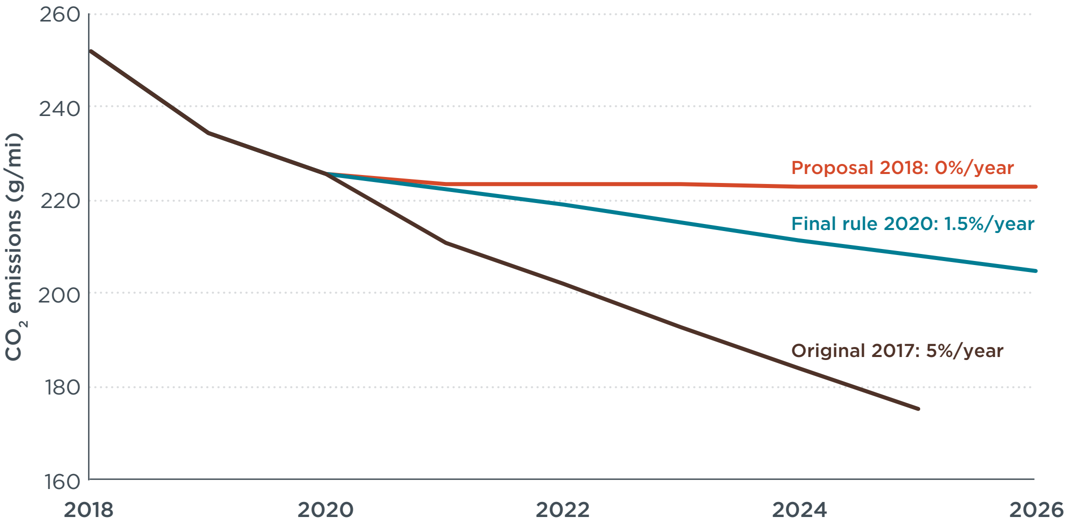

Figure 1. Greenhouse gas emission standard levels from original 2017, proposed 2018, and final 2020 standards.

The rule makes several significant changes to the off-cycle credit provisions. It adds technologies to the menu of those that qualify for off-cycle credits and streamlines the process by which automakers receive credits when they report deploying those technologies. It also extends a 0 g/mi rating for battery electric vehicles through model year 2026, instead of phasing in accounting for upstream emissions from electric power generation, as the original 2017 rule provided. Other provisions eliminate additional regulatory credit for hybrid and over-performing full-size pickup trucks and add a 2.0 multiplier for natural gas vehicles.

EFFECTS ON CONSUMERS

Compared to the original 2017 standards, the 2020 rule will make average fuel economy of passenger cars and light trucks worse. The less stringent targets will reduce manufacturers' need or incentive to deploy efficiency technologies that improve the rated test cycle miles per gallon. Manufacturers' increased ability to rely on off-cycle credits[4] and electric vehicle accounting[5] for compliance will further lower vehicles' consumer label fuel economy.

Figure 2 puts the 2020 rule changes in context for drivers of new vehicles. In the chart, regulatory test-cycle values are converted to EPA consumer fuel economy label values assuming real-world fuel economy (miles per gallon, mpg) 23% lower than test cycle values for combustion vehicles. Compared to the passenger car average fuel economy of 30 mpg in 2018, the original 2017 standards would have delivered 36.4 mpg by model year 2026, the 2018 proposal would have reached 31.1 mpg, and the final rule reaches 31.3 mpg. For light trucks, the 2018 average was 21.4 mpg, the original 2017 standards would have delivered 27.1 mpg by 2026, the 2018 proposal 21.9 mpg, and the final rule 22.9 mpg.

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[4] Off-cycle credits in the final 2020 standards in Figure 2 are counted as 15 grams CO_2 per mile (10 g/mi for cars, 20 g/mi for light trucks). See *Nic Lutsey and Aaron Isenstadt, How Will Off-Cycle Credits Impact U.S. 2025 Efficiency Standards?* (ICCT: Washington D.C., 2018), https://www.theicct.org/publications/US-2025-off-cycle. See also ICCT's supplemental public comments on the NHTSA Proposed Rule: The Safer Affordable Fuel-Efficient Vehicles Rule for Model Years 2021-2026 Passenger Cars and Light Trucks regarding the expanded use of technology credits, June 5, 2019, https://www.regulations.gov/document?D=NHTSA-2018-0067-12414.

[5] Electric vehicles for the original 2017 standards assumes 6% share by 2026 (8% for cars, 4% for light trucks), compared to an increase to half those levels for the 2020 final and 2018 proposal cases. See Nic Lutsey, *Modernizing vehicle regulations for electrification?* (ICCT: Washington, D.C., 2018), https://theicct.org/publications/modernizing-regulations-electrification.

