

# Benefits of U.S. state adoption of key heavy-duty engine and vehicle policies

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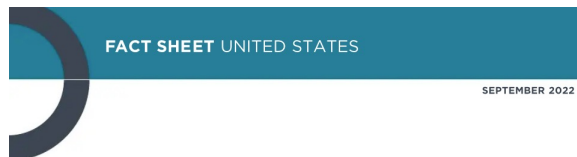
Webinar

# Published 27 Sep 2022: Benefits of adopting California MHD regulations

Summary Fact Sheet

Fact sheets for 16 states + DC

Spreadsheets for 18 states + DC



## Benefits of adopting key medium- and heavy-duty vehicle emissions control policies in U.S. states

Medium- and heavy-duty (M/HD) vehicles, including trucks and buses, emit climate-warming greenhouse gases (GHGs) as well as air pollutants that are harmful to human health. In July 2020, fifteen states and the District of Columbia, together representing roughly 35% of the U.S. M/HD market, signed a Memorandum of Understanding (MOU) to work together on a transition to M/HD zero-emission vehicles (ZEVs).<sup>1</sup> Zero-emission vehicles are powered by electric motors and not internal combustion engines. The signatories of this Multi-State MOU share a goal of 30% M/HD ZEV sales by 2030 and 100% ZEV sales no later than 2050. Many of these same states are pursuing new engine standards for diesel engines to address inequities in exposure to nitrogen oxides and ozone pollution. The combined efforts of these U.S. states are accelerating the national transition toward the cleanest combustion engines and zero-emission M/HD vehicles.

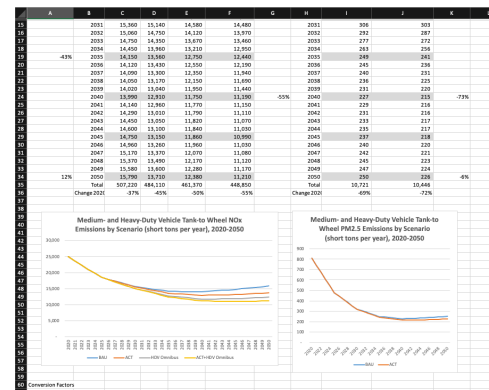
<sup>1</sup> <https://www.mhdmou.org/>

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THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Benefits of adopting California's Advanced Clean Truck Program, Heavy-Duty Vehicle Omnibus Standards and a 100% sales requirement in Colorado

September 2022



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<https://theicct.org/benefits-ca-multi-state-reg-data/>

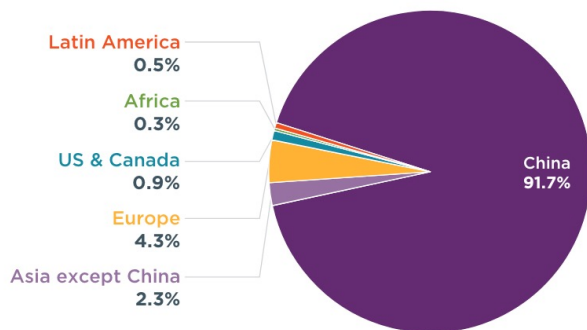
# Outline

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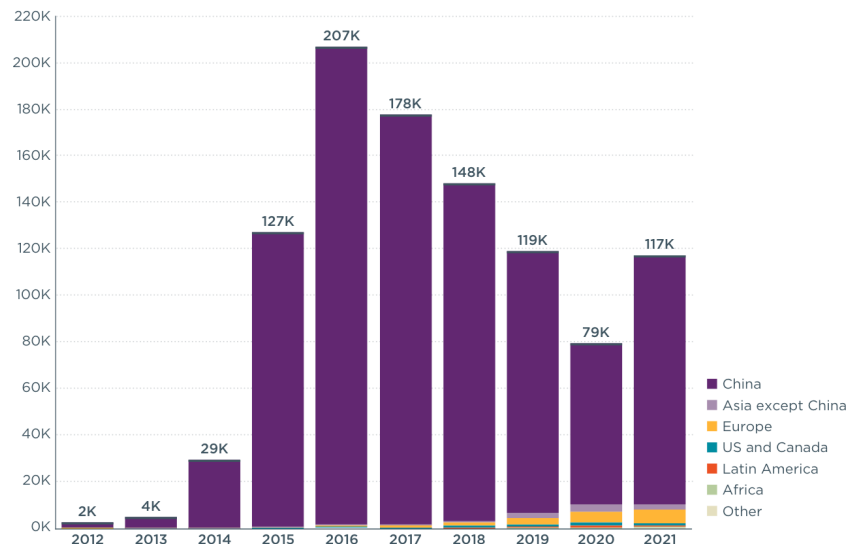
1. Overview
2. Approach to benefits modeling
3. Results
4. Final thoughts

# Global HD ZEV sales trends

HD ZEV sales market share by region, 2019-2021



Annual HD ZEV sales by region through 2021



Byusse, Claire. 2021. "Zero-Emission Bus and Truck Market in the United States and Canada: A 2021 Update." Washington, DC: International Council on Clean Transportation. <https://theicct.org/publication/update-ze-truck-bus-market-us-can-sept22/>.

