State-specific impacts of repealing EPA GHG vehicle standards

Methodology

In order to understand the state-specific impacts of EPA's repeal of the Endangerment Finding and all vehicle GHG standards, EDF conducted an analysis. The analysis is based on the emissions analysis EDF conducted previously but allocated those emissions and the impacts of the changes in emissions and fuel use to each state. Where feasible, state-specific factors and data were applied.

Analysis of vehicle emission impacts, EGU emission impacts, and fuel cost impacts

For EDF, ERM conducted an analysis allocating the vehicle and electricity generating unit emissions to states, the health impacts from those emissions, and the change in fuel costs from those changes.

For each zero-emission vehicle (ZEV) adoption scenario conducted by EDF at a national level previously,[1] a top-down analysis was performed to apportion national vehicle emissions and fuel consumption data across states. This apportionment was completed using ERM's vehicle turnover model and provided state-level vehicle miles travelled (VMT), tailpipe emissions (NOx, $PM_{2.5}$[2], SO_2, and VOC), and fuel/electricity consumption (gallons, MWh, etc.), by vehicle and fuel type.

Bottom-up analysis was then performed using state-level tailpipe emissions and fuel/electricity consumption to calculate the following state-level metrics:

- Electricity generating unit (EGU) emissions associated with electricity generation required to meet EV demand
- Health impacts (incidence and monetary value) of PM and ozone exposure associated with changes to vehicle and EGU emissions (premature mortalities, asthma attacks, missed school/work, emergency room/hospital visits)
- Fuel and electricity costs associated with fuel/electricity consumption

All state-level data were provided for years 2025-2055[3]. Tailpipe emissions, fuel/electricity consumption and costs, and EGU emissions were provided annually; annual and cumulative health impacts were provided in 5-year increments.

ERM vehicle turnover model

All vehicle data in this analysis were calculated using ERM's vehicle turnover model. This model incorporates user-defined ZEV adoption scenarios and utilizes vehicle type- and model year-specific data and assumptions extracted from U.S. EPA MOVES5 model to produce

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[1] https://library.edf.org/AssetLink/q6017oa85rgw8i4m4oh7a82phnm7i271.pdf

[2] Includes emissions from tire and brake wear

[3] ERM's vehicle turnover model provides results through 2050; approach to estimating 2051-2055 data described in following sections

annual outputs through 2050. Annual outputs are generated for each vehicle type[4] (by fuel type and model year); Table 1 shows how the MOVES5 vehicle types were aggregated to EDF vehicle type categories:

Table 1. MOVES5 vehicle type summary categories

MOVES regClassID	MOVES sourceTypeID	EDF Vehicle Type Category
20	21	Passenger Car
30	31, 32	Light Truck
41	31, 32, 43, 51, 52, 53	MDV
42	41, 42, 43	Bus
46	41, 42, 43	Bus
47	41, 42, 43	Bus
48	42	Bus
42	51, 52, 53	MDT
46	51, 52, 53, 61, 62	MDT
47	51, 52, 53, 61, 62	HDT

Although operational characteristics of each vehicle type and model year – such as age distribution, emission rates, VMT, etc. – were assumed to be consistent across states, state-level vehicle sales and in-use stock were estimated using state-level VMT data[5]. Furthermore, ERM applied state-level ZEV adoption forecasts to account for the significant geographical variation in current and expected ZEV adoption rates across vehicle types. Light-duty ZEV adoption forecasts were based on each state's 2024 battery electric and plug-in hybrid electric (BEV and PHEV) adoption rates relative to the national average. Medium- and heavy-duty ZEV adoption rates were based on the state's past adoption of the California Advanced Clean Trucks (ACT) rule or signatory status of the Multi-State Medium- and Heavy-Duty Zero Emission Vehicle Memorandum of Understanding (MHD ZEV MOU); if a state previously adopted ACT or signed the MHD ZEV MOU, it was assumed that its MHD ZEV adoption rate would be higher than that of states that did not previously adopt ACT or sign the MHD ZEV MOU[6].