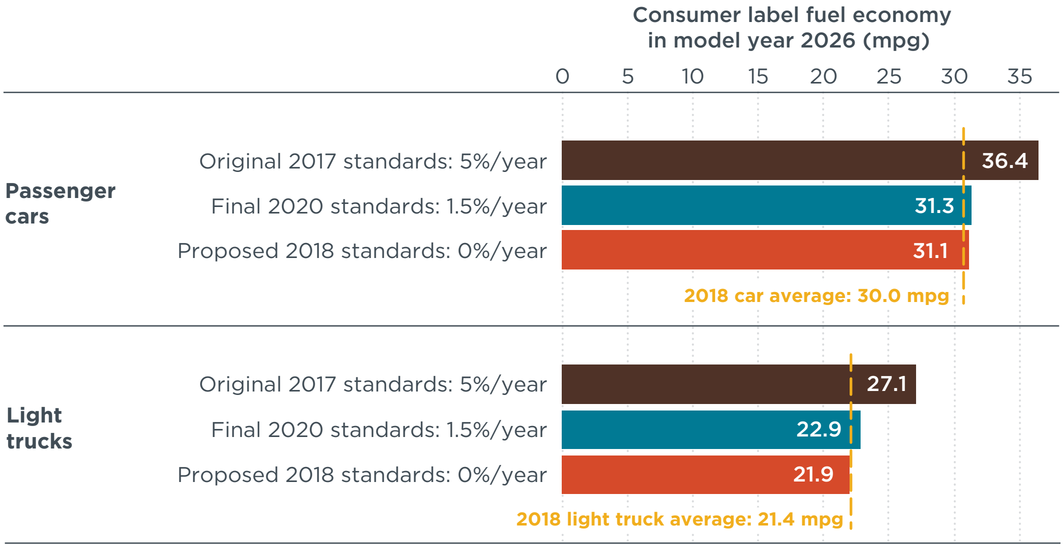

Figure 2. Consumer fuel economy of combustion vehicles in model year 2026 from original 2017, proposed 2018, and final 2020 standards.

As these two figures illustrate, while the final 2020 standards do require incremental efficiency improvement in combustion vehicles those effects are relatively small, due to the lower stringency and increasing use of technology credits. With the new final rule, car buyers in 2026 can expect on average 1.3 mpg better fuel economy (31.3 vs 30.0) and light truck buyers a 1.5 mpg gain (22.9 vs 21.4), compared to 2018, the latest year with official EPA numbers. Overall, the average consumer fuel economy for all combustion cars and light trucks by 2026 would increase from 25 mpg in 2018 to 27 mpg under the new final rule, compared to 31 mpg under the original rule. Because the separate car and light truck standards are indexed to vehicle size, the rule does not provide a compliance benefit for selling more cars or selling smaller vehicles.

CHANGES RELATING TO COSTS AND BENEFITS

Many changes to the CAFE modeling have been made in apparent response to public comments on the 2018 proposal. Examples of improvements include incorporation of more technology combinations, an improved technology selection algorithm, and less dramatic economic modeling effects on vehicle sales and scrappage. In other instances, new issues have been introduced, and issues flagged in public comments have not been corrected and do not reflect the research literature or real-world market trends. See the next section for a more detailed summary of the modeling.

Table 1 summarizes overall costs and benefits in the final 2020 rule and the proposed 2018 rule. The table shows the agencies' estimates of the effects of weakening the standards, relative to the original 2017 standards, using a discount rate of 3% (the agencies also analyze a 7% discount rate, discussed below). Negative numbers indicate an estimated economic benefit (i.e., a reduction in cost) from the rule, while positive numbers indicate estimated economic costs.

The three largest effects of the rollback, by the agencies' estimates, are on-vehicle technology, fatalities and crashes, and fuel expenses. These are also the numbers that changed the most from the proposal to the final rule. The first column shows the cost effects estimated for the 2018 proposal, which called for an annual rate of fuel economy improvement of 0%. The second column shows estimates in the 2020 analysis assuming the same flat annual rate of improvement. Differences between these columns reflect changes in the CAFE model or the assumptions fed into the model and summarize their effects. Comparing the two, the benefits from reducing vehicle technology costs decline by $116 billion; the benefits attributed to fewer crashes and fatalities fall by $133 billion; and the disbenefit from consumers having to spend more on fuel increased by $56 billion. By the agencies' estimate, the net overall effect of changes to the CAFE modeling and assumptions for the final 2020 rule flipped the result of 0%/year standards from a purported $184 billion economic benefit to a $16 billion economic cost to society. The final column shows the effect on the final 2020 rule, with its 1.5% annual rate of improvement, which is also a net disbenefit, estimated at $13 billion.

Table 1. Agency-estimated cost effects of proposed and final rules relative to original standards (billion 2018 U.S. dollars).

	2018 proposed rule (0%/year)	2020 analysis at 0%/year	2020 final rule (1.5%/year)
Vehicle technology	-$264	-$148	-$126
Fatalities and crashes	-$207	-$74.2	-$62.9
Congestion and noise	-$54.3	-$70.3	-$59.1
Fuel tax revenue	-$20.6	-$36.7	-$31.8
New vehicle consumer surplus	-	-$1.11	-$0.806
Consumer fuel expenses	$160	$216	$185
Pollution impacts	$5.79	$11.0	$7.04
Other impacts	$132	$63.3	$54.1
Additional travel	$63.9	$56.5	$47.2
Net overall cost of rollback	**-$184**	**$16.3**	**$13.1**

The discount rate, the assumed rate at which the value of costs and benefits declines each year in the future, is especially important for the final rationale for the standards. To estimate the costs and benefits shown in Table 1 the agencies used a discount rate of 3%. Not shown in the table, the agencies also estimated costs and benefits using a 7% discount rate. That estimate produced a final net benefit from the final 2020 rule of $16 billion, as compared to the $13 billion net cost for the 3% case (the rightmost column in the table). In justifying the final standards, the agencies refer to the results obtained using both discount rates and conclude: "The net benefits straddle zero, and are very small relative to the scale of reduced required technology costs."[6]

Another way to summarize the effects of changes in the agencies' modeling is to look only at the estimated technology cost of compliance on a per-new-vehicle basis. Indeed, the agencies themselves have out of necessity made that their focus, rather than the net cost-benefit outcome for society, arguing that "the costs to both industry and automotive consumers would have been too high under the standards set forth in 2012."[7] NHTSA's original CAFE model analysis for the 2017 standards estimated that the average model year 2025 vehicle would cost $1,170 more than the average

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[6] The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, 85 Fed. Reg. 84 (April 30, 2020). 24176.