# Zero-emission heavy-duty sales in North America

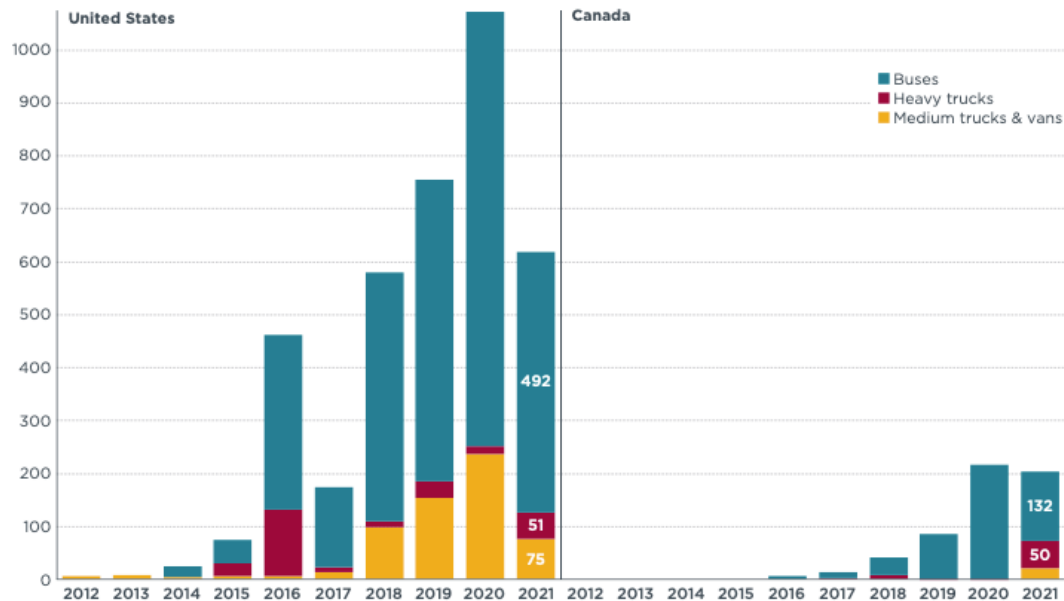


Figure 3. Zero-emission heavy-duty vehicle sales in North America

<https://theicct.org/publication/update-ze-truck-bus-market-us-can-sept22/>

# Federal policy on HD ZEV standards is evolving

| Scenarios                                          | 2027 | 2028 | 2029 | 2030 |
|----------------------------------------------------|------|------|------|------|
| Baseline (pre- Inflation Reduction Act)            | 3%   | 5%   | 6%   | 8%   |
| With EPA Phase II proposed revisions (28 Mar 2022) | 3%   | 5%   | 6%   | 8%   |
| Baseline with Inflation Reduction Act incentives   | TBD  | TBD  | TBD  | TBD  |
| New EPA supplemental Phase II proposal             | TBD  | TBD  | TBD  | TBD  |
| ICCT recommendation (16 May 2022) <sup>1</sup>     | 20%  | 30%  | 40%  | 50%  |

<sup>1</sup> <https://www.regulations.gov/comment/EPA-HQ-OAR-2019-0055-1211>

<sup>2</sup> <https://www.volvogroup.com/en/news-and-media/news/2022/jan/news-4158927.html>

<sup>3</sup> <https://www.volvotrucks.com/en-en/news-stories/press-releases/2022/sep/New-report-high-pressure-on-the-transport-industry-to-shift-to-electric.html>

# 2022 Multi-state MHD ZEV Action Plan

States should consider adopting:

- The ACT regulation
- Fleet purchase requirements
- California's HD omnibus regulation

This *Action Plan* was developed by the following jurisdictions\* through the Multi-State ZEV Task Force facilitated by the Northeast States for Coordinated Air Use Management (NESCAUM):

|             |                |                      |
|-------------|----------------|----------------------|
| California  | Massachusetts  | Rhode Island         |
| Colorado    | Nevada         | Vermont              |
| Connecticut | New Jersey     | Virginia             |
| Hawaii      | New York       | Washington           |
| Maine       | North Carolina | District of Columbia |
| Maryland    | Oregon         | Quebec               |
|             | Pennsylvania   |                      |

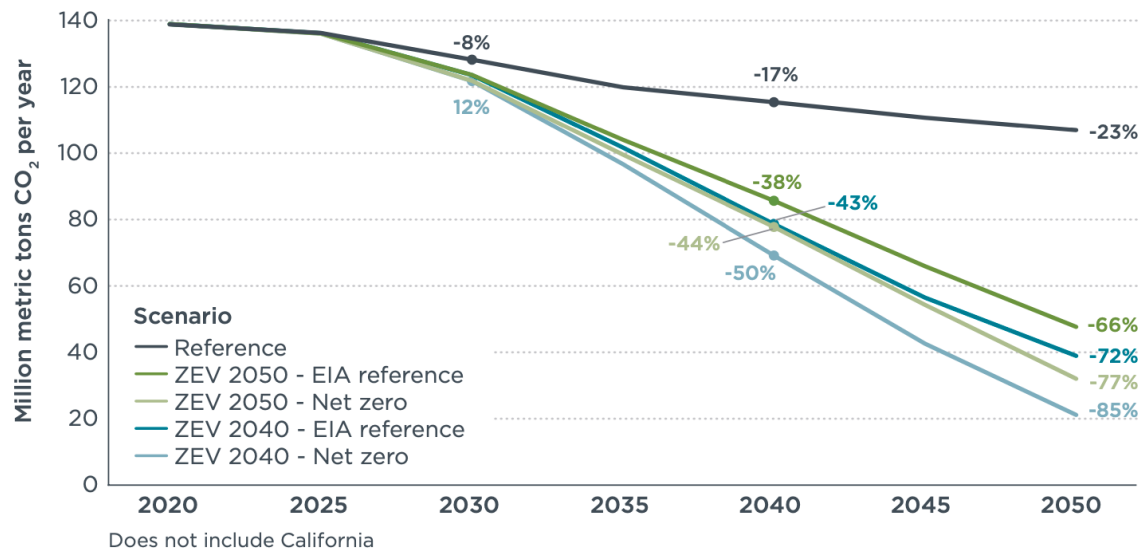


**ZEV** TASK FORCE // **MULTI-STATE MEDIUM- AND HEAVY-DUTY  
ZERO-EMISSION VEHICLE ACTION PLAN**  
A POLICY FRAMEWORK TO ELIMINATE HARMFUL TRUCK AND BUS EMISSIONS

