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THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

BRIEFING

JUNE 2019

The flawed benefit-cost analysis behind proposed rollback of the U.S. light-duty vehicle efficiency standards

This briefing paper reviews the benefit-cost estimate developed by the National Highway Traffic Safety Administration (NHTSA) and the U.S. Environmental Protection Agency (EPA) to justify the Trump Administration's August 2018 proposal to roll back the U.S. light-duty vehicle efficiency standards for 2020–2025.

A benefit-cost analysis is required for any significant federal regulatory proposal. The agencies' proposal, in this instance, would eliminate the need to improve vehicle fuel efficiency after 2020. This proposal reverses a regulation finalized by the outgoing Obama administration less than two years earlier, by the same agencies, with the same expertise, data, research, and tools at their disposal. Justifying such a reversal depends on reversing the conclusions of the previous benefit-cost analysis. The proposal achieved this by changing underlying assumptions, data inputs, and models used to make projections.[1]

The United States has two separate but harmonized light-duty vehicle standards that regulate fuel efficiency, under the purview of NHTSA, and greenhouse gas emissions, under the EPA. To meet their own statutory requirements, each agency performs its own separate benefit-cost analysis, which involves projecting technology availability, costs,

1 For a more thorough discussion of the rulemaking analysis and the points below, see ICCT's public comments on the rulemaking here: https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-5456

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consumer fuel savings, and other factors influencing the final effect of the regulation. Each agency has its own modeling for this purpose: EPA uses the Optimization Model for reducing Emissions of Greenhouse Gases from Automobiles (OMEGA); NHTSA uses the CAFE Compliance and Effects Modeling System, informally known as the Volpe Model. The models do not produce identical projections, as the agencies use different tools to examine the standards. From 2009, when the first Obama Administration vehicle regulations were proposed, until 2018 the models were closely aligned. But the analysis for the Trump Administration's rollback proposal, largely done by NHTSA using the Volpe Model, diverged sharply from that track record.

Table 1 summarizes three different benefit-cost estimates done for the U.S. light-duty vehicle regulations for fuel economy and GHG emissions. EPA's January 2017 Final Determination was the outcome of that agency's final analysis for the midterm evaluation, completed after the Technical Assessment Report and incorporating public comments on the TAR. It is that final determination that the Trump Administration's proposal would reverse. NHTSA's estimate for the 2016 Technical Assessment Report represents the last NHTSA analysis of the Obama Administration. This is the estimate most directly comparable to the benefit-cost analysis for the 2018 proposal, led by the same agency using the same fundamental modeling approach.

Table 1. U.S. fuel economy and GHG regulation impact estimates

		EPA Final Determination (January 2017)		NHTSA Technical Assessment Report (July 2016)		NHTSA Proposed Regulation (August 2018)	
	Factor	Cost	Benefit	Cost	Benefit	Cost	Benefit
Societal impact ($ billion)	Technology cost	$33		$87		$253	
	Crash		$1.8	$1.2		$197	
	Congestion	$6.2		$5.0		$52	
	Fuel savings		$92		$120		$133
	Pollution		$29		$37		$6
	Mobility		$10		$9		$61
	Other impacts		$12		$16		$126
Overall effect	Model years affected	2022-2025		2022-2028		2021-2029	
	Total number of vehicles	65 million		115 million		160 million	
	Benefit-cost ratio	3.7-to-1		2.0-to-1		0.6-to-1	

Sources: *EPA, "Final determination on the appropriateness of the model year 2022–2025 light-duty vehicle greenhouse gas emissions standards under the midterm evaluation" (2017).* 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" (July 2016). *EPA, NHTSA, "The safer affordable fuel-efficient vehicles rule for model years 2021-2026 passenger cars and light trucks; Notice of proposed rulemaking" (August 2018).*

Figure 1 graphically shows the impact estimates on a per-vehicle basis to highlight differences in the benefit-cost analyses. Green bars indicate benefits, red bars costs. Thus, the EPA in 2017 estimated $600 in total average per vehicle cost and $2,200 in benefits, the three largest factors in EPA's analysis are the technology cost ($500 per vehicle), fuel savings ($1,400), and pollution benefit ($440), and the overall benefit-cost ratio is 3.7-to-1.