[7] Ibid.

model year 2017 vehicle.[8] The Trump administration's 2020 final rule estimates that the 2017 standards would increase the cost of the average vehicle $2,400 over the same period—more than twice as large a jump in cost. As we have argued elsewhere, both these estimates are insupportably high. We estimate the incremental increase in vehicle cost to be less than $900.[9]

PERSISTENT MODELING FLAWS

Flaws remain in the final rule's benefit-cost analysis, related to technology costs, off-cycle credit modeling, pollution, fatalities and crashes, congestion, and noise.

TECHNOLOGY COSTS

Among the changes made to the final rule cost evaluation in response to public comments on the 2018 proposal are the addition of new powertrain technology combinations (turbocharging with cylinder deactivation) and one new technology (variable compression ratio).[10] Changes to the technology selection algorithm and cost-effectiveness metric reduce problems where modeled automaker compliance included cost-ineffective technologies. Yet several flawed assumptions regarding technologies remain unaddressed.

Turbocharging. Modeling of turbocharging correctly is especially critical because the deployment of the technology is increasing in the market, and the original 2017 standards projected that nearly half of 2025 vehicles would feature it. In the final 2020 analysis, the agencies constrain turbocharging technology by using a less-efficient engine map when data are available from a state-of-the-art benchmarked turbocharged engine.[11] The agencies' turbocharging costs are too high: downsizing a V6 engine to a turbocharged in-line 4-cylinder engine results in a real-world cost reduction of hundreds of dollars,[12] but the agencies continue to incorrectly assert that that technology change will actually produce a $160 cost increase.

High compression ratio engines. The analysis restricts high compression ratio (HCR) engine technology to 21% of 2026 vehicles. The agencies' HCR restrictions are unfounded, as the agencies' own data shows that HCR is more cost-effective than other technologies and HCR is being widely applied across vehicle types by many companies in the real-world. Further, the analysis disallows combinations of HCR with other engine technologies that already exist in the real world. Mazda and Volkswagen have engines with turbocharging, HCR, and cylinder deactivation, but such combinations are disallowed in agency modeling. Toyota has HCR with cooled exhaust

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[8] 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, 77 Fed. Reg 199 (Oct. 15, 2012), table I-16 ($1,257 in 2025 minus $239 in 2017, adjusted from 2010 dollars to 2018 dollars by 1.15), https://www.regulations.gov/document?D=NHTSA-2010-0131-0412.

[9] Nic Lutsey et al., *Efficiency technology and cost assessment for U.S. 2025–2030 light-duty vehicles* (ICCT: Washington D.C., 2017), http://www.theicct.org/US-2030-technology-cost-assessment. For a more thorough discussion of the rulemaking analysis and points below, see ICCT's public comments on the rulemaking here: https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-5456.

[10] "Compliance and Effects Modeling System: The Volpe Model," National Highway Traffic Safety Administration, 2020 Final Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, https://www.nhtsa.gov/corporate-average-fuel-economy/compliance-and-effects-modeling-system.

[11] Mark Stuhldreher et al., "Benchmarking a 2016 Honda Civic 1.5-Liter L15B7 Turbocharged Engine and Evaluating the Future Efficiency Potential of Turbocharged Engines," *SAE Int. J. Engines* 11, no. 6 (April 2018):1273–1305, 2018, https://doi.org/10.4271/2018-01-0319

[12] Aaron Isenstadt et al., *Downsized boosted gasoline engines* (ICCT: Washington, D.C., 2016), http://www.theicct.org/downsized-boosted-gasoline-engines

gas recirculation,[13] but the agencies disallow that combination as well. Ford, GM, Hyundai, and Nissan hybrids have HCR, but in the agencies' modeling, these companies are not allowed to have HCR uptake in the agency modeling in future years.

Electric vehicles. The agencies modified their battery electric vehicle (BEV) modeling but introduced new flaws that inflate costs and constrain BEV uptake. The agency battery cost per kilowatt-hour (kWh) projections are demonstrably high for several reasons. The agencies apply low-volume battery production of 20,000 units per year in 2020, when two-thirds of global battery cell production is by companies supplying over 200,000 units per year.[14] The agencies assume annual cost-reduction learning rates of about 4.5%, when the appropriate rate is 7%-9%.[15] The agencies include a retail price equivalent factor of 1.5 that double-counts battery indirect costs (e.g., overhead, research and development, warranty) that are already included within the battery cost studies the agencies cite. With these errors, the agencies ultimately model battery packs as still costing $200/kWh by 2026—higher than in studies they cite and than automakers have reported for 2018–2021.[16] For the final rule, the CAFE compliance modeling ultimately dismisses market and automaker trends and projects that BEVs will represent less than 1% of new 2025 vehicles.