**JULY  
2022**



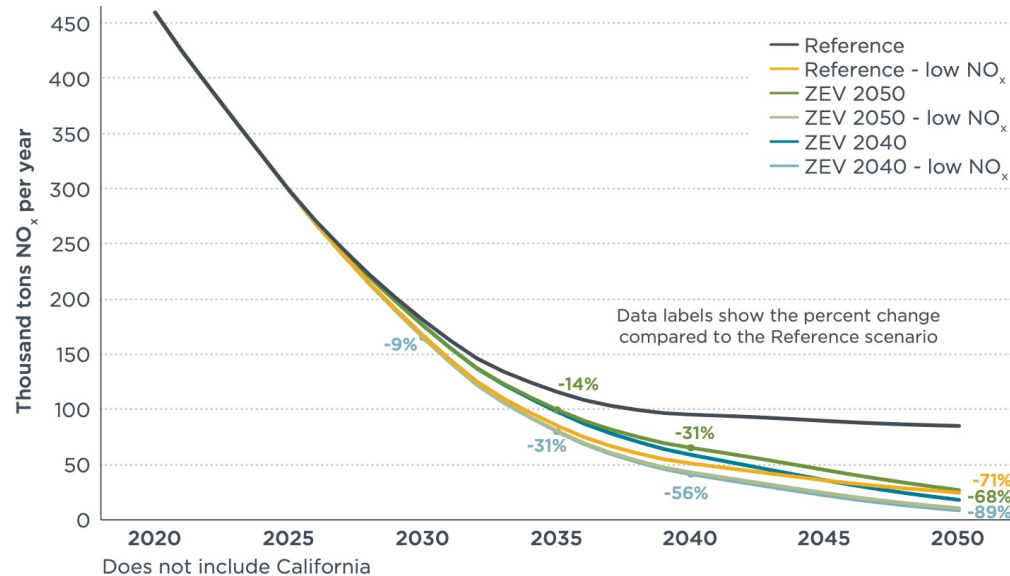
# CO<sub>2</sub> Benefits of Multi-State MOU ACT adoption



**Figure 6.** Comparison of medium- and heavy-duty vehicle fuel lifecycle CO<sub>2</sub> emissions across scenarios. Data labels show the percent change compared to 2020.



# NO<sub>x</sub> benefits of multi-state HDV Omnibus adoption



**Figure 7.** Comparison of medium- and heavy-duty vehicle tailpipe NO<sub>x</sub> emissions across scenarios. Data labels show the percent change compared to the Reference scenario.

# November 2021: Benefits of adopting California MHD regulations

## Adopted ACT in 2021

- NY, NJ, MA, WA, OR

## Adopted HDV Omnibus in 2021

- MA, OR

## Adopted CA Phase II GHG in 2021

- MA

**Table 1.** Cumulative emissions avoided with 2025 implementation of ACT, HDV Omnibus, and CA Phase II GHG tractor-trailer standards (All EV Scenario)

| State          | 2020-2040       |                   |                       | 2020-2050       |                   |                       |
|----------------|-----------------|-------------------|-----------------------|-----------------|-------------------|-----------------------|
|                | NO <sub>x</sub> | PM <sub>2.5</sub> | WTW CO <sub>2</sub> e | NO <sub>x</sub> | PM <sub>2.5</sub> | WTW CO <sub>2</sub> e |
| Colorado       | 32,600          | 213               | 16.24                 | 88,460          | 546               | 53.52                 |
| Connecticut    | 7,320           | 41                | 3.51                  | 20,410          | 126               | 9.91                  |
| D.C.           | 1,640           | 11                | 0.37                  | 4,600           | 34                | 1.46                  |
| Massachusetts  | 26,950          | 196               | 18.63                 | 71,960          | 549               | 54.49                 |
| Maryland       | 36,480          | 233               | 5.73                  | 99,760          | 613               | 13.51                 |
| Maine          | 10,410          | 66                | 6.38                  | 28,770          | 182               | 18.79                 |
| North Carolina | 52,780          | 306               | 12.29                 | 142,620         | 790               | 31.14                 |
| New Jersey     | 45,220          | 303               | 32.45                 | 125,380         | 844               | 95.95                 |
| Oregon         | 45,910          | 321               | 28.98                 | 125,690         | 829               | 92.42                 |
| Pennsylvania   | 84,480          | 479               | 14.64                 | 231,140         | 1,328             | 34.38                 |
| Rhode Island   | 4,740           | 25                | 1.96                  | 13,080          | 76                | 5.59                  |
| Vermont        | 3,010           | 16                | 1.31                  | 8,190           | 44                | 3.70                  |
| Washington     | 44,080          | 285               | 15.70                 | 122,350         | 794               | 44.03                 |

# September 2022: Benefits of adopting California MHD regulations

GOAL Estimate annual and cumulative NO<sub>x</sub>, PM, and WTW CO<sub>2</sub>e benefits of adoption of

- Advanced Clean Trucks Rule
- HDV Omnibus Rule
- 100% HD ZEV sales in 2040 requirement
- CA GHG Phase II (NY-VT only)

**Table 1.** Emissions reduction potential of adopting remaining key M/HD policies in U.S. states

| State          | 2020-2050                      |                                  |                                                |
|----------------|--------------------------------|----------------------------------|------------------------------------------------|
|                | NO <sub>x</sub><br>(U.S. tons) | PM <sub>2.5</sub><br>(U.S. tons) | WTW CO <sub>2</sub> e<br>(million metric tons) |
| Colorado       | 119,263                        | 967                              | 77.06                                          |
| Connecticut    | 25,148                         | 194                              | 20.21                                          |
| D.C.           | 5,276                          | 50                               | 2.71                                           |
| Delaware       | 22,519                         | 157                              | 16.37                                          |
| Illinois       | 252,240                        | 1,885                            | 187.77                                         |
| Maine          | 34,786                         | 266                              | 28.59                                          |
| Maryland       | 120,920                        | 926                              | 60.33                                          |
| Nevada         | 46,991                         | 328                              | 19.69                                          |
| New Jersey     | 60,490                         | 373                              | 26.60                                          |
| New Mexico     | 99,288                         | 671                              | 74.14                                          |
| New York       | 72,840                         | -                                | 9.96                                           |
| North Carolina | 192,628                        | 1,389                            | 149.48                                         |
| Pennsylvania   | 282,147                        | 2,079                            | 129.68                                         |
| Rhode Island   | 15,900                         | 119                              | 11.49                                          |
| Vermont        | 9,880                          | 74                               | 8.08                                           |
| Virginia       | 130,507                        | 884                              | 106.78                                         |
| Washington     | 61,030                         | 354                              | 25.57                                          |