State-level apportioning of national emissions and fuel data

The first step of ERM's analysis required the breakdown of EDF-provided national data to the state-level. ERM considered the following national ZEV adoption scenarios, provided by EDF:

- **Compliance**; EDF's baseline ZEV adoption forecast in which the 2024 vehicle emission standards are maintained
- **Low ZEV (high-emitting)**; EDF's low ZEV adoption forecast if 2024 vehicle emission standards are repealed
- **High ZEV (low-emitting)**; EDF's high ZEV adoption forecast if 2024 vehicle emission standards are repealed

For each scenario and vehicle type, ERM utilized its vehicle turnover model to create state-level ZEV adoption forecasts. As mentioned earlier, state light-duty ZEV (BEV+PHEV) adoption forecasts are tied to historical 2024 data. For example, Figure 1 shows the ZEV adoption forecasts for passenger cars across states (associated with the "Compliance" scenario). Note that California has the highest ZEV adoption rate for each year through 2050 because it had the

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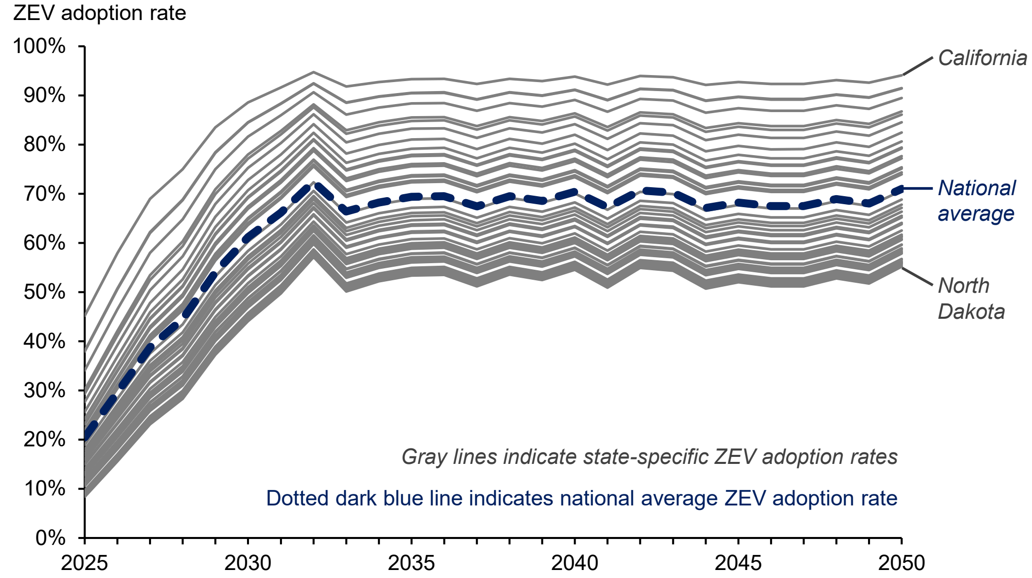
[4] Vehicle type denoted by unique vehicle source use type (sourceTypeID) and regulatory class (regClassID) combinations in MOVES5

[5] 2022 data (developed by HPMS for MOVES5 application); all data beyond 2022 projected using HPMS national VMT projections and EIA AEO 2025 regional sales forecasts

[6] More detail into state-level LD and MHD ZEV adoption rates provided in "State-level apportioning of national emissions and fuel data" section

highest state-level adoption in 2024; conversely, North Dakota has the lowest ZEV adoption rate for each year through 2050[7] because it had the lowest state-level adoption in 2024.

Figure 1. Passenger car ZEV forecasts ("Compliance" scenario)



Gray lines indicate state-specific ZEV adoption rates

Dotted dark blue line indicates national average ZEV adoption rate

For medium- and heavy-duty ZEV (BEV+PHEV for MDV, BEV+FCEV for HDV) forecasts, ERM first referenced EPA analysis that estimated the MHD ZEV sales shares in ACT and non-ACT states relative to the national average under the 2024 vehicle emission standards. For each vehicle type, ERM used these relationships to split national ZEV forecasts into two distinct forecasts: one for states with high ZEV adoption and one for states with low ZEV adoption. To account for the uncertainty associated with ACT implementation and assign value to the MHD ZEV MOU, ERM applied the high ZEV forecast to ACT states and non-ACT states that signed the MHD ZEV MOU; all other states were subject to the lower ZEV forecast. As an example, Figure 2 shows the ZEV (BEV+FCEV) adoption forecasts for buses across the two "categories" of states (associated with the "Compliance" scenario).