Off-cycle credits. The agencies modified the analysis of off-cycle credit costs and projections in the 2020 rule, but in doing so again introduced new errors. The 2018 proposal assumed off-cycle credit use that was naturally occurring, without adding cost, and assumed only 5 g/mi by 2026, the same level as in 2017.[17] The new 2020 analysis assumes 10 g/mile of off-cycle credit use for all vehicles, and assumes that the technologies deployed to qualify for and receive those credits will cost on average $780 per vehicle over 2023–2026. But at approximately $80 per g/mi over 2017–2026, the off-cycle credit cost is more that 6 times greater than the test-cycle technologies deployed by 2020. And Fiat-Chrysler, Ford, Jaguar Land Rover, and Volvo already received 9.8–10.0 g/mile in off-cycle credits in model year 2018. The agencies' offer no rationale to explain why these or other automakers would voluntarily add off-cycle technology packages to their vehicles at such exorbitant costs before deploying the many available on-cycle engine, transmission, and vehicle technologies, which would be far more cost-effective by the agencies' estimates.[18] To credibly model automakers' voluntary use of off-cycle credits, the costs associated with deploying those vehicle technologies would have to be lower than test-cycle technologies applied in 2018, the off-cycle technologies would have to be included

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[13] John Kargul et al., "Benchmarking a 2018 Toyota Camry 2.5-Liter Atkinson Cycle Engine with Cooled-EGR," SAE Int. J. Adv. & Curr. Prac. in Mobility 1, no. 2 (April 2019):601–638, https://doi.org/10.4271/2019-01-0249

[14] Benjamin Sharpe et al., *Canada's Role in the Electric Vehicle Transition* (ICCT: Washington, D.C., 2020), https://theicct.org/publications/canada-zev-transition.

[15] Nic Lutsey and Michael Nicholas, *Update on Electric Vehicle Costs in the United States through 2030* (iCCT: Washinton, D.C., 2019), https://theicct.org/publications/update-US-2030-electric-vehicle-cost.

[16] Chris Davies, "VW I.D. EV boast: We'll hugely undercut Tesla's Model 3 says exec," *SlashGear*, July 17, 2017, https://www.slashgear.com/vw-i-d-ev-boast-well-hugely-undercut-teslas-model-3-says-exec-17491688/; Paul Lienert and Joseph White, "GM races to build a formula for profitable electric cars." Reuters, January 8, 2018, https://www.reuters.com/article/us-gm-electric-insight/gm-races-to-build-a-formula-for-profitable-electric-cars-idUSKBN1EY0GG; "2018 Annual Shareholder Meeting," Tesla, accessed June 5, 2018, https://www.tesla.com/shareholdermeeting; UBS, "Tearing down the heart of an electric car: Can batteries provide an edge, and who wins?" (November 19, 2018), http://xqdoc.imedao.com/16764c45aca1ea83fdfe1636.pdf

[17] Model year 2017 off-cycle credit use was 5.1 g/mile, and model year 2018 was 6.5 g/mi in model year 2018. U.S. EPA, "The 2018 EPA Automotive Trends Report: Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975" (March 2019), https://www.epa.gov/automotive-trends/download-2018-automotive-trends-report-previous-year; U.S. EPA, "The 2019 EPA Automotive Trends Report: Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975" (March 2020), https://www.epa.gov/automotive-trends/download-automotive-trends-report

[18] U.S. EPA, "The 2019 EPA Automotive Trends Report"

within the normal cost-effectiveness algorithm, and off-cycle credits would have to be projected to surpass 10 g/mile by 2026.[19]

Indirect costs. The agencies' use a uniformly and inappropriately high retail price equivalent factor of 1.50, thereby adding 50% indirect cost to all technologies. Up to 2017 the agencies used a more realistic indirect cost multiplier (ICM) method that differentiated among technologies with differing, and generally lower, indirect cost factors (often between 1.1 and 1.5). That method was vetted via peer review and handled technologies with different supply chain and manufacturing characteristics in a more complex and accurate way.[20] Upon examining the issue, the National Research Council concluded, "The committee conceptually agrees with the agencies' method of using an indirect cost multiplier instead of a retail price equivalent to estimate the costs of each technology since ICM takes into account design challenges and the activities required to implement each technology." [21]

POLLUTION IMPACTS

In the 2020 rule, the agencies use the same low social cost of carbon they did in the 2018 proposal to estimate the costs of CO_2 emissions. Estimates prior to the 2018 proposal set the social cost of carbon at $47–$78 per ton (the range reflects the rise over 2022–2050), per the recommendation of a federal government interagency working group.[22] The 2020 final rule lowers that to $7–$10 per ton by limiting the focus to domestic (rather than global) CO_2 damages, despite extensive public comments criticizing the change and contra the consensus in the research literature.[23] By design, global values of the social cost of carbon account for the widespread impacts of CO_2 mitigation and the full impact of CO_2 emissions unfolding over the long term. The domestic-only values in the 2020 rule underestimate the geographic and the temporal effects of CO_2 emissions.