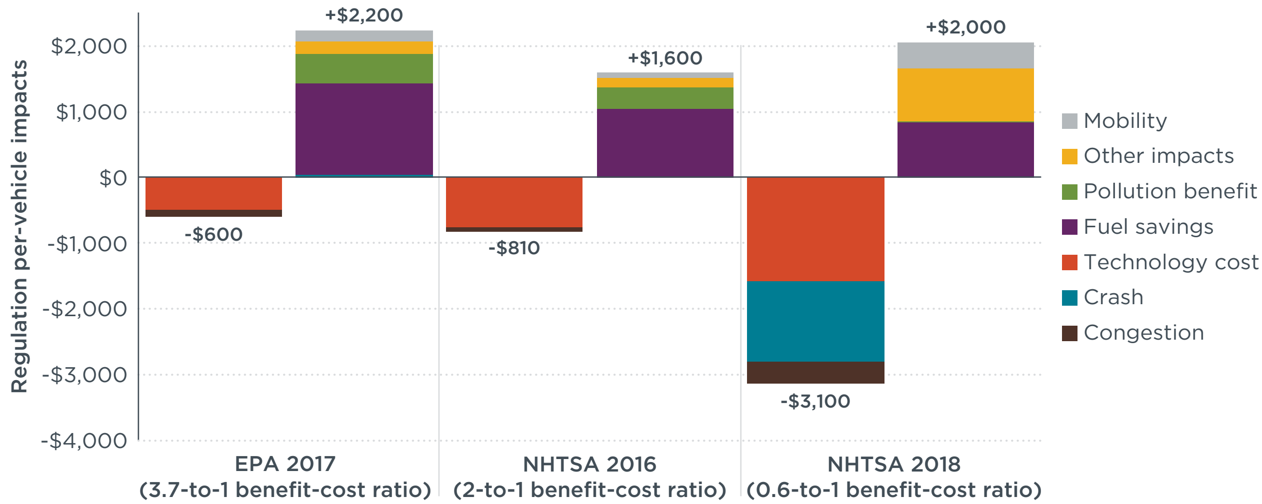

Figure 1. U.S. fuel economy and GHG regulation impact estimates, per vehicle

Table 2 summarizes the changes in estimated impacts from the earlier analyses to the 2018 proposal that is largely based on NHTSA modeling. The revised analysis estimates higher technology costs (2–3 times the earlier analyses), fatalities and crash costs (by up to 120 times), and congestion costs (3–7 times). It estimates lower fuel-saving benefits (by 21%–41%) and pollution benefits (by 89%–92%).

Table 2. Per-vehicle efficiency and GHG regulation impacts from three analyses

Regulation impact	Impact per regulated vehicle ($/vehicle)			Change, 2016/2017 to 2018 analysis	Factors in change
	EPA 2017	NHTSA 2016	NHTSA 2018		
Technology cost	-$502	-$758	-$1,581	109% to 215%	• Less technology is available • Technologies offer less benefits • Technology costs are greater
Crash	$28	-$10	-$1,236	-4553% to -11937%	• Sales response: Lower vehicle sales (by about 1%) and more use of older vehicles • Rebound effect: Drivers capitalize on fuel savings by driving more
Congestion	-$96	-$44	-$324	238% to 644%	• Rebound effect
Fuel savings	$1,409	$1,048	$832	-21% to -41%	• In absence of new 2020+ standards, efficiency assumed to increase from 36 in 2020 to 38.4 mpg in 2026
Pollution	$441	$323	$35	-89% to -92%	• CO_2 damages are reduced by 85% • Rebound effect
Mobility	$155	$79	$382	146% to 383%	• Rebound effect
Other impacts	$187	$139	$790	322% to 469%	• Largely to offset crash impact, as drivers freely choose to drive more

The rightmost column of the table notes factors in the changes from the earlier analyses to 2018, which are detailed in the rest of this briefing.

INCREASING TECHNOLOGY COSTS

The NHTSA-led 2018 regulatory analysis assumes far higher technology costs than the previous two assessments, and this change substantially increases the overall estimated cost of the standards. The main component in this increase is the cost of new technologies to improve vehicle efficiency and reduce greenhouse gas emissions. Primarily these are engine, transmission, mass reduction, aerodynamic, and tire rolling resistance technologies on gasoline combustion vehicles. These technologies were extensively assessed in the earlier analyses. The National Research Council also performed a similar technology assessment.[2] Arguably these assessments were conservative, declining to take into account emerging auto industry developments.[3] The NHTSA 2018 analysis rejects those earlier analyses and determines that less technology is available in the time frame of the regulation, delivering fewer benefits, at greater costs.

In the 2018 analysis, the agencies limit technology availability in several ways. One way is by excluding engine-efficiency technologies. Mazda is deploying homogeneous charge compression ignition (HCCI) in some of its engines, Volkswagen and Mercedes are deploying electric turbocharging, Volkswagen and Mazda are deploying Miller-cycle engines, and Nissan is deploying variable compression ratio engines. The agencies have available engine maps to simulate these technologies along with other engine technologies. Nevertheless, they exclude them from consideration.

The 2018 analysis artificially restricts manufacturers to specific technology paths in ways that the earlier analyses do not, and which are contradicted by empirical evidence. An example is the use of high-compression ratio (HCR) engine technology, which is already deployed on Mazda and Toyota non-hybrids and on Ford, General Motors, Hyundai, and Nissan hybrids. By the agencies' own earlier analyses, HCR is among the most cost-effective compliance technologies available to manufacturers. But the 2018 NHTSA analysis modeling restricts it from being deployed on 70% of the fleet. In addition, the analysis imposes compatibility constraints that prevent technologies from being applied together for purposes of modeling technology change in response to more stringent fuel-economy standards, despite the fact that examples already exist of those technologies being used together on vehicles. Examples of this include turbocharging with cylinder deactivation and cooled exhaust gas recirculation on non-turbocharged engines.

