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Diary of a Wimpy Carbon Tax: Carbon Taxes as Federal Climate Policy

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Diary of a Wimpy Carbon Tax: Carbon Taxes as Federal Climate Policy

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Abstract

In this short note, I use MIT's Emissions Prediction and Policy Analysis (EPPA) Model to calculate the carbon tax required to replace the major federal climate change policies that existed as of 2016: Corporate Average Fuel Economy (CAFE) Standards on light-, medium-, and heavy-duty vehicles; the Clean Power Plan (CPP); and the Renewable Fuel Standard (RFS). I first use the Regulatory Impact Analyses of each policy to estimate each policy's respective greenhouse gas emission reductions in 2020, 2025, and 2030. Next, I use the EPPA model to simulate the carbon tax required to achieve the same emission reductions in each of the three benchmark years. The results suggest that a modest carbon tax can replace these three flagship climate change policies. If the carbon tax is applied to all greenhouse gases, adjusted for the gas' respective global warming index, the required carbon tax in 2020 is roughly \$7 per tonne. In 2025, the required tax increases to roughly \$22 per tonne; in 2030 the required tax is roughly \$36 per tonne. These results underscore the economic power of a carbon tax, compared to the economically inefficient policies currently in place.

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1 Introduction

There is near-unanimity among the scientific community that greenhouse gas emissions from human activity are causing climate change and that the costs will be large. There is also near-unanimity among economists that putting a price on greenhouse gas emissions through either a carbon tax or a cap-and-trade system is required to efficiently address anthropogenic climate change. Despite this, pricing greenhouse gas emissions has been vilified from both the left and right. From the left, pricing carbon has been referred to as a "wimpy" way to address climate change or viewed only as a way to raise revenues to fund subsidy programs. There are also concerns that such a tax would be regressive and impact other at-risk socio-economic groups more—with low-income and minority households bearing a greater burden of the tax. From the right, carbon pricing is lumped in with other taxes that are, from an economics standpoint, a drain on the economy even though carbon pricing improves the efficiency of economies.

Recent legislative activity suggests carbon taxes may be gaining some policy momentum, however. Senator Coons (D-Del), Representative Francis Rooney (R-Fla), and Representative Dan Lipinski (D-Ill) all recently introduced separate carbon tax proposals in their respective chambers, adding to a previous proposed bill from Representative Ted Deutch (R.-Fla). This momentum is juxtaposed on a period of declining efforts by the US to address climate change under the current administration. Much to the chagrin of environmental groups, two of the three flagship climate change policies that existed as of 2016 have largely been eliminated. The administration has effectively paused light-duty Corporate Average Fuel Economy (CAFE) standards, which incentivize vehicle manufacturers to increase the average fuel economy of their fleet, and is reversing the Clean Power Plan (CPP), which would have reduced greenhouse gas emissions from the electricity sector . The Renewable Fuel Standard, which requires a certain share of biofuels in all major fuels sold in the marketplace, and CAFE standards for medium- and heavy-duty vehicles remain in place for now.

In this short note, I use MIT's Emissions Prediction and Policy Analysis (EPPA) Model (for a description of the EPPA model see Chen et al. (2016)) to calculate the carbon tax required to replace the major federal climate change policies that existed as of 2016: Corporate Average Fuel Economy (CAFE) Standards on light-, medium-, and heavy-duty vehicles; the Clean Power Plan (CPP); and the Renewable Fuel Standard (RFS).[1] This exercise serves two related purposes. First, it allows us to gauge just how wimpy a carbon tax is. That is, if a carbon tax were an ineffective tool, and we believed that CAFE standards, the CPP, and the RFS were meaningful pieces of legislation, then the carbon tax required to replace these policies would be large. Second, if instead one were to view a carbon tax as an effective tool, then the level of the carbon tax required to replace these policies would tell us something about how important these policies are in addressing climate change.

[1] More papers using the EPPA model for policy analysis can be accessed here: https://globalchange.mit.edu/research/research-tools/human-system-model.