REBOUND EFFECT

A rebound factor is applied to model how much more vehicles are driven when the cost of driving declines. The greater the assumed rebound effect, the more the regulation's fuel savings are negated. The agencies' 2020 final rule estimates the rebound effect at 20%, doubling the 10% effect estimated in the agencies' pre-2018 analyses. That is, for the final 2020 analysis, a 10% percent reduction in per-mile driving cost results in a 2% increase in driving. To support the use of a higher rebound effect, the agencies cite the same studies used in earlier analyses but reach a different conclusion by putting more weight on the studies with higher elasticity coefficients. This increases the influence of backward-looking studies with large historical fuel-price

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[19] Lutsey and Isenstadt, *How Will Off-Cycle Credits Impact U.S. 2025 Efficiency Standards?*

[20] RTI International, "Automobile Industry Retail Price Equivalent and Indirect Cost Multipliers" (prepared for U.S. EPA, EPA-420-R-09-003, February 2009) https://cfpub.epa.gov/si/si_public_pra_view.cfm?Lab=OTAQ&dirEntryID=205147. Alex Rogozhin et al., "Using indirect cost multipliers to estimate the total cost of adding new technology in the automobile industry" *International Journal of Production Economics* 124, no. 2 (April 2019): 360–368 https://doi.org/10.1016/j.ijpe.2009.11.031

[21] National Research Council, *Cost, Effectiveness and Deployment of Fuel Economy Technologies for Light-Duty Vehicles,* (National Academies Press: Washington, D.C., 2015), https://doi.org/10.17226/21744.

[22] Interagency Working Group on Social Cost of Carbon, "Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866" (February 2010), https://19january2017snapshot.epa.gov/sites/production/files/2016-12/documents/scc_tsd_2010.pdf

[23] Richard Newell, "Unpacking the Administration's Revised Social Cost of Carbon," *Resources,* October 10, 2017, https://www.resourcesmag.org/common-resources/unpacking-the-administrations-revised-social-cost-of-carbon/. National Academies of Sciences, Engineering, and Medicine, *Valuing climate damages: updating estimation of the social cost of carbon dioxide* (The National Academies Press: Washington, D.C., 2017) https://doi.org/10.17226/24651.

changes (to which consumers appear to react more strongly) rather than vehicle-technology changes (which are the actual effect of the standards). More appropriate studies incorporating rising incomes, increased urbanization, and changing fueling costs indicate a rebound effect of 10% or less that declines over time.[24]

SALES AND SCRAPPAGE EFFECT

In response to critical comments on the 2018 proposal, the agencies updated the fleet modeling of vehicle sales and scrappage for the 2020 rule. Several major errors identified in public comments were addressed, which reduced the agencies' 2018 projected increases in the driving of used cars and associated fatalities. Yet sales and scrappage modeling still have unrealistically and unreliably high effects for several reasons.

Enhanced consumer value. In accounting for how efficiency technology affects vehicle sales, the agencies fail to include the enhanced value of efficiency technology. In a logical inconsistency, the agencies incorporate how consumers naturally value 2.5 years of fuel-saving benefits into their compliance model, but base their sales-scrappage model on the upfront cost alone. In addition to fuel savings, many CO_2-reduction and efficiency technologies offer improved performance (e.g., mass reduction also improves handling, turbocharging also improves acceleration), thereby increasing the consumer value of a vehicle. Instead of valuing all these effects, the agencies include just upfront cost, while neglecting other consumer-demanded attributes that they acknowledge have tangible marketable value, to assume a sales decline from the deployment of efficiency technologies.

Uncertain modeling of price elasticity of demand. The agencies compound the problems created by flawed fleet modeling with their assumed vehicle-price sales elasticity. The complex consumer value effects, which the agencies handled one-sidedly by only considering cost, inherently make attempts to project changes in new sales due to efficiency technology very uncertain, a point made in the public comments on the 2018 proposal. Notwithstanding, for the final rule the agencies have increased the assumed new-vehicle price elasticity, contradicting the evidence and magnifying the effect. They apply a price elasticity of -1 in the 2020 rule (i.e., a one percent increase in the average new vehicle price produces a one percent decrease in sales), which is three to five times higher than in the 2018 proposal.[25] The agencies cite no evidence demonstrating a past vehicle sales decline linked with such standards, and have not applied such a relationship in any of their hundreds of past vehicle emission, efficiency, or safety standards.

Unexpected modeling behavior. In another change from the 2018 proposal, and past practice, the fleet sales-scrappage model dynamically changes the share of new car and truck fleets based on efficiency increases that are imposed by new, more stringent standards. This produces unexpected and unrealistic modeling outcomes. In the agencies' new dynamic fleet share model, improved car efficiency leads to consumers buying *fewer* cars, whereas improved truck efficiency causes *more* truck sales in future years. This effect is unexplained and unsupported by real-world evidence,

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[24] See Kenneth A. Small and Kurt Van Dender, "Fuel Efficiency and Motor Vehicle Travel: The Declining Rebound Effect," *Energy Journal* 28, no. 1 (2007), https://www.jstor.org/stable/41323081; Kenneth Gillingham, "Policy Brief: The Rebound Effect and the Rollback of Fuel Economy Standards" (December 4, 2018), http://environment.yale.edu/gillingham/Gillingham_ReboundFuelEconomyStds.pdf.