Figure 2. Bus ZEV forecasts ("Compliance" scenario)

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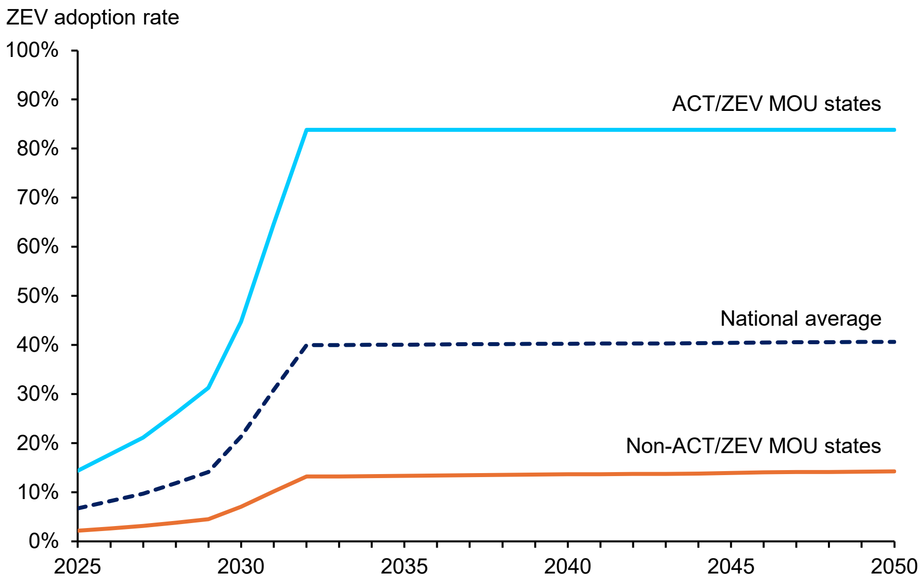
[7] 2050 ZEV adoption rates effectively assumed to be maintained through 2055



For each national ZEV scenario, application of state-level ZEV adoption rates generated the following state-level data forecasts for all vehicle types (by fuel type and model year):

- Vehicle sales, stock, VMT, fuel/electricity consumption, and emissions

Due to the utilization of different turnover models and underlying assumptions, these state-level results corresponded with national results (i.e., sum of all state-level results) that differed from national data previously modeled by EDF. To align ERM state-level results with EDF national data, ERM determined the state-level share of every metric in context of national ERM results (e.g., state share of NOx emissions from light truck gasoline consumption)[8] and applied this share to the applicable EDF national value[9,10,11]. These final state-level results aligned with national EDF data across all scenarios and were used for subsequent analyses, including fuel costs, EGU emissions, and health impacts.

Fuel cost forecasts

State-level fuel and electricity consumption results were combined with fuel and electricity price projections to estimate annual fuel and electricity costs. Baseline (2025) fuel and electricity prices were compiled for each state using a variety of resources:

- Gasoline and diesel: AAA Fuel Prices (prices specific to December 2025)
- Compressed natural gas (CNG) and E-85: Clean Cities and Communities Alternative Fuel Price Report (prices provided for seven U.S. regions; specific to July 2025)

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[8] Due to budget and time constraints, state-level VOC emissions were not calculated within ERM's turnover model; state-level NOx shares (by vehicle and fuel type) were applied to EDF's national VOC emissions data to produce state-level VOC emissions. As discussed later, this only impacts HDV VOC emissions.

[9] Because LMDV NMOG+NOx standards were not considered in EPA's proposed repeal and national NOx and VOC emissions were assumed to stay constant across each ZEV adoption scenario, state-level LMDV NOx and VOC emissions were similarly assumed to stay constant across scenarios and vehicle/fuel types. This decision avoided scenarios in which state emissions – and therefore health impacts – increase or decrease despite the standard not changing.

[10] EPA MOVES5 (and consequently, ERM's vehicle turnover model) does not include ethanol (E-85) as a fuel type for MDVs. To align with national EDF data, ERM applied the state-level share of light truck E-85 metrics to estimate state-level MDV E-85 metrics.