My analysis requires two steps. I first use the regulatory impact analyses (RIAs) of each policy to estimate each policy's estimated greenhouse gas emission reductions in 2020, 2025, and 2030. I calculate both the lower- and upper-bound of emission *reductions*. I take these reductions as given and do not critically analyze the accuracy of the estimated reductions even in the face of changes in the baseline. That is, the thought experiment in this research note is: "what carbon tax would be required to achieve the same *reductions* that are estimated in the RIAs across CAFE, CPP, and the RFS?" It is not: "what carbon tax would be required to achieve the same *emission levels* that are estimated in the RIAs across CAFE, CPP, and the RFS?" Doing so would be difficult given the different timing and baselines across the federal policies. Insofar as the baselines have changed since the RIAs have been written, for example one could argue that abatement under the CPP is overstated given the increase in state-level policies and solar cost reductions relative to the assumed baseline. This is less of an issue for my thought experiment, but would certainly affect the carbon tax to meet the emissions *levels* in the CPP RIA.

Next, I use the EPPA model to simulate the carbon tax required to achieve the same emission reductions in each of the three benchmark years. I report results from two types of carbon taxes: a carbon tax that taxes all greenhouse gases according to their global warming potential and a carbon tax that is only applied to carbon dioxide.

The results suggest that a modest carbon tax can replace these three flagship climate change policies. Table 1 reports all of the results. If the carbon tax is applied to all greenhouse gases, adjusted for the global warming potential, the required carbon tax in 2020 is roughly \$7 per tonne. In 2025, the required tax increases to roughly \$22 per tonne; in 2030 the required tax is roughly \$36 per tonne. These results underscore the economic power of a carbon tax, compared to the economically inefficient policies currently in place. If we instead restrict ourselves to only taxing carbon dioxide, the required tax increases to roughly \$22 per tonne in 2020, \$40 per tonne in 2025, and \$58 per tonne in 2030 .

These results imply that modest carbon taxes can replace CAFE standards, CPP, and the RFS. To put these numbers into perspective a \$10 carbon tax is equivalent to taxing gasoline roughly 10 cents per gallon. On the electricity side, the national average emission rate for electricity generation is roughly 1 pound per kWh in 2017.[2] Therefore a \$10/ton carbon tax would increase costs by a half of a penny per kWh (\$0.005/kWh). The average electricity price is \$0.11/kWh, so this represents an increase of 4.5 percent. For a coal-dominated electricity grid, such as in Wyoming, Kentucky, or West Virginia, the average emissions per kWh is 2 pounds. Therefore, that same carbon tax of \$10 per tonne would increase electricity prices by \$0.01/kWh, or a 11 percent increase relative to the average electricity price in these markets of roughly \$0.09/kWh. In cleaner markets such as Washington and Idaho, average emission rates are roughly 0.2 pounds per kWh, implying an increase in average costs of roughly \$0.001/kWh, less than a two percent increase relative to their roughly \$0.08/kWh average electricity prices. Heating is another carbon intensive activity. Combusting 1000

[2] https://www.eia.gov/electricity/state/westvirginia/index.php.

cubic feet of natural gas leads to roughly 0.058 tons of carbon dioxide, while the US average residential price of natural gas is roughly $11 per 1000 cubic feet. Therefore a $10 per tonne carbon tax would present a roughly 5 percent increase.

An alternative way to view the impact of these taxes on consumers is to calculate per capita expenses across all sectors. The EPA reports per capita CO2 emissions across states with the most recent year being 2016.[3] The range across states is considerable, with Wyoming having per capita emissions of 100 metric tons per year (∼91 US tons). North Dakota has the second highest per capita emissions of 65 US tons. At the low end of the spectrum per capita emissions in states like California and much of the Northeast are below 10 US tons per year.

It is tempting to take these numbers and multiply them by a given carbon tax in order to calculate per capita increases in annual expenses. This would be a mistake, however. A second frequent misconception of carbon taxes is that they are regressive—their burden falls disproportionally onto the poor. This is misleading for three reasons. First, recent work (Goulder et al. (2019)) has shown that once you consider the effect of carbon taxes on wages, transfer income, and capital returns, carbon taxes are actually progressive. Second, one cannot discuss changes in annual expenses or the regressivity of carbon taxes without discussing how the revenue will be used. A complete discussion of the options and their impact on different socio-economic groups or states is beyond the scope of this research note. However, I note that a tax-and-dividend plan, a carbon tax that recycles the revenues on a per-household basis, is *progressive* even ignoring the additional effects listed above, since the carbon footprint of wealthy households is, on average, larger . Finally, these concerns ignore the regressivity of the current set of policies. Recent work has shown that these are actually *more* regressive than a carbon tax, even ignoring the revenues that a carbon tax generates (Davis and Knittel (2016)).