[25] The agencies apply -0.2 to -0.3 in the August 2018 proposed rulemaking. See The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, 83 Fed. Reg. 165 (August 24, 2018). 43075.

so it is unclear if the modeling decision is intentional or a basic error. In either case, the consequence in the model is to artificially increase both fuel consumption and technology costs, because per-vehicle technology costs and fuel consumption per mile are inherently higher for light trucks. This skews the cost-benefit analysis in favor of any rollback of the emission and fuel economy standards.

CRASH-RELATED COSTS

The 2020 final rule estimates lower crash costs than the 2018 proposal. After much criticism of the 2018 proposal's projection of 12,700 lives saved from the proposed rollback, the agencies' made changes to the sales and scrappage model that reduce the number of avoided fatalities by more than two-thirds. The final rule projects it will save over 3,400 lives, relative to the 2017 original standards. Yet the 2020 agency analysis still does not correctly address three sources of crash-related costs: the sales and scrappage model, additional driving due to the rebound effect, and safety concerns of mass reduction.

Sales and scrappage crash costs. Although several major changes were made in the fleet model, the final 2020 sales and scrappage modeling still generates unreasonable crash effects. Over the simulated lifetimes of 2017–2029 vehicles, the 2020 analysis projects that the finalized standards will save more than 450 non-rebound fatalities and nearly 6,300 non-rebound non-fatal injuries, compared to the original 2017 standards. These modeled crashes account for around 18% of the total cost of the additional crashes attributed to the original standards. To get these results, the agencies apply conceptual econometric models that assume that higher efficiency standards cause reduced new sales, reduced scrappage, and more crash fatalities and injuries. There is no real-world evidence that supports these assumptions, and these conceptual econometric models have never been used in vehicle standards by EPA or NHTSA or any other regulatory agency anwhere else in the world.

Rebound crash costs. The 20% rebound effect has additional impacts on the outcome of the analysis beyond reducing fuel savings. With the higher rebound effect, the agencies project that the final rolled-back regulation saves 2,620 lives and $17.7 billion from rebound-related crashes, as compared with the original standards. As in the 2018 proposal, the agencies affirm that any additional rebound-effect driving is "freely chosen rather than imposed by the standards and imply personal benefits at least equal to the sum of their added costs and safety consequences."[26] However, in contrast to the 2018 proposal, which assumed that all rebound-associated crashes would be internalized in drivers' decisions to drive more and therefore that that benefit fully offsets the disbenefits of crashes, in the final 2020 analysis, they assume that only 90% of the rebound-associated crash costs are offset by the benefits of additional driving. There is no real-world basis for this assumption, and the effect of it is to include all the associated costs but only 90% of the estimated benefits from the same rebound phenomenon. This agency assumption inflates the net estimated benefit of rolling back the original standards by several billion dollars.

Mass reduction crash costs. For the 2020 rule, the agencies maintain their position from the 2018 proposal that vehicle mass reduction increases the risk of injury or death in the event of a crash. This is counter to the fact that the 2018 proposal and 2020 rule analyses themselves unambiguously establish that the link between vehicle mass

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[26] The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, 83 Fed. Reg. 165 (August 24, 2018), 43148

and safety is not statistically significant. That the link is so tenuous is attributable to the fact that reductions in vehicle mass are accompanied by improved vehicle design and engineering and the use of new lightweight materials such as high-strength steel. Nevertheless, contradicting their own statistical analyses, the agencies use the mass-fatality relationship to project a rise in crash-related deaths—specifically, 269 more deaths (and additional injuries) related to vehicle mass reduction under the original 2017 standards than in the final rolled-back standards, with an impact on the cost analysis of $1.8 billion.

CONGESTION AND NOISE COSTS

Congestion and noise costs in the regulation are indirectly affected by the agency assumptions about how much driving increases or decreases. Unprompted by either new research or public comments, the 2020 rule doubled the congestion cost from the value used in the 2018 proposal and prior analyses, and increased the noise cost more than 15%. Without these changes, the changes to fleet modeling for the final rule summarized above would have reduced congestion and noise effects from the original 2017 standards. With the new assumptions, increased congestion and noise effects more than offset the diminished fleet-level driving effects reflected in the revised 2020 benefit-cost analysis.

REVISING THE REGULATORY ANALYSIS

Correcting for the modeling flaws summarized above substantially alters the benefit-cost outcome. Figure 3 shows the effect of correcting specific instances of faulty data and modeling assumptions on the estimate of net economic benefits to society of the original standards. The blue bar at left of the chart represents the agencies' estimated -$16 billion net cost of retaining the original 2017 standards, at a 7% discount rate. The green bars show the impacts of various corrections, beginning with the use of a standard 3% discount rate, which by itself adds $29 billion in net benefits. As noted above, the agencies gave their analysis alternate outcomes that straddle zero in terms of net societal benefits. Consequently, correcting any of six elements shown in the figure (i.e., discount rate, technology, pollution, rebound, scrappage, or congestion) would make the benefit-cost ratio of the original standards positive. By implication, any such correction would make the benefit-cost ratio of the 2020 rule negative—that is, confirm that rolling back the original 2017 standards imposes a net economic cost on society.