For purposes of the 2018 proposal, the agencies also limit the benefits of existing technologies in ways that the earlier analyses did not. The 2018 rulemaking analysis reduces the effectiveness of many engine technologies, including some that are quite common in the 2025 fleet as that is modeled for the analysis. For example, cooled exhaust gas recirculation (EGR) at a $350 cost with is modeled at a 0% per-mile CO_2 improvement (and at a $350 cost); previously, the agencies had estimated that this technology would deliver a 2% to 5% benefit, based on vehicle simulation modeling.

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2 National Academies of Sciences, Engineering, and Medicine, "Cost, Effectiveness, and Deployment of Fuel Economy Technologies for Light-Duty Vehicles," (National Research Council; Division on Engineering and Physical Sciences; Board on Energy and Environmental Systems; Committee on the Assessment of Technologies for Improving Fuel Economy of Light-Duty Vehicles, Phase 2, 2015), https://www.nap.edu/initiative/committee-on-the-assessment-of-technologies-for-improving-fuel-economy-of-light-duty-vehicles-phase-2

3 Nic Lutsey, Dan Meszler, Aaron Isenstadt, John German, Josh Miller, "Efficiency technology and cost assessment for U.S. 2025–2030 light-duty vehicles" (ICCT: Washington DC, 2017), http://www.theicct.org/US-2030-technology-cost-assessment.

In another example, the benefit delivered by advanced turbocharging varies widely in the agencies' modeling—and, implausibly, is sometimes zero or even negative. The effectiveness of common fuel-efficiency technologies like stop-start, mild hybrids, and transmissions with more gears is also reduced. Incorporating lower benefits from these technologies into the modeling has the effect of increasing the amount of higher-cost hybrid technology that the agencies project manufacturers will be forced to use to comply with rising fuel-economy targets.

To new limitations on technology deployment options and reduced benefits from energy-efficiency gains attributed to specific technologies, the agencies add to the 2018 analysis higher technology costs that do not reflect the latest industry information. Examples include variable valve timing, turbocharged downsizing, cooled EGR, for which cost estimates used by the agencies are generally 30% to 100% higher than estimates from automakers' and suppliers' real-world developments through 2018, as analyzed by the ICCT and by the EPA.[4] For advanced cylinder deactivation, the agency costs are overstated by more than 100%. The agencies also fail to reflect findings from technology developments[5] showing that a 5% to 10% reduction in vehicle curb mass by 2025 actually reduces vehicle cost, and that the auto industry will likely deploy at least 15% mass reduction by 2025 at near zero net cost (and consistently less than $500 per vehicle). The agencies' modeled hybrid costs are typically $5,000 or more per vehicle, more than double other estimates.[6] The combination of reduced technology availability and high hybrid costs especially drives up the agencies' projected 2025 compliance costs.

The effect of any of these individual decisions may be small. But cumulatively these changes in technology assumptions largely explain the doubling and tripling of technology costs noted in Table 2. Another important related change for the 2018 analysis is the agencies' use of a uniformly high retail price equivalent for all technology of 1.50 (i.e., adding 50% indirect cost to all technologies). This is in contrast to the more realistic previous indirect cost multiplier method that differentiates technology having differing, and generally lower, cost depending on technology complexity. The agencies also assume slower learning rates, which diminishes the technology cost reduction over time. They also unjustifiably move aerodynamic and rolling-resistance technology into the 2016 baseline, which reduces the use of these technologies by manufacturers as compliance strategies in later years, for purposes of the model.

Figure 2 shows the cumulative reduction in fuel consumption (horizontal axis) and associated cost (vertical axis) as additional technology is added to the baseline 2016 vehicle according to the NHTSA-led 2018 proposal and the EPA 2017 analysis. The figure also shows ICCT's 2017 analysis, which updated technology and cost values based on industry announcements. These cost curves show the medium car major technology pathway, based on each regulatory fleet compliance model. The other major vehicle classes would have analogous charts with a similar fundamental relationship.

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4 International Council on Clean Transportation, "Comments on the Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021-2026 Passenger Cars and Light Trucks," https://www.theicct.org/news/comments-safe-regulation-2021-2026

5 Nic Lutsey, Dan Meszler, Aaron Isenstadt, John German, Josh Miller, "Efficiency technology and cost assessment for U.S. 2025–2030 light-duty vehicles" (ICCT: Washington DC, 2017), http://www.theicct.org/US-2030-technology-cost-assessment.

6 John German, "Hybrid vehicles: Trends in technology development and cost reduction" (ICCT: Washington DC, 2015), https://www.theicct.org/publications/hybrid-vehicles-trends-technology-development-and-cost-reduction