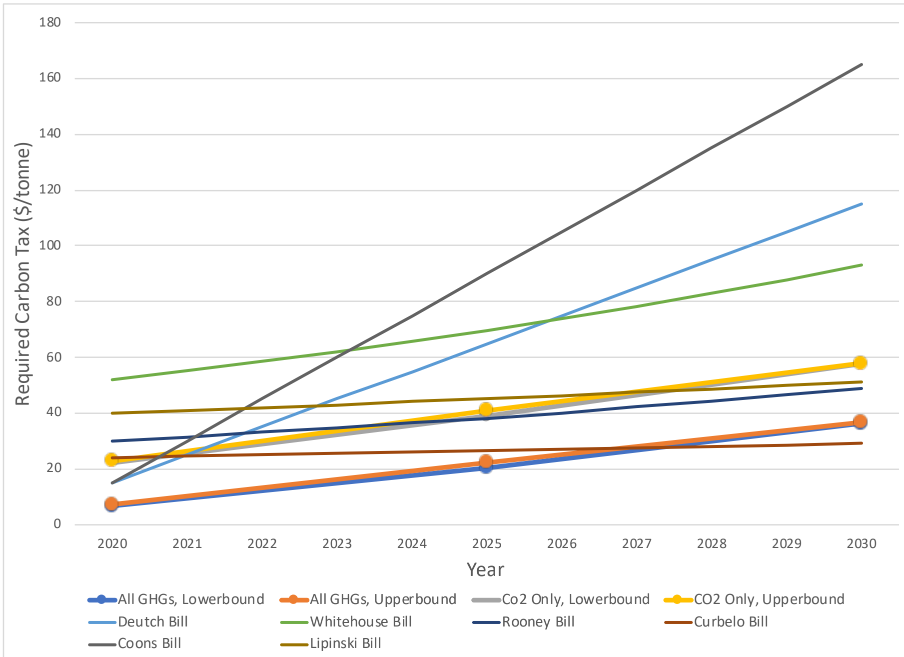
Table 1: Required Carbon Taxes ($s per tonne) Necessary to Replace CAFE, CPP, and RFS

	All Greenhouse Gases		CO_2 Only	
Year	Lower Bound Scenario	Upper Bound Scenario	Lower Bound Scenario	Upper Bound Scenario
2020	$6.77	$7.29	$22.20	$22.79
2025	$20.55	$22.51	$39.12	$41.14
2030	$36.34	$36.75	$57.70	$57.93

Next, I compare these required carbon taxes to the recent Congressional bills. Figure

[3] https://www.eia.gov/environment/emissions/state/analysis/pdf/stateanalysis.pdf.

Figure 1: Carbon Taxes Required to Replace the CAFE, CPP, and RFS Compared to the Current Congressional Bills



1 plots the four simulated required carbon taxes, along with the carbon tax path of the six current Congressional bills discussed above. I am grateful to the Columbia University's Center on Global Energy Policy for providing me with the time paths for the Congressional bills.[4] Figure 1 suggests that, provided these bills apply to all greenhouse gas emissions, all but the Curbelo bill would more than replace the greenhouse gas emission abatement from all three of the flagship climate policies. The Curbelo bill exceeds the reductions of these other bills initially, but falls short around 2027. Therefore, it too may exceed the abatement of CAFE, CPP, and the RFS. From this perspective, it would seem that environmentalists should strongly support each of these bills.

I argue that this thought experiment opens the door for building a consensus around climate change and climate change policy that replaces the policies that we had been relying on to reduce greenhouse gas emissions with a carbon tax that achieves the same reductions. Why should stakeholders prefer this scenario to the status quo? A useful way to think about how different stakeholders view my proposal to the current situation is to categorize stakeholders across two dimensions: (a) their interest in reductions in GHG emissions and

[4]More information is available here: https://energypolicy.columbia.edu/what-you-need-know-about-federal-carbon-tax-united-states.

(b) their concern about the costs associated with those reductions. Some stakeholders, such as environmentalists, place more weight on (a), call them E-types. Others, may care more about the costs of such a policy and care only about (b), call them C-types.

Replacing existing policies with a carbon tax that achieves the same level of reduction as the set of policies the carbon tax is replacing ensures that all stakeholders prefer it to the status quo, at least "weakly", meaning stakeholders either prefer it outright, or are indifferent between the compromise and the current policy environment. To see this, imagine a spectrum of voters between, and including, the E- and C-types. The E-only types are indifferent between this compromise and the status quo. GHG emissions are the same under both scenarios. The C-types, and anyone in between the two extremes, prefer the compromise as the costs are lower, while holding constant abatement.