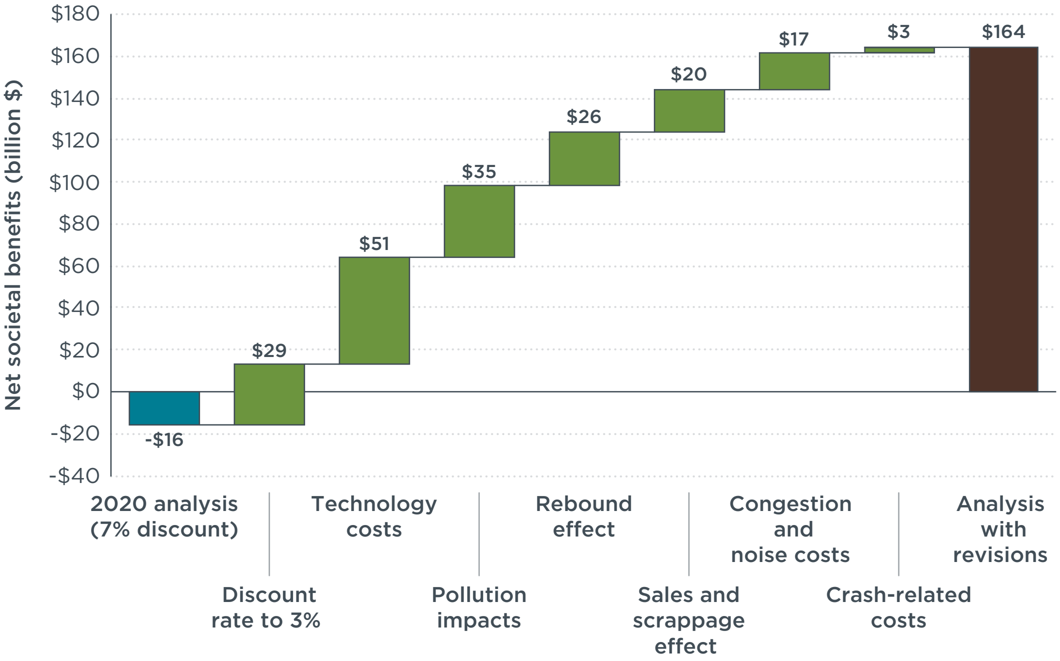

Figure 3. Effects of correcting flawed assumptions in the final 2020 benefit-cost analysis on the net economic impact of the original 2017 standards.

Remedying deficiencies in the agencies' technology costs produces the most significant change. Corrections here include revising the CAFE Model to include lower and more accurate turbocharging costs; removing empirically inaccurate constraints on the use of high compression ratio engines; adjusting electric vehicle costs to reflect best available battery cost studies; correcting the off-cycle cost modeling; and approximating the use of more appropriate indirect costs. Modifications to technology costs along these lines match our own technical research, and we have checked them against the agencies' own sensitivity analyses of related regulatory scenarios they have analyzed. They add up to benefits totaling $51 billion that should be recovered for the benefit-cost analysis.

Rectifying the other defects in the final rule's benefit-cost analysis identified above changes the net outcome further. Restoring the greenhouse gas pollution benefits to their global value recovers another $35 billion in net benefits. Setting the rebound effect from 20% back to 10%, consistent with both past practice and current research on the declining effect, accrues $26 billion more in benefits. Turning off the unvetted sales-and-scrappage model eliminates its uncertain impacts and reinstates $20 billion. Restoring the congestion and noise costs to more appropriate values results in $17 billion. Eliminating the crash costs attributable to uncertain sales and scrappage effects, freely chosen rebound driving, and mass-reduction effects that are not statistically significant returns $3 billion. All together, these corrections make a $180 billion change in the outcome of the benefit-cost analysis of the original 2025 standards, from a $16 billion net economic cost to society to a $164 billion net economic benefit.

Figure 4 shows the impact of the same set of revisions in terms of their effect on the overall benefit-to-cost ratio. Beginning with the agencies' 0.9:1 ratio, the benefits of maintaining the original standards are 10% lower than the costs. Correcting the analytical flaws in the final rule brings the revised ratio to 2.2:1. The magnitude of each correction (represented by the size of the bars in Figure 4) is not proportional to the absolute effect in billions of dollars (as shown in Figure 3 above) because some assumptions change the benefits (ratio numerator), some the cost (ratio denominator), and some both. With an ultimate benefit-cost ratio of 2.2, rectifying these seven key flaws brings the analysis back approximately in line with previous analyses.[27]