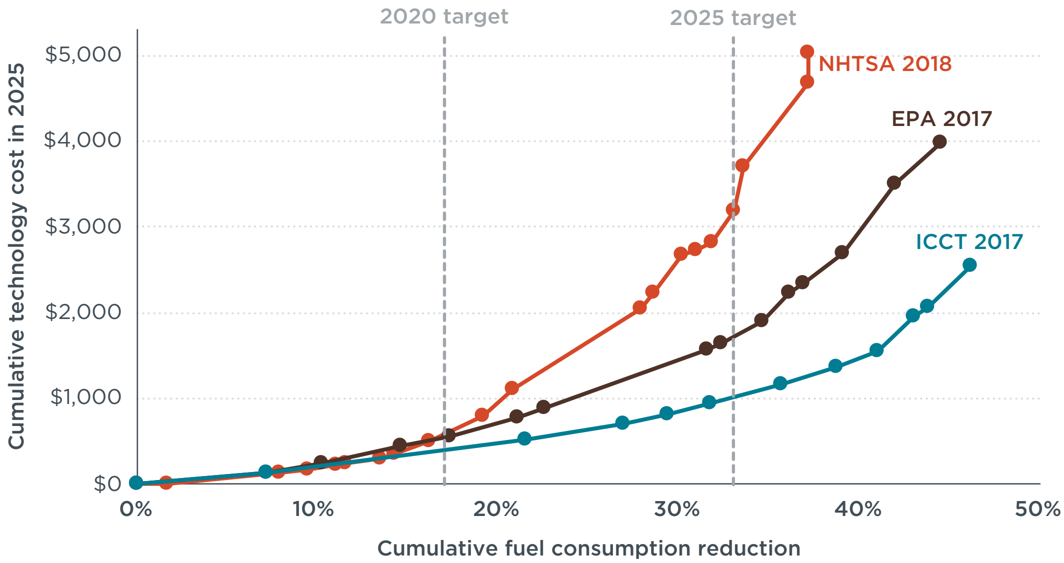

Figure 2. Cumulative fuel-consumption reduction technology and associated costs, compared with the adopted 2020 and 2025 regulatory targets for medium-sized cars.

The two vertical hashed lines in the chart indicate the average fuel-consumption reduction needed for all medium-sized cars to meet the adopted 2020 and augural 2025 regulatory targets. While all three analyses estimate about $500 in new technology costs to reach the 2020 regulatory target, which is a 17% reduction in fuel use per mile versus model year 2016, they diverge sharply thereafter. The 2018 agency analysis estimates twice the cost to comply with the 2025 target (33% reduction) as the EPA 2017 analysis, and three times that of the ICCT 2017 analysis.

CHANGING ASSESSMENT OF FUEL-SAVING BENEFITS

Fuel-saving benefits are the difference in total fuel consumption between a projected national vehicle fleet with rising fuel-economy standards and one without the standards. A key change the agencies made in the 2018 benefit-cost analysis was to assume that fleet average fuel economy would continue to rise even without the augural 2025 regulatory targets in place, a change that appreciably reduced the estimated benefit of the 2025 standard. Figure 3 shows projected test-cycle fuel economy improvement from the augural standards and the improvement in fleet fuel economy projected even in the absence of rising targets. The augural standard would improve fleet average fuel economy from 32 miles per gallon (mpg) in 2016, to 41 mpg in 2021, to 44 mpg in 2026, reducing the fuel cost of driving by 28% from 2016 to 2025, and by 14% from 2020 to 2026. By projecting a 1% per year improvement after 2020 even if the targets were frozen at 2020 levels, NHTSA's revised 2018 analysis eliminates nearly a quarter of the augural standards' fuel-saving benefits.

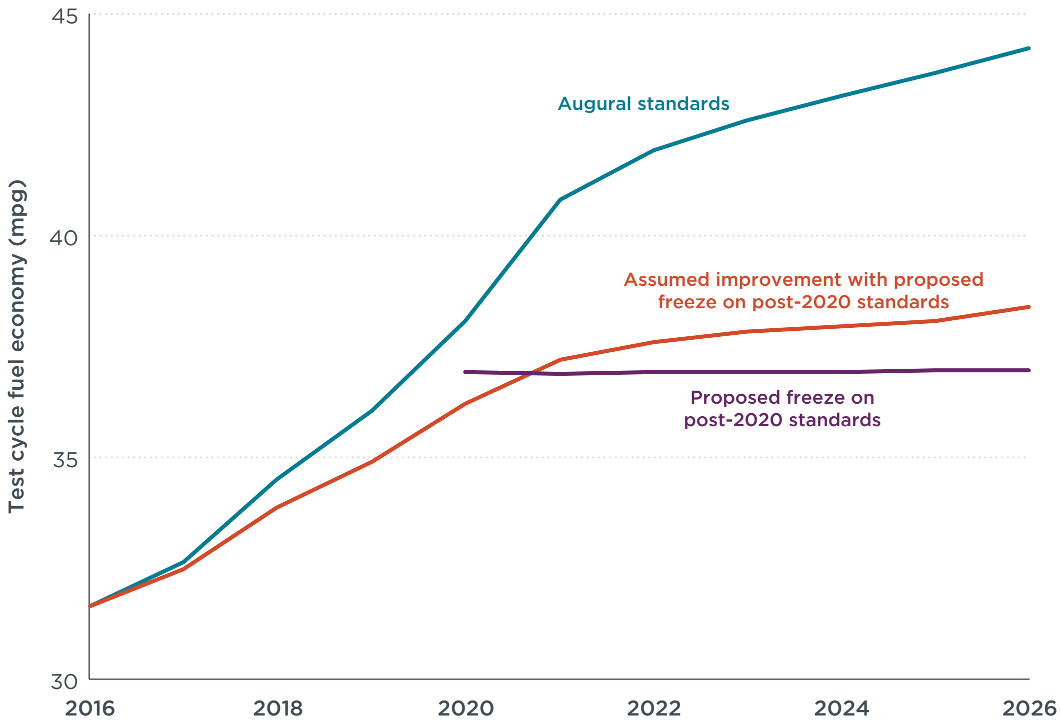

Figure 3. Agency-estimated fuel economy for 2016–2025 to meet augural and proposed rollback standards (and proposed frozen standards shown)