There is also a carbon tax level that leaves the C-types indifferent and benefits the E-types.[5] This carbon tax holds the costs of abatement constant, and maximizes emission reductions. This holds because the existing policies are inefficient. Existing work has found, for example, that the RFS is three times more expensive than a carbon tax that achieves the same greenhouse gas reductions (Holland et al. (2015)). Jacobsen (2013) finds that tightening CAFE standards is as much as six times more expensive than reducing GHGs through a carbon tax. Bushnell et al. (2017) finds that the costs of the CPP could have varied by a factor of two depending on how it would have been implemented across the states.[6] I leave this calculation for future work.

2 Details

2.1 Greenhouse gas savings under each policy

We aggregated projected reductions of CO2-equivalent, CO_{2e}, emissions reported in regulatory impact analyses under each policy. This acts as the required emissions reductions the carbon tax must meet. In this section, I describe those calculations.

Renewable Fuel Standard

For the Renewable Fuel Standard, we incorporated renewable fuel requirements promulgated under the 2007 Energy Independence and Security Act (EISA). The final regulatory impact analysis, released in 2010, estimates emissions reductions in 2022 relative to projected volumes of renewable fuel in the Energy Information Agency (EIA)'s 2007 Annual

[5]This is an obvious simplification as E-types may be concerned about additional factors, other than just emission reductions, such as the distributional effects of the carbon tax. These concerns are certainly valid. However, it is important to understand that because the carbon tax generates revenues, if properly designed a carbon tax can address these valid concerns.

[6]The CPP left open to the states whether they would address their targets through a mass-based or a rate-based standard and whether states would meet their target individually or pool targets across other states. A mass-based standard with all states in a single pool is effectively a national cap-and-trade program and therefore the economically efficient sectoral-specific policy. A rate-based standard is a performance standard and therefore less efficient. See Bushnell et al. (2017) for the details.

Energy Outlook (AEO). This reference case also incorporates estimates of fuel consumption and prices from the 2009 AEO. EPA assumes that the production of renewable fuels results in an energy equivalent decrease in the production of petroleum-based fuels, applying 2005 refining energy use and emissions for gasoline and diesel. Lifecycle emissions for renewable fuels are estimated based on the mix of plants and feedstock projected in 2022. EPA's analysis does not account for any reductions in world crude oil prices, which might partly offset the decreased demand for conventional fuels .

The EISA establishes separate volumetric requirements for cellulosic biofuel, biomass-based diesel, total advanced biofuel, and total renewable fuels. EPA has consistently revised downward the requirements for advanced biofuels, as the industry has developed more slowly than expected. In our analysis, we adopt EPA's projected emissions reductions from the final regulatory impact analysis, which includes the initial target volumes for advanced biofuels. Consequently, our analysis likely overestimates the overall emissions reductions from renewable fuels by 2022, as advanced biofuels result in higher emissions reductions than non-advanced fuels (principally corn ethanol) on an energy-equivalent basis.

In the final regulatory impact analysis, estimated net changes in emissions include those related to the production of renewable fuels, including domestic and international land use changes; those related to the production of gasoline and diesel fuel; and differences in tailpipe emissions between renewable and conventional fuels. The regulatory impact analysis also reports annualized net emissions reductions, using a 30-year time horizon and no discounting. These emissions changes are presented in Table 2, below.

Table 2: Impact of Renewable Fuel Standards on GHG Emissions in 2022 (MMT CO_{2e})

Emissions Changes	Lower Bound Scenario	Most Likely Scenario	Upper Bound Scenario
One-Time Land Use Change	331.9	312.8	296.9
Annual Benefits of Renewable Fuels	-150	-150	-150
Annualized Net Emissions Change	-136.1	-138.4	-140.3

Clean Power Plan

In the final regulatory impact analysis for the Clean Power Plan, the U.S. EPA relied on the Integrated Planning Model (IPM) to project power sector behavior under future market conditions with and without the Clean Power Plan. EPA used input data consistent with the EIA's 2015 AEO, and incorporated federal and most state laws and regulations in effect or enacted and clearly delineated by March 2015.