# Modeling set-up and results

# Modeling Set-Up



- EPA's MOVES3 model (released Nov. 2020) used
- MOVES3 does not allow for direct modeling of heavy-duty EVs (only light-duty vehicle types can be electric in MOVES)
- ICCT and STI chose to run MOVES3 as-is and apply post-processing adjustments to account for these vehicles

# MOVES Approach



- STI used MOVES at the County scale, similar to the way MOVES is used for regulatory purposes
- STI modeled the representative counties in each state that are used to generate the National Emissions Inventory (NEI) (2017 is the most recent complete update), and used NEI apportionment factors to calculate statewide inventories

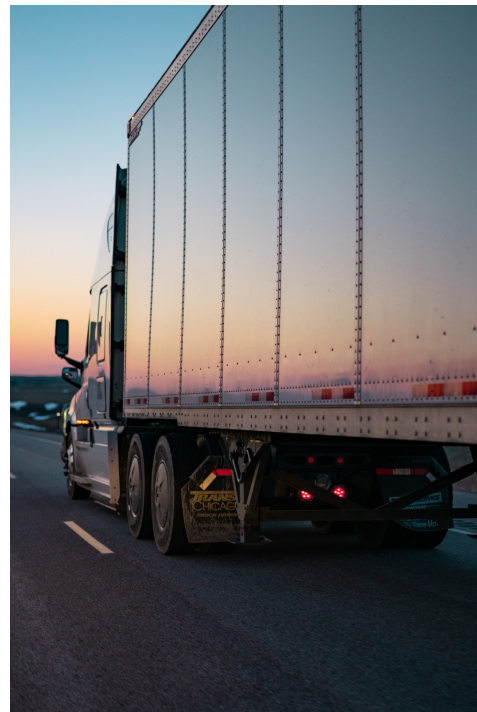
# MOVES Inputs

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- STI used MOVES inputs for the representative counties from the 2017 NEI as a starting point
  - Some states provided updated input data, such as vehicle miles travelled, vehicle population, and/or vehicle age distributions
  - MOVES default growth rates used to project VMT and vehicle population to future years, unless states provided growth rates
  - MOVES default runs were also used to develop interpolation factors for interim years

# Post-Processing

- Adjustment factors were applied to MOVES output:
  - ACT: CARB projections of EV market penetration mapped to MOVES vehicle types; MOVES emissions reduced proportionally
  - GHG Phase 2 Trailers: ICCT estimates of emissions impacts used to *increase* MOVES CO<sub>2</sub> emissions
  - Low-NOx Omnibus: CARB emissions inventory projections used to develop NO<sub>x</sub> reduction factors





# Affected MOVES Regulatory Classes

| EPA Regulatory Class Codes | Description                                            |
|----------------------------|--------------------------------------------------------|
| 41                         | Class 2b and 3 Trucks (8,500 lbs < GVWR <= 14,000 lbs) |
| 42                         | Class 4 and 5 Trucks (14,000 lbs < GVWR <= 19,500 lbs) |
| 46                         | Class 6 and 7 Trucks (19,500 lbs < GVWR <= 33,000 lbs) |
| 47                         | Class 8a and 8b Trucks (GVWR > 33,000 lbs)             |
| 48                         | Urban Transit Bus                                      |

# Post-Processing

| Topic                                     | Description                                                                                                                                                                | EPA Regulatory Classes Affected | Pollutants Affected                  |
|-------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|--------------------------------------|
| <b>GHG Phase 2 Trailer provisions</b>     | Adjustment to remove the benefit of the trailer component of the HDV Phase 2 GHG rule                                                                                      | 46, 47                          | CO <sub>2</sub> (emissions increase) |
| <b>Advanced Clean Trucks program</b>      | Adjustment to reflect phased introduction of electric HDVs into the fleet. Also includes use of GREET emissions factors to calculate resulting increase in grid emissions. | 41, 42, 46, 47                  | All (emissions decrease)             |
| <b>Low-NO<sub>x</sub> Omnibus program</b> | Adjustment to reflect ARB's proposed Low-NO <sub>x</sub> Omnibus rule                                                                                                      | 42, 46, 47                      | NO <sub>x</sub> (emissions decrease) |

# Well-to-Tank Emissions



- Energy consumption for the EV portion of the fleet used to calculate:
  - Utility emissions increase from EV charging
  - Refinery emissions decrease from fuel usage reductions
- Used emissions factors from DOE's GREET model, with future factors adjusted for anticipated state renewable energy projections



# ACT sub-scenarios: “ACT EVs”

- For the “ACT EVs” scenarios, STI fully incorporated CARB’s assumptions regarding EV fleet penetration under ACT:
  - EVs produced to meet GHG Phase 2 standards, which don’t represent incremental new EVs under ACT (roughly 20%)
  - New vehicles are purchased out of state but registered in CA (10-15%)
  - EVs purchased in CA that migrate out of state over time
    - 22.5% for light HD
    - Up to 33% for medium HD
    - Up to 66% for HD combination trucks