The problem with assuming a natural market-driven increase in fuel economy is that it is contradicted by historical experience. From 1986 to 2004 in the United States, when fuel economy standards were frozen, tested fuel economy in fact decreased from 26 mpg to 24 mpg, as engine-efficiency improvements were used to make vehicles bigger and faster, rather than allow them to travel further on a gallon of fuel.[7] Even with more stringent fuel economy and CO2 standards, the auto industry has not improved fuel efficiency from 2016 to 2017.[8]

The only historical instance in which average fuel economy rose without the driver of a fuel-efficiency standard occurred in Europe from 2005 to 2010, when vehicle efficiency improved at a rate of about 0.5% per year. But in that instance there was a different driver: fuel prices, which averaged the equivalent of $4.00 per gallon—60% higher than the $2.53 per gallon U.S. average gasoline price in 2017, and 40% higher than the $2.81 per gallon average in 2018.

The effect of this change on the regulation's overall benefit-cost analysis is substantial. As shown in Table 2, the average per-vehicle reduction in fuel savings in the agencies' 2018 re-analysis is 21% (compared to the NHTSA 2016 analysis) to 41% (relative to the EPA 2017 analysis). Most of that reduction comes from this change in the underlying assumptions of the analysis.

7 U.S. Environmental Protection Agency, "The EPA Automotive Trends Report: Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975," (March 2019) https://www.epa.gov/automotive-trends/download-automotive-trends-report

8 National Highway Traffic Safety Administration, "Projected Fuel Economy Performance Report," (February 14, 2017), https://one.nhtsa.gov/CAFE_PIC/MY 2016 and 2017 Projected Fuel Economy Performance Report Final.pdf and "Manufacturer Projected Fuel Economy Performance Report," (April 30 2018), https://one.nhtsa.gov/cafe_pic/MY_2017_and_2018_Projected_Fuel_Economy_Performance_Report.pdf

INCREASED CRASH-RELATED COSTS

Among the cost factors evaluated in the agencies' benefit-cost analyses of fuel economy targets are some related to vehicle accidents: the effects of light-weighting vehicles, sales changes caused by the standards, and additional driving as the cost per mile falls due to better fuel economy (i.e., the rebound effect). Crash-related costs are dramatically increased in NHTSA's 2018 analysis.

Table 3 compares the crash costs from NHTSA's 2018 and 2016 analyses, as well as EPA's 2017 analysis. NHTSA's 2018 analysis acknowledged that light-weighting effects are not statistically significant. In any case these effects are relatively small, and are therefore not discussed further here. However, modeled rebound effects and vehicles sales response effects greatly increased in the 2018 NHTSA analysis, transforming insignificant final benefit-cost outcomes in the earlier analyses (a $2 billion benefit in the EPA 2017 analysis, a $1 billion cost in the NHTSA 2016 analysis) into a large $197 billion cost.

Table 3. Crash-related costs from three regulatory analyses

	Cost (billions)			Rationale for NHTSA 2018 changes
	EPA 2017	NHTSA 2016	NHTSA 2018	
Light-weighting	$4.5	$10	-$2.4	Increased use of light-weighting technology increases risk of fatality and injury in crashes.
Rebound effect	-$2.7	-$11.6	-$107	More driving is assumed from drivers capitalizing on fuel savings (20% rebound effect vs 10% in previous analyses), leading to more crashes.
Sales response and scrappage model	N/A	N/A	-$88	Assumed sales response model predicts more technology results in lower new vehicle sales (by about 1%). New vehicle scrappage model creates additional used vehicles and used vehicle activity, leading to increased crash/fatality costs.
Total	**$1.8**	**-$1.2**	**-$197**	

Notes: Negative numbers are a disbenefit to society, positive numbers are a benefit. "N/A" means the factor was not quantified. The breakdown of rebound and non-rebound effects is based on sensitivity cases; numbers do not sum due to rounding.

In 2018 NHTSA doubled the assumed rebound effect, from 10% in the earlier analyses (i.e., for a 20% percent reduction in per-mile driving cost, a 2% increase in driving) to 20%. To support the 2018 decision, the agencies cite the same studies, but conclude differently. The agencies put more weight on the studies with higher elasticity coefficients. Ultimately, their choice to raise the assumed rebound effect relies more on backward-looking studies with large historical fuel price changes (which consumers appear to react more strongly to) rather than vehicle technology changes. More appropriate studies incorporating rising incomes, increased urbanization, and reduced driving fuel costs indicate a rebound effect of 10% or less that declines over time.[9]

9 See Kenneth A. Small, Kurt Van Dender, "Fuel Efficiency and Motor Vehicle Travel: The Declining Rebound Effect," Energy Journal Vol. 28, No. 1 (2007), https://www.jstor.org/stable/41323081 and 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

Doubling the size of the rebound effect influences the benefit-cost outcome in ways that extend far beyond crash-related costs. Illustrating the incoherence of their new approach, the agencies' 2018 analysis offsets the rebound crash-related costs of $107 billion: on the rationale that an individual's choice to drive more because it costs less is "freely chosen rather than imposed," the agencies count an equal-but-opposite $107 billion benefit for greater mobility. Adding and subtracting costs like this allows the agencies to claim that the rollback saves $500 billion dollars and still count the related fatalities, despite the offsetting benefits they acknowledge. In addition, the rebound causes significant overall disbenefits—more congestion, emissions, and fuel costs—that are counted elsewhere in the 2018 analysis (see "Other impacts," below).