EPA estimated emissions reductions under the Clean Power Plan for two illustrative compliance scenarios, a rate-based scenario in which affected electricity generating units (EGUs) in each state must achieve a given average emissions rate and a mass-based scenario in which affected sources must not exceed a given mass of emissions. EPA's modeling results suggest that the mass-based scenario would achieve greater emissions reductions by the 2025 interim compliance date; we therefore adopted the illustrative mass-based scenario as our upper bound for 2025 emissions reductions and the illustrative rate-based scenario as our lower bound. In both scenarios, EPA specified demand-side energy efficiency exogenously, based on demand reduction levels already achieved or required in states leading on energy efficiency improvement; under the rate-based scenario, states were allowed to procure renewable energy or demand-side energy efficiency outside of their borders.

The final regulatory impact analysis reports emissions reductions relative to 2005 historic emissions and to a baseline business-as-usual scenario. Our analysis incorporated emissions reductions relative to the 2005 baseline, provided in Table 3 below. In the final regulatory impact analysis, EPA did not quantify changes in non-CO2 GHG emissions or changes in CO2 emissions outside of the electricity sector. Nonetheless, EPA determined that upstream methane emissions from natural gas and coal production were likely to decrease under the regulation, although the net impact would be small relative to the change in direct CO2 emissions from power plants.

Table 3: Projected Emissions Reductions from Clean Power Plan (MMT CO2)

Year	Emissions Reductions Under Rate-Based Scenario	Emissions Reductions Under Mass-Based Scenario
2020	-542.5	-553.4
2025	-680.4	-709.4
2030	-790.2	-788.3

We also examined emissions standards for new, modified, and reconstructed power plants, finalized by EPA in 2015. However, the final regulatory impact analysis for this rule-making projected that no non-compliant fossil fuel capacity would be constructed in absence of this regulation, a finding which remained robust under several sensitivity analyses. As such, we did not include any additional emissions reductions associated with this regulation in our analysis.

CAFE Standards

Finally, we examined the final regulatory impact analyses for Phase I and Phase II Corporate Average Fuel Economy (CAFE) standards for passenger cars and light-duty trucks, as well as Phase I standards for medium- and heavy-duty vehicles. We also considered the draft regulatory impact analysis for proposed Phase II fuel economy standards for medium- and heavy-duty vehicles.

For passenger cars and light-duty trucks, EPA projects changes in both upstream and downstream emissions. The final regulatory impact analysis for Phase I standards, covering model years (MY) 2012 through 2016, estimates emissions reductions relative to the National Highway and Traffic Safety Administration (NHTSA) CAFE standards for MY 2011. For both the reference and the control scenarios, EPA's analysis develops a baseline fleet based on MY 2008 data, and then uses projections for vehicle sales and fleet composition from AEO 2010 to develop a reference fleet for the period under consideration. The analysis also applies historical data on VMT growth rates and vehicle survival rates; adjusts for a 10-percent "rebound effect" in driver behavior; and accounts for significant program flexibilities, such as manufacturers paying fines in lieu of compliance, manufacturer over-compliance, credit trading, and flexible fuel vehicle credits. EPA notes that increased emissions from electricity use by electric vehicles would reduce slightly the estimated emissions benefits, by 24.8 MMT CO_{2e} over the lifetime of the program; however, given its relatively small magnitude, we do not attempt to translate this lifetime adjustment into annual adjustments, and therefore do not include this impact in our analysis.

For Phase II standards for passenger cars and light-duty trucks, covering model years 2017 through 2025, the regulatory impact analysis estimates emissions reductions relative to the final Phase I standards for MY 2016. The reference case assumes no additional compliance flexibilities that might result in environmental dis-benefits, as well as no penetration of electric vehicles (EVs) or plug-in electric vehicles (PHEVs). EPA uses the MY 2008 and MY 2010 fleets as alternative baselines, and then applies data from AEO 2011 and 2012 to develop a reference fleet for 2017-2025. These alternative baselines reflect uncertainty in sales volumes, vehicle technologies, and consumer demand, and therefore capture information about both more recent fleet composition and fleet composition prior to the recession. EPA's analysis again applies historical data on VMT growth rates and vehicle survival rates, and adjusts for a 10-percent rebound effect.

Overall estimated emissions reductions from Phase I and II standards are reported in Table 4 below. EPA does not provide direct estimates of 2025 emissions reductions for Phase I standards or Phase II standards using the 2010 baseline fleet. For Phase I standards, our analysis adopts an average of 2020 and 2030 estimates; for the Phase II standards, we assume that the same proportion of 2030 emissions reductions reached by 2025 under the 2008 baseline fleet scenario will be reached under the 2010 baseline fleet scenario.