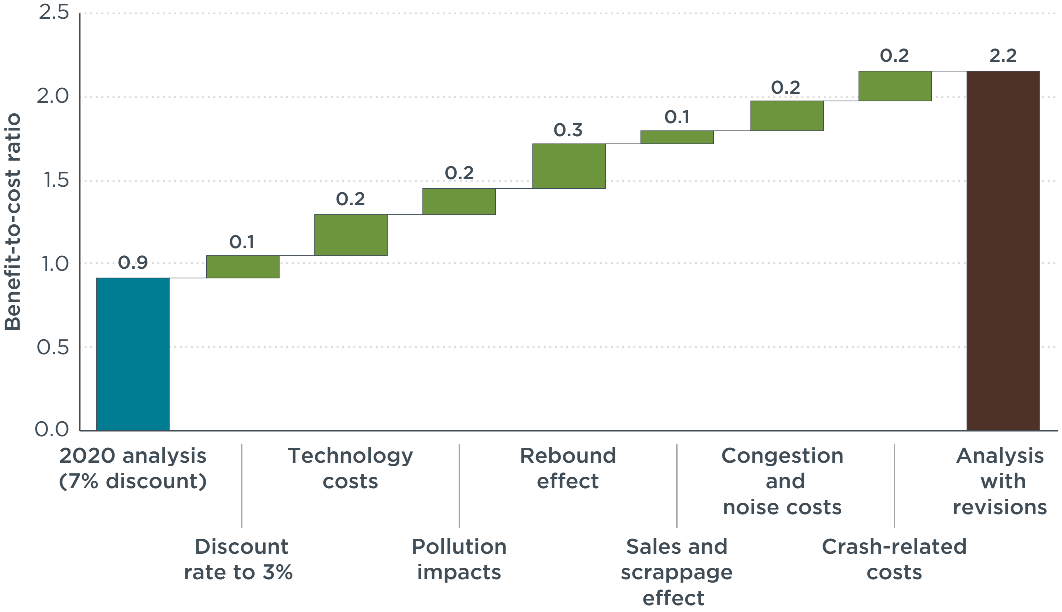

Figure 4. Effects of correcting flawed assumptions on the benefit-cost ratio in the final 2020 benefit-cost analysis.

The per-vehicle costs associated with the results illustrated in Figures 3 and 4 provide additional context. Correcting the agencies' final 2020 analysis along these lines reduces average per-vehicle cost from the agencies' 2025 cost estimate of $2,400, as compared to the reference 2017 costs, to $1,500. This method, showing the cost increment per vehicle from a 2017 reference point or baseline, is how the agencies present costs in the new rule. However, for greater applicability to today's vehicle prices, we can report these costs versus average 2020 vehicle costs. Compared with model year 2020 vehicle cost, the new final rule estimates the original standards cost $1,500 per model year 2025 vehicle, but the fixes we identify above suggest the more appropriate cost is 40% less, at $890.

Even with the corrections summarized here, the benefit-cost analysis and per-vehicle technology cost outcome probably does not fairly reflect the most likely real-world outcomes, due to additional flaws in the NHTSA compliance modeling framework that cannot be readily fixed or reconciled. Comparable EPA-led and ICCT bottom-up technology and cost evaluations of available advanced technologies with state-of-

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[27] U.S. EPA, "Final determination on the appropriateness of the model year 2022–2025 light-duty vehicle greenhouse gas emissions standards under the midterm evaluation" (EPA-420-R-17-001, January 2017), https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100QQ91.pdf. U.S. EPA, NHTSA, and California Air Resources Board, "Draft technical assessment report: Midterm evaluation of light-duty vehicle greenhouse gas emission standards and corporate average fuel economy standards for model years 2022-2025" (EPA-420-D-16-900, July 2016), https://nepis.epa.gov/Exe/ZyPDF.cgi/P100OXEO.PDF?Dockey=P100OXEO.PDF.

the-art engine maps and supplier input have resulted in lower cost estimates.[28] As compared to those analyses, the 2020 agency analysis incorrectly models technology effectiveness, availability, and cost for Miller-cycle engines, e-boost, cylinder deactivation, mass reduction, hybrids, and cooled exhaust gas recirculation.

In another example, the NHTSA-led CAFE compliance model outputs inappropriately show overcompliance with the standards. For example, NHTSA's model predicts that even if standards require a 0% annual rate of improvement, the auto industry delivers greater than a 1.5% per year improvement. This undermines the agency analysis that they are setting maximum feasible standards, as it shows that they believe business-as-usual industry actions *without stronger post-2020 standards* would achieve compliance with the 1.5% per year standards. Correcting this overcompliance would greatly reduce the agencies' technology costs and improve the overall benefit-cost proposition in their increased-stringency cases. The model does not match historical automaker compliance behavior; manufacturers customarily bank credits from over-complying and later apply them during years of under-compliance, to apply less technology and reduce costs while still meeting the standards. Fixing these issues would likely bring the benefit-cost ratio higher than shown above.

CONCLUSION

The final 2020 regulatory analysis justifying the rollback of the 2025 efficiency standards represents a continuation of the flawed benefit-cost analysis from the Trump administration's 2018 proposed regulation. The modeling performed by NHTSA on which the benefit-cost analysis relies, though improved in some respects from the 2018 proposal, continues to inflate technology costs and diminish associated benefits. The modeling also introduces new errors that do not reflect the research literature and real-world technology trends. Some of the flaws, such as regulation-induced sales decline or rebound-related deaths, are unprecedented in the history of vehicle regulation.

The agencies still manage only to justify the rolled-back standards by the thinnest of margins. They arrive at two final outcomes in their benefit-cost analysis, which "straddle zero" in terms of the estimated net benefit to society of keeping the 2025 fuel economy standards unchanged. In normal circumstances a decisive net-benefit analysis is a minimum threshold for finalizing or overturning major standards. In this case, the agencies arrive there by relying on the high 7% discount rate to valuate future costs and benefits, and then arbitrarily judging that the absolute costs "would have been too high." Revising any single instance of numerous significant faulty or unsupported assumptions in the analysis flips the final benefit-cost ratio in favor of maintaining the original standards.

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[28] U.S. EPA, "Final determination." Nic Lutsey et al., "Efficiency Technology and Cost Assessment for U.S. 2025–2030 Light-Duty Vehicles" (ICCT: Washington, D.C., 2017), https://theicct.org/publications/US-2030-technology-cost-assessment.