The increased crash-related costs of $88 billion in NHTSA 2018 due to sales and used-car market effects are attributable to a change in the sales response model. Previous regulatory analyses reflect the fact that consumers place a value on incremental 3% to 4% per year fuel economy improvements and maintain similar vehicle purchasing patterns. The 2018 re-analysis, however, assumes that consumers do not value those efficiency gains. On that basis, the model projects that new vehicle sales decline by 150,000 to 200,000 by 2025 under the augural standards, equivalent to about 1% of annual sales (approximately 17 million in 2018). This assumption, in turn, slows the scrappage of older vehicles built to less-safe designs and equipped with less safety technology, which then are driven more miles.

These modeled fleetwide effects are novel, have never been validated, and have never been employed in regulatory analyses. NHTSA and EPA have done dozens of efficiency, emissions, and safety regulations that impose vehicle costs; never has either agency modeled such sales-response and scrappage effects. The newly estimated impacts, $88 billion, are immense; and yet there is no peer-reviewed vehicle model behind them.[10] Major new regulatory analyses methods (e.g., vehicle simulation, engineering teardown, fleet compliance models) typically do involve expert analysis and peer-reviewed models.

As an indication of how questionable NHTSA's new CAFE scrappage model is, EPA advised changes be made because the "the scrappage model produced vastly unrealistic growth in the overall fleet size, which in turn causes an unrealistic over-inflation of the fatalities estimated for the Augural standards."[11] Due to the scrappage model and rebound assumptions, the 2018 re-analysis projects a total of 12,680 deaths attributable to the augural standards over the life of the regulated vehicles (in 2017 in the United States, 37,133 people died in motor vehicle accidents). By contrast, the original rulemaking analysis in 2012 and the subsequent analyses NHTSA and EPA in 2016 and 2017 projected between -500 and +200 deaths attributable to the 2025 standards. That is, the established regulatory agency fleet modeling approach—without using the new and unvetted model with questionable fleet-level effects—estimates that the number of crash-related deaths remains about the same and might actually decline slightly.

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10 See Bento et al., "Flawed analyses of U.S. auto fuel economy standards," Science **362** (6419), http://science.sciencemag.org/content/362/6419/1119

11 See Regulations.gov. Review Materials for The Safer Affordable Fuel-Efficient Vehicles Rule for Model Years 2021-2026 Passenger Cars and Light Trucks NPRM. August 14, 2018. https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0453*: "The new vehicle sales model produces small reductions in projected sales under the Augural standards, while the scrappage model projects an increase in fleet size that far outweighs the sales reductions (by a factor of 60:1.)" When EPA corrected the CAFE modeling discrepancies in June 2018, the adopted standards did not result in a fatality increase, but the discrepancies remained in the agencies' August 2018 analysis.*

REDUCED POLLUTION IMPACTS

Pollution-related impacts of fuel-economy regulation include not only reduced CO_2 emissions but also lower levels of other pollutants that affect local air quality, such as particulate matter or volatile organic compounds. NHTSA's 2018 analysis reduces the projected environmental benefits of these impacts in the augural standards by 80% to 90% from the estimates in the earlier analyses (table 4).

Table 4. Pollution impacts from three regulatory analyses

	Impact (billions)			Rationale for NHTSA 2018 changes
	EPA 2017	NHTSA 2016	NHTSA 2018	
CO_2 damage	$20	$27	$4.3	Lower estimated fuel savings and increased rebound effect; lower estimated social cost of carbon ($7–$10/ton vs. $47–$78/ton)
Local air pollution	$9	$11	$1.2	Lower reductions in emissions of NOx, VOC, PM, SO_2 due to lower fuel savings, rebound effect. Most upstream petroleum supply emissions are assumed to occur overseas and are excluded
Total	**$29**	**$37**	**$5.5**	

Notes: Positive numbers are a benefit to society. NO_x = oxides of nitrogen; VOC = volatile organic compounds, PM = particulate matter, SO_2 = sulfur oxides.

The changes discussed above made in NHTSA's 2018 re-analysis to the sales response and scrappage projects, and the changed assumption for rebound effect, account for part of the reduction in estimated environmental benefit, by reducing projected fuel savings. Not only does the smaller change in fuel consumed directly limit the reduction in exhaust pollutant emissions, it also reduced benefits gained by reducing emissions upstream in the petroleum production supply chain.

But the greater part of the reduction in the climate benefit derives from reducing the social cost of carbon. The earlier estimates set the social cost of carbon at $47–$78 per ton (the range reflects the rise over time from 2022-2050), in line with the recommendations of an interagency working group under the Obama administration. NHTSA's 2018 analysis lowers that to $7–$10 per ton by limiting the focus to domestic (rather than global) damages from CO_2 emissions.