# ACT sub-scenarios: “All EVs”

- For the “All EVs” scenarios, STI incorporated CARB’s assumption regarding out-of-state purchases, but not the GHG Phase 2 “carve-out” or out-of-state migration
- “All EVs” projections better represent the full population of EVs within a state



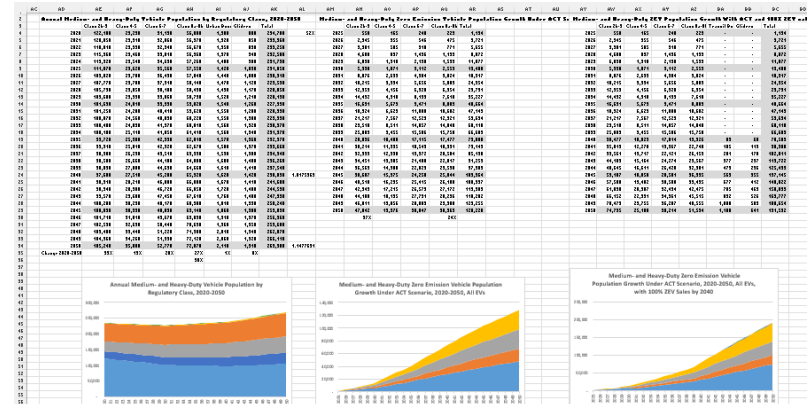
# Impact of CARB assumptions on ACT EV sales

Relative outcomes per 1000 vehicles sold in 2035:

| Calendar year 2035<br>(ACT program<br>reaches steady<br>state) | Total new<br>model year<br>vehicles<br>registered | New model<br>year vehicles<br>purchased in-<br>state | EVs sold<br>under either<br>ACT or GHG<br>Phase 2 | Incremental<br>EVs due to<br>ACT<br>program<br>only | MY2035 EVs (ACT or<br>GHG Phase 2)<br>remaining in-state<br>after 5 years (in<br>2040) |
|----------------------------------------------------------------|---------------------------------------------------|------------------------------------------------------|---------------------------------------------------|-----------------------------------------------------|----------------------------------------------------------------------------------------|
| Regulatory class 41                                            | 1000                                              | 1000                                                 | 550                                               | 370                                                 | 550                                                                                    |
| Regulatory classes 42<br>& 46                                  | 1000                                              | 897                                                  | 654                                               | 475                                                 | 564                                                                                    |
| Regulatory class 47                                            | 1000                                              | 880                                                  | 421                                               | 252                                                 | 295                                                                                    |

# Results

- Results presented in a spreadsheet including--
  - Unadjusted MOVES output
  - Emissions estimates for the scenarios; GREET upstream emissions for the ACT scenarios
  - Estimated EV fleet penetration under ACT
  - All post-processing adjustment factors



# 2021 Analyses

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- Projected emissions for 14 states: Colorado, Connecticut, the District of Columbia, Maine, Maryland, Massachusetts, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Rhode Island, Vermont, Washington
- All three programs modeled (ACT, Omnibus, and GHG Phase 2 trailers)
- Calculated-
  - NO<sub>x</sub>, PM<sub>2.5</sub>, CO<sub>2</sub>e emissions by year;
  - ZEV sales, population and VMT by year;
  - Cumulative change in NO<sub>x</sub>, PM<sub>2.5</sub>, and CO<sub>2</sub>e emissions, 2020-2050



# 2022 Updates

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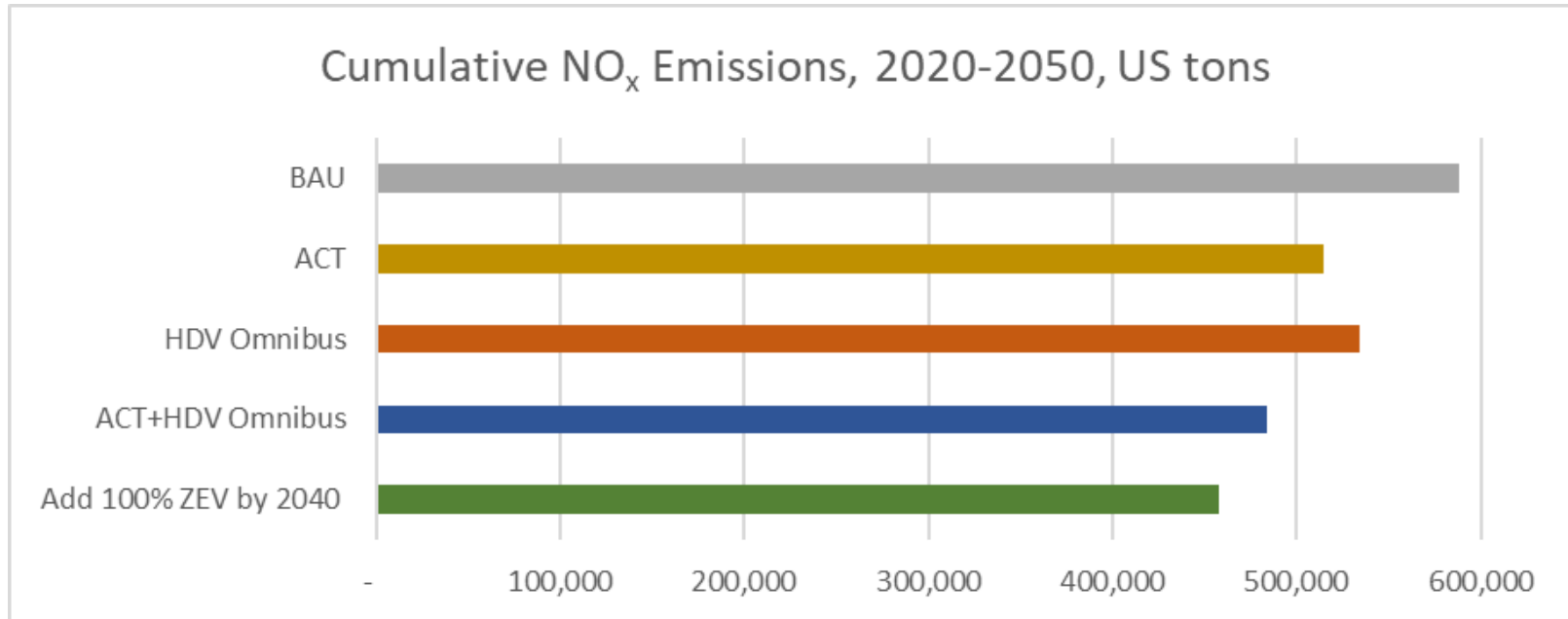
- Added Delaware, Illinois, Nevada, New Mexico and Virginia
- GHG Phase 2 trailer scenario removed for most states; added new scenario with 100% ZEV sales by 2040
- Re-analyzed states that had already adopted ACT (with ACT as their new BAU scenario)
- Re-modeled Colorado and North Carolina with new MOVES inputs
- Added ZEV efficiency factors to the calculation of grid emissions, and updated with GREET2021
- Pending: modeling of British Columbia and Quebec