[11] Because ERM state-level data only extended through 2050, 2050 state-level shares were assumed to stay constant through 2055 and consequently applied to national EDF data between 2050-2055 (inclusive)

- Electricity: U.S. EIA Electric Power Monthly (prices specific to September 2025)
- Hydrogen: U.S. AEO 2025: Alternative transportation side case (prices provided for nine U.S. regions with 2024 baseline)

These prices[12] were then combined with regional price forecasts from U.S. AEO[13] to produce state-level fuel costs (in terms of 2024 USD) for all vehicle types across each scenario between 2025-2055 (inclusive). The cumulative fuel costs were discounted at 3%.

EGU emission forecasts

State-level electricity consumption results were used to estimate the corresponding electricity generation and associated EGU emissions. Since electricity consumed in a state is not necessarily generated in that state, multiple power sector market datasets were harmonized to estimate – for each state – where and how (i.e., energy source) electricity is generated.
The first step of this analysis required matching the spatial attributes of electricity load data (via NREL Cambium) with generation data (via EPA eGRID); NREL Cambium balancing authorities (sub-state geographies) were assigned to the power markets associated with regions defined by EPA eGRID[14]. This provided state-level load and the quantity of generation (by fuel type) of each eGRID region delivered to each state. This load-generation relationship was assumed to be maintained through 2055, but future changes to fossil (coal, natural gas, and oil) and zero-emitting generation were estimated using EIA AEO 2023 (No IRA side case) forecasts[15]. Ultimately, year-over-year forecasts (by fuel type, via EIA AEO) were applied to baseline eGRID generation (2023) to estimate the future composition of electricity generation that is delivered to each state. In other words, generation (by fuel type) was forecast for every unique state origin-destination combination. National average CO_2, NOx, SO_2, VOC, and $PM_{2.5}$ emission rates associated with coal, gas, and oil electricity generation[16] were then applied to applicable generation to estimate EGU emissions for each origin-destination combination.

Health impacts for Vehicle and EGU emission changes

After forecasting state-level vehicle and EGU emissions associated with BEV/PHEV electricity demand across ZEV adoption scenarios, ERM used EPA's CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA) to estimate a range of health impacts resulting from EPA's proposed vehicle emissions standard repeal. Because health effects of specific pollutants are a function of geography and the source of emissions, ERM extracted

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[12] Converted to 2024 USD using relevant monthly Consumer Price Index for All Urban Consumers (CPI-U)

[13] AEO 2023 (No IRA side case) was referenced for residential and commercial electricity prices; AEO 2025 (Alternative transportation side case) was referenced for all other fuel prices. AEO forecasts extend through 2050; 2050 prices were assumed to stay constant through 2055.

[14] Assignment of NREL Cambium balancing authorities to eGRID regions was performed using Esri ArcGIS Pro; balancing authorities could be assigned to multiple eGRID regions (load allocated to each eGRID region prorated based on share of balancing authority area within each eGRID region)

[15] NREL Cambium balancing authorities were also assigned to EIA AEO regions (Electricity Market Module, EMM) using Esri ArcGIS Pro; balancing authorities could be assigned to multiple EMM regions (load allocated to each EMM region prorated based on share of balancing authority area within each EMM region). Furthermore, EIA AEO 2023 regional forecasts were modified to align with national power sector assumptions provided by EDF (national generation share forecasts, by fuel type, originally provided by Energy Institute); 2050 values were assumed to stay constant through 2055.

[16] Calculated using most recent eGRID data; emissions rate (kg/MWh or equivalent) assumed to stay constant through 2055

state-specific COBRA factors[17] for each relevant sector (electric utility and highway vehicles), fuel type (coal, natural gas, and oil for electric utilities; gasoline, diesel, CNG, and E-85 for highway vehicles), and vehicle type (light- and heavy-duty vehicles[18]). ERM processed COBRA factors to capture the total U.S. impacts (incidence and economic) of pollutant emissions; that is, the factors account for impacts that occur within and outside of the state in which emissions originate. Thus, application of these factors result in national health impacts associated with state emissions, and do not only include health impacts experienced within the focus state. For instance, emissions from Maryland vehicles and EGUs have health impacts in Maryland and neighboring states; all of these impacts are captured within the Maryland-specific COBRA factors. Finally, the range of health impacts of EPA's proposed repeal were calculated by comparing health effects of the "Low ZEV" and "High ZEV" adoption scenarios against the "Compliance" scenario (i.e., health effects of proposed repeal scenarios less health effects of compliance/baseline scenario). Since COBRA only models impacts in the contiguous U.S., health impacts for Hawaii and Alaska were not calculated. For the monetized health harms, the time between the emissions and the associated health impacts were calculated using a 2% discount rate. EDF used a 3% discount rate to calculate the net present value.