Additionally, NHTSA 2018 assumes that 50% of increased gasoline consumption would be supplied from domestic refining, and that 90% of this additional refining would use imported crude petroleum. This assumption effectively pushes much of the upstream air pollution effects outside the U.S., and therefore outside the benefit-cost analysis.

OTHER IMPACTS

The treatment of congestion, refueling time, energy security, and increased mobility also influence the outcome of the NHTSA 2018 re-analysis. These factors have consistently been included in the agencies' benefit-cost analyses, although their effects are relatively small compared to those discussed above.

Table 5. Other impacts from three regulatory analyses

	Impact (billions)			Rationale for NHTSA 2018 changes
	EPA 2017	NHTSA 2016	NHTSA 2018	
Congestion	-$6.2	-$5.0	-$52	Higher rebound effect; changes to vehicle scrappage model result in greater projected numbers and increased driving of used vehicles
Refueling time	$7.6	$6.1	$8.4	Similar on a per-vehicle basis
Energy security	$4.6	$8.7	$11	Similar on a per-vehicle basis
Increased mobility	$10	$9.1	$61	Higher rebound effect
Rebound offset	N/A	$1.2	$107	Offset due to agency rebound effect for crash-related disbenefit (see Table 2)
Total net impact	**$16**	**$20**	**$135**	

Notes: Negative numbers are a disbenefit to society, positive numbers are a benefit. No rebound offset was included in the EPA 2017 analysis.

Congestion refers to inducing driving, and is linked to rebound and sales-response effects. Refueling time declines as vehicles get more efficient over time. Energy security is an estimate of the broader energy benefits to the U.S. economy from more efficient vehicles. Increased mobility and rebound offset are agency estimates of benefits to vehicle owners from more efficient vehicles that cost less per mile to drive.

As shown in Table 4, congestion disbenefits increase to $52 billion in NHTSA's 2018 re-analysis. This appears to be largely the result of the greatly increased rebound effect. As mentioned earlier, along with the additional mobility from the rebound effect the NHTSA 2018 analysis increases a rebound effect offset to negate the crash-related disbenefits. The valuation of time spent refueling and the energy security benefits from reduced oil use are roughly similar to earlier analyses on a per-vehicle basis.

REVISING THE REGULATORY ANALYSIS

The cumulative effect of the many changes to assumptions in the NHTSA-led agency 2018 analysis flips the regulation's benefit-cost ratio from positive to negative. It's useful to examine how the benefit-cost ratio changes when the assumptions are changed to more reasonable values to highlight the relative effect of each of the major assumption changes.

Figure 4 estimates the impact of the technical assumptions within the agencies' 2018 benefit-cost analysis. Starting from the left, the 2018 analysis resulted in an estimate that showed the augural 2025 standards providing a net disbenefit, at -$176 billion (i.e., $502 billion cost and $326 billion in benefits). Moving to the right in the figure, each step with a green box changes one major assumption at a time. These steps show our best research-based estimates on how the assumption changes individually impact the regulation's benefit-cost analysis. The steps are cumulative. The final column to the right includes all changes.