# Example Results (Virginia): Cumulative Pollutant Reductions

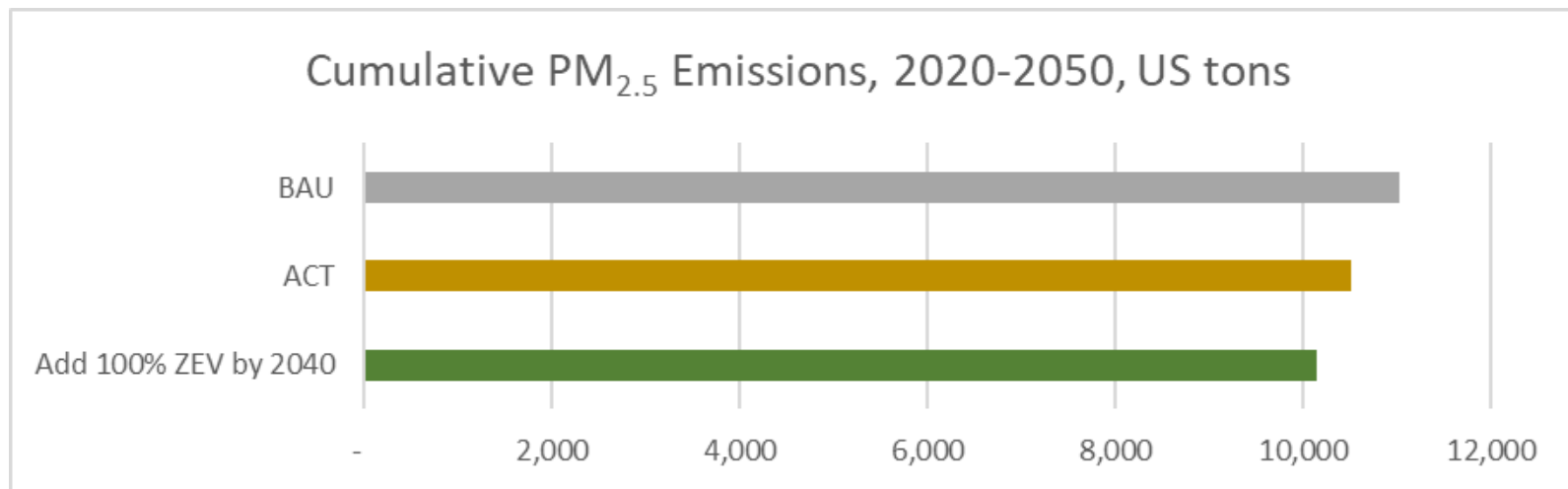
| Program                                       | Cumulative Emissions Reduction |                                  |                             |
|-----------------------------------------------|--------------------------------|----------------------------------|-----------------------------|
|                                               | NO <sub>x</sub><br>(U.S. tons) | PM <sub>2.5</sub><br>(U.S. tons) | CO <sub>2</sub> e<br>(MMT*) |
| ACT                                           | 73,170                         | 524                              | 79.40                       |
| HDV omnibus                                   | 53,220                         | N/A                              | N/A                         |
| ACT + HDV omnibus                             | 104,200                        | 524                              | 79.40                       |
| ACT + HDV omnibus + 100% HD ZEV sales in 2040 | 130,507                        | 884                              | 106.78                      |