Allocation of Upstream Fossil Emissions to States and Estimate of Health Impacts

EDF previously modeled the increase in emissions from upstream fossil fuel production. For more information about that methodology EDF's previous analysis.[19] The methodology described below details how the national emissions were allocated to states. EDF used estimates of the emissions related to the production of gasoline and diesel fuel contained in DOE's GREET2024 model and projections of the impact of relaxed GHG standards on crude oil production and refining from EIA's AEO2025. Like EPA's estimates, these national emission impacts for criteria air pollutants (CAPs) only included those expected to occur over U.S. soil.

EDF split upstream fossil fuel emissions into five categories:

1) Crude oil production,
2) Crude oil transportation,
3) Crude oil refining,
4) For gasoline, ethanol production,
5) Distribution of non-ethanol gasoline blendstock and finished diesel fuel and ethanol for gasoline blending

The design of DOE's GREET model includes the estimation of the emissions related to each of these steps, and their separate treatment when projecting the location of these emissions. While both GREET and AEO2025 include some regional-specific information, the regions are defined too broadly and only apply to a limited number of factors to be of direct use here. Instead, historic, state-specific data regarding crude oil production, refining and ethanol production were used to allocate national emissions to specific states.

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[17] Incidence and monetary value per metric ton of pollutant (NOx, SO_2, $PM_{2.5}$, and VOC); for the monetized health harms, the time between the emissions and the associated health impacted were calculated using a 2% discount rate. A 3% discount rate was used to calculate the net present value.

[18] Relevant for highway vehicles, only

[19] https://library.edf.org/AssetLink/q6017oa85rgw8i4m4oh7a82phnm7i271.pdf

EIA publishes crude oil production by U.S. state.[20] That data for 2024 is used here to allocate emissions related to crude oil production and transportation to each state. The transportation of crude oil occurs between the area where it is produced or imported and refineries. However, allocating these emissions to individual states besides those producing crude oil is beyond the scope of this analysis. Also, the emissions associated with crude oil transportation domestically are generally much lower than those from oil refining and ethanol production. As a reasonable approximation, emissions related to crude oil transportation were allocated based on the average of each state's percentage of crude oil production and its percentage of U.S. refining capacity, which is addressed in below.

EIA does not publish gasoline nor diesel fuel production from refineries by state. However, it does publish refinery capacity by refinery and refinery location.[21] Since the U.S. refining industry operates at roughly 90% of capacity and operating at 100% capacity is not practically achievable over an annual period, capacity is a reasonable estimate of relative refinery production. EIA also publishes the capacity of several refinery processes, such as atmospheric distillation, catalytic cracking, hydrocracking and the desulfurization of several refinery streams, including naphtha (destined for gasoline) and diesel fuel.

Some refineries do not produce either gasoline or diesel fuel. While these refineries tend to have relatively small total capacities, their exclusion improves the accuracy of the state-specific allocation. The production of gasoline requires either catalytic cracking or hydrocracking, or both, as well as naphtha desulfurization. Some volume of diesel fuel can be produced from crude oil without catalytic cracking or hydrocracking, but diesel fuel desulfurization is still required. Thus, with one exception, EDF excluded refineries which had no catalytic cracking nor hydrocracking units. The exception was made for a handful of refineries which did not have these cracking units, but did have diesel fuel desulfurization units, as there would be no reason to have this unit if diesel fuel was not being produced and sold.

EIA also publishes ethanol production by state which was used to allocate ethanol production emissions to a state level.[22]

These breakdowns of crude oil production, refinery capacity for onroad fuel producing refineries, and ethanol production by state, in percentage terms, were used to allocate national CAP emission impacts to each state.

Estimating Health Impacts of Upstream Fossil Emissions

EDF used two methods to estimate the health impacts of the change in upstream fossil emissions.