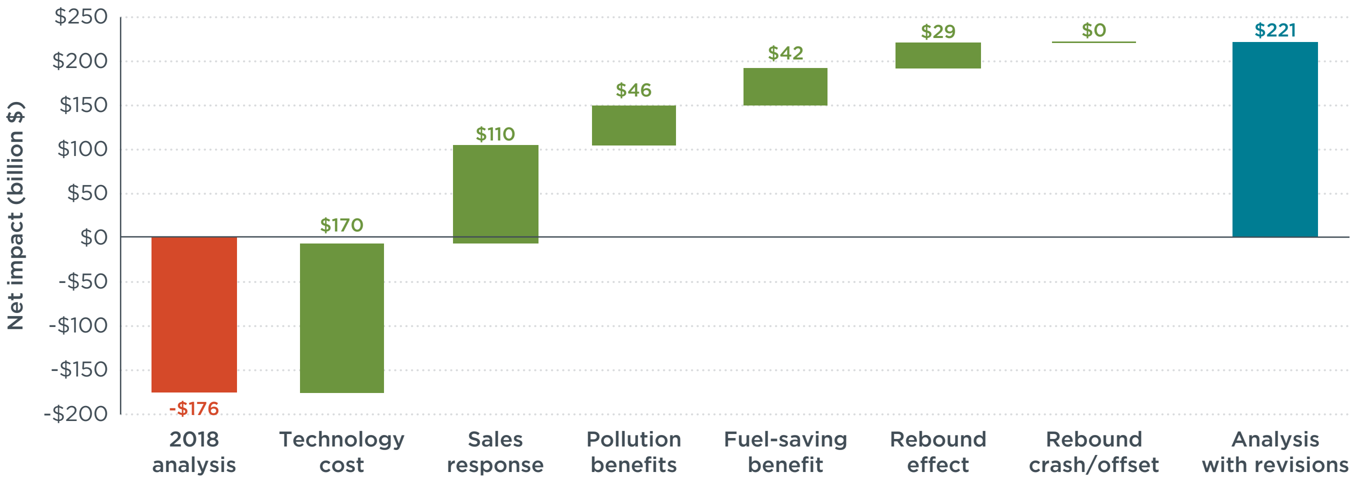

Figure 4. Net societal impact after revising 2018 agency modeling assumptions

The first step changes the associated technology cost to reflect the most recent data on vehicle efficiency technology cost and availability (in year 2025, this reduces the incremental cost by two-thirds), reducing costs by $170 billion.[12] The next most consequential 2018 modification is the agencies' decision to make vehicle sales decline as a result of the post-2020 efficiency improvements. This novel sales-response assumption adds $110 billion in economic costs due to increased crash-related costs. Following these, in order of their impact on the final outcome, are pollution benefits ($46 billion), fuel-saving benefit ($42 billion), and the changes to the rebound effect ($29 billion).

The cumulative effect of the changes in the agencies' 2018 analysis depicted in Figure 4 is the difference between a net cost of $176 billion and a net benefit of $221 billion—a positive swing of $397 billion. In the 2018 analysis, the regulatory agencies add about $300 billion in technology, crash-related, and congestion costs, while devaluing about $100 billion in fuel savings and pollution benefits.

Figure 5 shows effects on the regulation's overall benefit-to-cost ratio from the same changes to NHTSA's modeling assumptions. The 2018 regulatory analysis indicated a 0.6 benefit-to-cost, which would mean the benefits are 40% lower than the costs. Changing the six major assumptions as indicated above brings the ratio to 3.2. The magnitude of each of the assumption adjustments (represented by the size of the incremental bars in Figure 5) is not proportional to the absolute effect in billions of dollars (as shown in Figure 4 above) because some assumptions change the benefits (ratio numerator), some the cost (ratio denominator), and some both. With an ultimate benefit-cost ratio of 3.2, restoring the six assumptions brings the analysis back approximately in line with the previous 2016–2017 analyses (see Table 1).

12 See Figure 2 as an example of medium-sized car, and, for fleet analysis, see Nic Lutsey, Dan Meszler, Aaron Isenstadt, John German, Josh Miller, "Efficiency technology and cost assessment for U.S. 2025–2030 light-duty vehicles," (ICCT: Washington DC, 2017), http://www.theicct.org/US-2030-technology-cost-assessment.

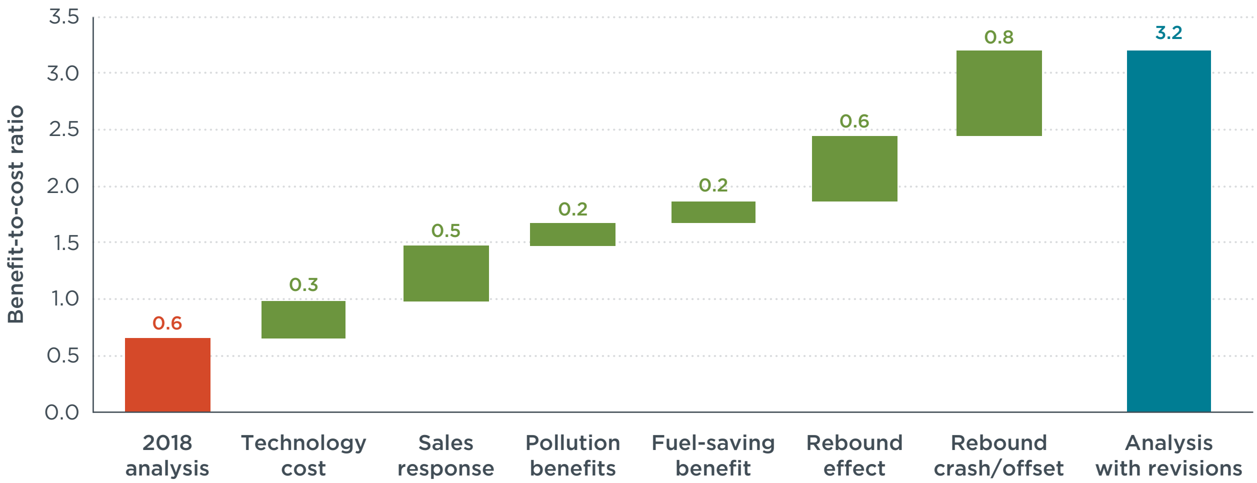

Figure 5. Benefit-cost ratio after revising 2018 agency modeling assumptions

CONCLUSION

The NHTSA-led 2018 regulatory re-analysis represents a departure from previous benefit-cost analyses done by that agency, as well as the EPA. Incorrect assumptions—such as restricting technology availability, increasing the cost of existing technologies, assuming vehicle sales decline due to efficiency improvements, increasing fatalities from greater use of older vehicles, and removing energy and emission-reduction benefits—inflate costs by $300 billion and devalue benefits by $100 billion. The effect of the agencies' new 2018 changes is to reverse the benefit-cost ratio from more than 3-to-1 to less than 1-to-1. In estimating an increase in vehicle efficiency standards to be detrimental to the public interest, the 2018 re-analysis—despite the fact that it relies on the same available agency expertise, data, research, and tools—reverses the findings of just two years earlier.