\*million metric tons

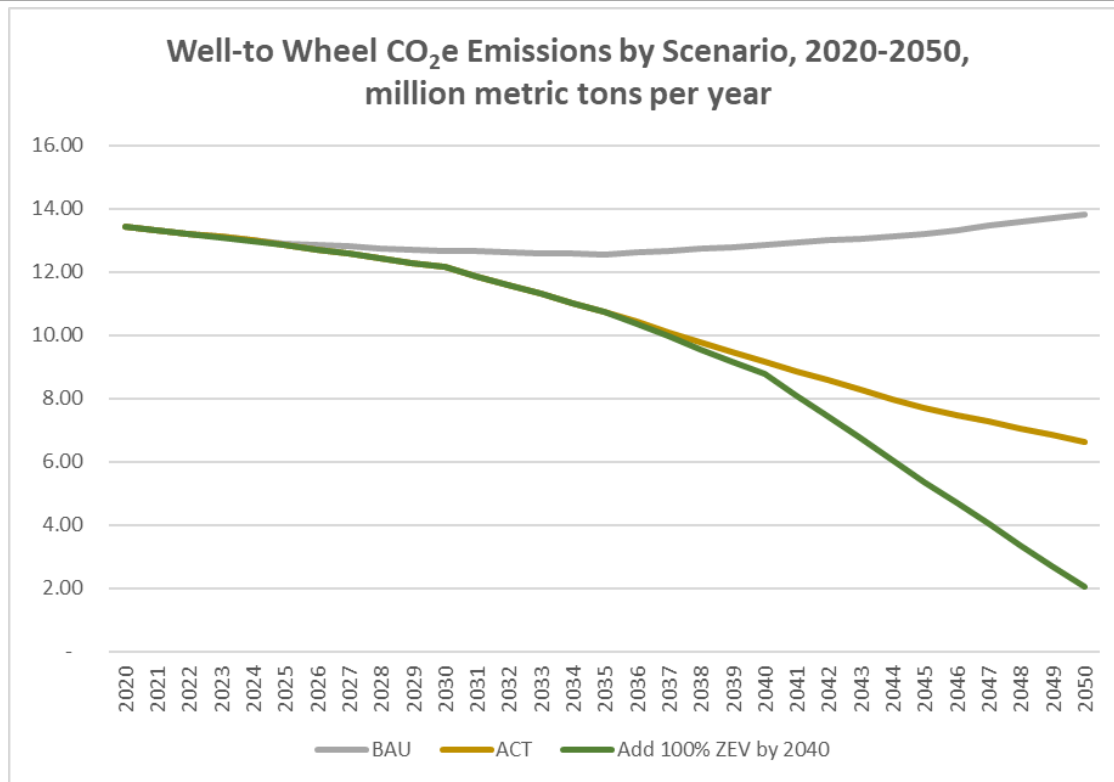
# Example Results (Virginia): NO<sub>x</sub>



# Example Results (Virginia): PM<sub>2.5</sub>



# Example Results (Virginia): CO<sub>2</sub>e



# Example Results (Virginia): ZEV Population

| Year   | Effect of 100% ZEV sales requirement in MY2040 on M/HD vehicle population, by fuel type |                        |         |
|--------|-----------------------------------------------------------------------------------------|------------------------|---------|
|        | Internal combustion engine vehicles                                                     | Zero emission vehicles | Total   |
| 2025   | 458,010                                                                                 | 2,380                  | 460,390 |
| 2030   | 431,772                                                                                 | 27,418                 | 459,190 |
| 2035   | 392,735                                                                                 | 82,585                 | 475,320 |
| 2040** | 333,479                                                                                 | 160,391                | 493,870 |
| 2045   | 239,895                                                                                 | 278,565                | 518,460 |
| 2050   | 159,244                                                                                 | 388,916                | 548,160 |

\*\*100% ZEV sales begin

# Differences between states

Several factors contribute to differing trends among states, including:

- VMT and vehicle population growth rates
- Vehicle age distribution (rate of fleet turnover)
- Relative population of different HD vehicle types
- Renewable energy policies (WTW CO<sub>2e</sub>)