Method 1

EDF used EPA's CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (hereafter referred to as the COBRA model). EPA published its latest version of COBRA in March of 2025.[23] The desktop version is programmed to estimate health impacts in 2016, 2023 or 2028. However, EPA also publishes additional input files which can be used to project health impacts in five year increments from 2030 to 2050. EDF used the desktop version of COBRA with these additional input files to project the health impacts of the above-mentioned emission

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[20] PET_CRD_CRPDN_ADC_MBBL_A.xls

[21] Table 1. Number and Capacity of Operable Petroleum Refineries by PAD District and State

[22] prod_phy_bf.xlsx

[23] User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA), Version: 5.2, U.S. EPA, March 2025

impacts nationally, which were then apportioned to individual states based on each state's emission impacts.

COBRA is designed to use five distinct input files. The first two describe county specific emissions of NOx, PM, Sox and VOC in 2028 from a wide variety of emission sources. One such file describes emissions in the baseline case, here consisting of the current set of emission standards. The second such file describes emissions in the "control" case, which here reflects the rescission of the GHG standards. The third file is referred to as the "Incidence" file and contains an extensive set of factors describing the effect of each pollutant's emissions on a wide range of health impacts, such as premature mortality or the experience of asthma symptoms. The fourth file contains estimates of the population in each county of the U.S. in the year of question. The fifth file contains monetary valuations of the various health impacts in the year of question. The various input files can be found on EPA's COBRA website.[24]

While the two emissions files describe emission projections for 2028, their purpose in COBRA is to reflect changes in emissions which are then used to estimate changes in various measures of public health. As is the case with all reduced form models (e.g., EPA estimates of the monetized benefits per ton (BPTs), BENMAP, etc.), COBRA uses the slope of the effect of various emission sources and types on ambient levels of PM and ozone to project the changes in public health due resulting from the change in emissions. These changes in ambient ozone and PM are based on very extensive air quality modeling of changes in emissions in each country in the U.S. These ambient pollutant impacts in COBRA were developed using EPA's CAMx model.

EDF developed generic "control" emission inputs files which reflected a 10% reduction in each pollutant (VOC, PM, Sox, VOC) from several selected emission sources (refineries, marine vessels, ethanol plants, crude oil production, heavy-duty diesel trucks, etc.). COBRA was run using these various control emission files to project the public health impacts of the changes in emissions. These public health impacts were then put on a "per ton" basis and combined with the above estimated emission impacts associated with the rescission of the GHG standards to estimate the total health impacts of the rescission. The 2023$ were converted to 2024$ by multiplying the health harms by 1.03.[25] Cumulative impacts were discounted at 3%.

Method 2

EDF also used incidence and benefit per ton values from BenMAP to estimate the impacts of changes upstream fossil emissions, specifically EDF used oil and natural gas, oil and natural gas transmission, and refineries.[26] Since BenMAP does not have a sector for ethanol production or T&D, EDF used the COBRA values calculated above for those sector emissions. Incidence per ton and benefit per ton values were only available through 2040 so EDF linearly extrapolated the factors using the slope between the 2035 to 2040 factors. The 2019$ were converted to 2024$ by multiplying the health harms by 1.23.[27] Cumulative impacts were discounted at 3%.

The range of health impacts from upstream fossil emissions includes both the two methods described above and the two scenarios for low and high emitting fleets of vehicles.

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[24] https://www.epa.gov/cobra/cobra-future-input-files

[25] https://www.bls.gov/data/inflation_calculator.htm

[26] https://www.epa.gov/benmap/estimating-benefit-ton-reducing-directly-emitted-pm25-pm25-precursors-and-ozone-precursors

[27] https://www.bls.gov/data/inflation_calculator.htm

Allocating Climate Harms

The global societal costs of the increase in climate pollution from each state were also calculated. In contrast to the criteria pollutant emissions where the emissions and harms were allocated, as best as possible, to the state where the emissions occur, for climate pollution and climate harms, the impacts are allocated to the state that is causing the increase in emissions. The only piece of the analysis where this changes the methodology substantially from the description above for criteria pollutant impacts is for upstream fossil where the increase in GHG emissions associated with the fuel used in a state was attributed to that state rather than the state where the fuel was produced. Once again, the sector emissions modeled earlier by EDF were allocated to states in a top-down methodology.

Monetized climate harms were converted from 2022$ used previously to 2024$ by multiplying the values by 1.06. Total discounted monetized climate harms were allocated to states based on their total climate emissions. Consistent with the previous analysis, climate harms were discounted at 2%.