For medium- and heavy-duty vehicles, EPA estimates net changes in upstream and downstream emissions and in HFC emissions from air conditioning leakage. Estimated emissions reductions from Phase I standards, covering MY 2014 through 2018, are reported relative to the performance of the MY 2010 fleet. Projections from AEO 2011 were used to estimate future vehicle sales and VMT. EPA's analysis also accounts for a rebound effect that ranges from 0.50 percent for combination tractors to 1.33 percent for vocational vehicles. Estimated emissions reductions from Phase I standards are reported in Table 5 below; in our analysis, we adopt a weighted average of 2018 and 2030 estimates since EPA does not report estimated emissions reductions in 2025 directly.

Emissions reductions from proposed Phase II standards for medium- and heavy-duty

Table 4: Impacts of Phase I and II CAFE Standards for Passenger Cars and Light-Duty Trucks on GHG Emissions (MMT CO_{2e})

Year	Phase I: Annual Emissions Reduction	Phase II: Annual Emissions Reduction (2008 Baseline Fleet)	Phase II: Annual Emissions Reduction (2010 Baseline Fleet)
2020	-156.3	-27	-28
2025	-231.9 (calculated)	-140	-126.6 (calculated)
2030	-307.4	-271	-262
2040	-401.5	-455	-423
2050	-505.9	-569	-506

vehicles, which would cover model years 2021 through 2027, are reported relative to both a "more dynamic" and "less dynamic" baseline. Both baseline scenarios incorporate the impacts of Phase I standards; the "more dynamic" baseline assumes additional fuel efficiency improvements beyond Phase I standards for tractors and trailers, while the "less dynamic" baseline assumes very little improvement in vehicle emissions. EPA applies historic VMT growth rates, taken from AEO 2014, and again adjusts VMT to account for a rebound effect in driver behavior. EPA does not estimate the impacts of delayed fleet turnover on the overall change in emissions. Estimated emissions reductions from proposed Phase II standards (as compared to the more dynamic baseline scenario) are reported in Table 6 below; values for 2030 are not reported directly, so we adopt an average of 2025 and 2035 emissions reductions. In our analysis, we assume that EPA's preferred standards will be adopted in the final rulemaking.

The emission reductions across Tables 2 through 6 are aggregated in 2020, 2025, and 2030 to form the basis for the abatement targets that the carbon taxes must meet. I calculate lower- and upper-bounds for these targets. Table 7 summarizes these calculations. To put these numbers into perspective, US total CO_2 emissions in 2018 are estimated to be were 5,319 MMT.[7]

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Table 5: Annual Total GHG Emissions Reductions from Phase I Standards for Medium- and Heavy-Duty Vehicles (MMT CO_{2e})

Year	Downstream Emissions Impacts	Upstream Emissions Impacts	HFC Emissions Impacts	Total Emissions Impacts
2018	-22	-6	-0.1	-29
2025	-	-	-	-56.4 (calculated)
2030	-61.9	-14.2	-0.4	-76
2050	-89	19	-0.6	-108

Table 6: Annual Total GHG Emissions Reductions from Phase II Standards for Medium- and Heavy-Duty Vehicles (MMT CO_{2e})

Year	Downstream Emissions Impacts	Upstream Emissions Impacts	HFC Emissions Impacts	Total Emissions Impacts
2025	27.2	9.3	0.09	36.6
2030	-	-	-	-76.8 (calculated)
2035	86.9	29.7	0.25	116.9
2050	123.0	42.0	0.3	165.3

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Table 7: Summary of Project Emission Reductions

Year	Policy	Lowerbound Reductions (MMT of CO_{2e})	Upperbound Reductions (MMT of CO_{2e})
2020	RFS	136.1	140.3
	CPP	542.5	553.4
	CAFE LD Phase 1	156.3	156.3
	CAFE LD Phase 2	27	28
	CAFE HD Phase 1	29	29
	CAFE HD Phase 2	–	–
	Totals	890.9	907.0
2025	RFS	136.1	140.3
	CPP	680.4	709.4
	CAFE LD Phase 1	231.9	231.9
	CAFE LD Phase 2	126.6	140
	CAFE HD Phase 1	56.4	56.4
	CAFE HD Phase 2	36.6	36.6
	Totals	1268.0	1314.6
2030	RFS	136.1	140.3
	CPP	790.2	788.3
	CAFE LD Phase 1	307.4	307.4
	CAFE LD Phase 2	262	271
	CAFE HD Phase 1	76	76
	CAFE HD Phase 2	76.8	76.8
	Totals	1648.5	1659.8

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