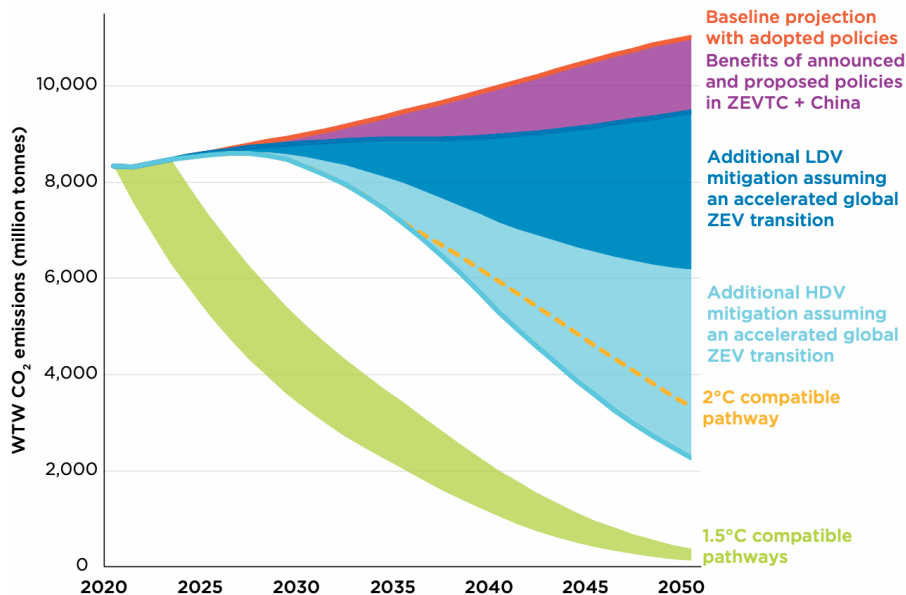
# Final thoughts



# Final Thoughts: The Climate Imperative

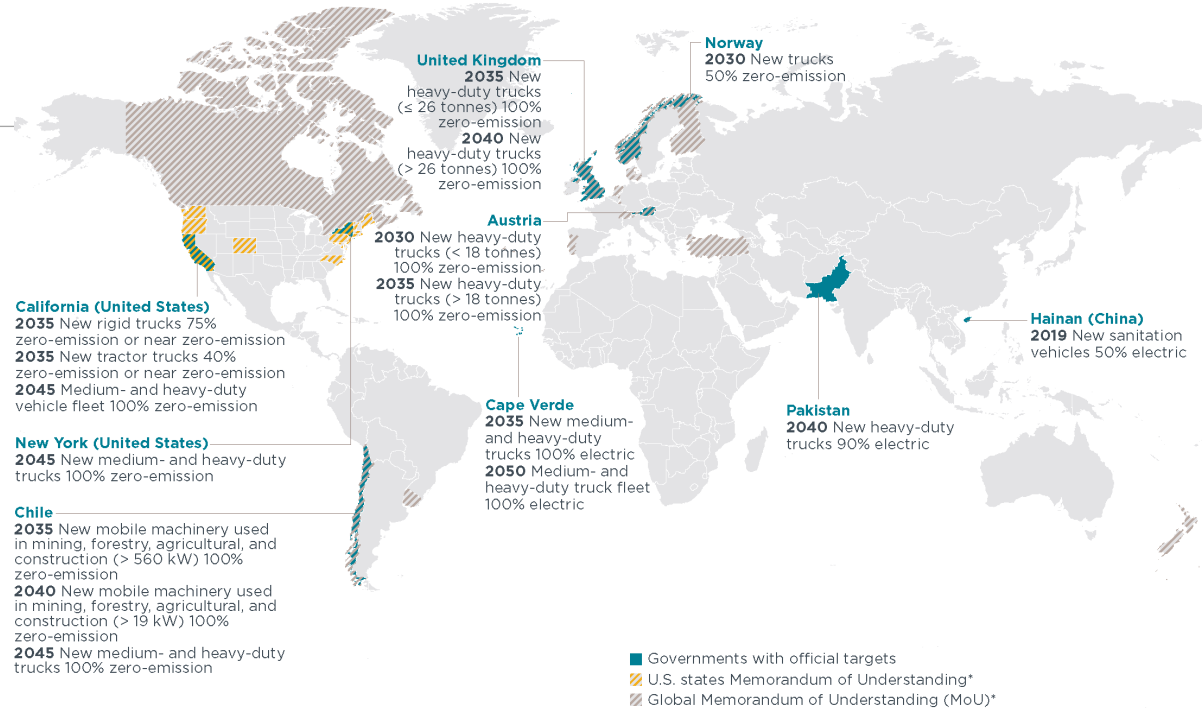
## GOALS

1. At least 45% HD ZEV sales in 2030
2. 100% HD ZEV sales no later than 2040



**Figure 1.** Global WTW CO<sub>2</sub> emissions from cars, vans, trucks, and buses compared to 1.5°C and 2°C compatible emissions pathways. Source: Sen and Miller (2022).

# Government commitments to HD ZEVs



U.S. states Memorandum of Understanding (MoU)

California, Colorado, Connecticut, Hawaii, Maine, Maryland, Massachusetts, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Rhode Island, Vermont and Washington and the District of Columbia

2030 New medium- and heavy-duty vehicles 30% zero-emission

2050 New medium- and heavy-duty vehicles 100% zero-emission

Note: Governments with an at least 40% new truck sales target.

\* Not necessarily yet reflected in an official national/state policy document such as a climate or transport strategy/plan, in a law, or in a similar framework.

Global Memorandum of Understanding (MoU)

Austria, Canada, Chile, Denmark, Finland, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Scotland, Switzerland, Turkey, United Kingdom, Uruguay, Wales

2030 New medium- and heavy-duty vehicles 30% zero-emission

2040 New medium- and heavy-duty vehicles 100% zero-emission

# HD ZEV Manufacturer Commitments

| Manufacturer                 | Commitment                                                                                                                                                                          |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Daimler Trucks <sup>15</sup> | 100% sales of CO <sub>2</sub> -neutral vehicles in driving operation (tank-to-wheel) in Europe, North America and Japan by 2039                                                     |
| Ford <sup>16</sup>           | 67% zero-emission commercial vehicle sales by 2030 in Europe, 100% by 2035                                                                                                          |
| Navistar <sup>17</sup>       | 50% zero-emission sales by 2030, 100% by 2040                                                                                                                                       |
| Traton Group <sup>18</sup>   | 50% zero-emission sales of Scania trucks by 2030, 100% by 2040<br>60% zero-emission sales of MAN delivery trucks by 2030<br>40% zero-emission sales of MAN long-haul trucks by 2030 |
| Volvo Trucks <sup>19</sup>   | 50% sales of electric trucks by 2030 globally, 70% in Europe<br>100% fossil fuel free vehicles by 2040                                                                              |

<sup>15</sup> "Environment," Daimler Trucks, accessed Sept 27, 2022, <https://www.daimlertruck.com/sustainability/e-environment/>

<sup>16</sup> Ford Motor Company, "Helping Build a Better World: Integrated Sustainability and Financial Report 2022" (Dearborn, MI, n.d.), <https://corporate.ford.com/content/dam/corporate/us/en-us/documents/reports/integrated-sustainability-and-financial-report-2022.pdf>.

<sup>17</sup> McDaniel, Jason, "Navistar launches new truck with its 'last' internal combustion engine", Bulk Transporter, August 16, 2022, <https://www.bulktransporter.com/equipment/trucks/article/21248846/navistar-launches-new-truck-last-ice-powertrain>.

<sup>18</sup> Traton Group, "Traton Group Boosts Investment in Electric Mobility"; Matthias Rathmann, "CEO Levin zur Antriebswende: Warum Traton auf Batterien setzt," Eurotransport, September 7, 2022, <https://www.eurotransport.de/artikel/ceo-levin-zur-antriebswende-warum-traton-auf-batterien-setzt-11213350.html>.

<sup>19</sup> Volvo Trucks, "New report - High pressure on the transport industry to shift to electric," accessed October 11, 2022, <https://www.volvotrucks.com/en-en/news-stories/press-releases/2022/sep/New-report-high-pressure-on-the-transport-industry-to-shift-to-electric.html>; "Towards Fossil Free Transport," Volvo, accessed September 27, 2022, <https://www.volvogroup.com/en/future-of-transportation/going-fossil-free.html>.

# HD ZEV production sites in North America



© 2022 Mapbox © OpenStreetMap

# Published work

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## **Summary fact sheet**

<https://theicct.org/benefits-ca-multi-state-reg-data/>

## **Individual state (plus DC) fact sheets and data spreadsheets**

<https://theicct.org/benefits-ca-multi-state-reg-data/>

## **Original methods paper**

<https://theicct.org/publication/benefits-of-state-level-adoption-of-california-medium-and-heavy-duty-vehicle-regulations/>

## **Previous work published 1 November 2021**

<https://theicct.org/publication/state-level-hdv-emissions-reg-fs-dec21/>

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