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ACC II Program Analysis

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Summary of Findings

- Adopting ACC II will provide substantial emissions reductions and associated health benefits in every state analyzed
- Together with California, the 16 states analyzed account for 37% of the 2022 U.S. light-duty vehicle market and are home to 38% of the U.S. population
- Combined emissions avoided in the 16 states, 2025-2040:
  - 135,700 US tons of NO_x
  - 9,200 US tons of $PM_{2.5}$
  - 1.1 billion metric tons of CO_2e (well-to-wheel)
- The combined total of net health benefits in the 16 states in calendar year 2040: $6.5 billion dollars

Project Overview

- Analyze benefits of the ACC II program in 16 states:
  - CO, CT, DE, MA, MD, ME, MN, NJ, NM, NV, NY, OR, RI, VA, VT, WA
  - Emissions modeling with MOVES3
  - Define a business as usual (BAU) scenario for future years
  - Apply ACC II credit to BAU for two scenarios:
    - Implementation of ACC II starting in model year 2026
    - Implementation of ACC II starting in model year 2027
  - Estimate changes in upstream emissions using DOE's GREET model
  - Estimate ZEV population/sales/VMT by year
  - Conduct COBRA modeling to characterize health benefits
  - Produce a summary spreadsheet and fact sheet for each state

Baseline MOVES Modeling

- Ran MOVES at the County scale, using state input data (NEI and/or state-provided), for 2017, 2030, 2040
  - Modeled NO_x, $PM_{2.5}$, WTW CO_2e, plus VOC, NH_3 and SO_2 for COBRA inputs
- Ran MOVES at the Default scale to generate interpolation factors for 2017, 2020-2040 in 5-year increments
- Result:
  - County-scale results for 2017, 2030, 2040
  - Interpolated County-scale estimates for 2020, 2025, 2035
  - Interpolated annual estimates for intervening calendar years so that all years are covered

BAU Scenario

- Purpose: adjust MOVES output to reflect current fleet ZEV population, and future ZEV population/emissions without ACC II
- EPA's December 2021 LDV GHG rule used as BAU
    - Estimated emissions reductions provided by OTAQ staff applied to MOVES3 output
    - EPA-estimated ZEV sales penetration used to project future BAU ZEV population
- Result: adjusted baseline (lower tailpipe emissions, higher ZEV population and grid emissions)

Upstream Emissions/Net Benefits

- GREET grid emissions rates and petroleum fuel production emissions used to calculate changes in upstream emissions
  - ZEVs result in increased grid emissions, and lower petroleum sector emissions
- Grid emissions rates from GREET and eGRID are used, adjusted with state-provided renewable energy projections
- Net emissions change calculated for criteria pollutants/ precursors and CO_2e

Developing ACC II Adjustments

- ACC II involves multiple changes for conventional vehicles that can't be explicitly modeled in MOVES:
  - Tighter NMOG+NO_x standards
  - Cold-start standards
  - Evaporative standards
  - Aggressive driving standards
- CARB provided overall emissions reductions, but not reductions for individual elements
- Applying an overall emissions reduction to MOVES model output is the only practical way to reflect these changes

Total All Vehicle Types % Reduction From CARB Baseline				
CY	**Nox**	**PM2.5**	**ROG**	**CO2**
2026	0.004	0.003	0.002	0.008
2027	0.010	0.007	0.006	0.023
2028	0.020	0.013	0.012	0.043
2029	0.032	0.021	0.020	0.068
2030	0.049	0.030	0.030	0.098
2031	0.069	0.041	0.043	0.135
2032	0.094	0.053	0.057	0.177
2033	0.123	0.066	0.073	0.224
2034	0.156	0.080	0.091	0.276
2035	0.194	0.096	0.111	0.333
2036	0.235	0.111	0.133	0.388
2037	0.278	0.126	0.155	0.441
2038	0.323	0.140	0.180	0.491
2039	0.371	0.153	0.206	0.539
2040	0.419	0.166	0.236	0.583

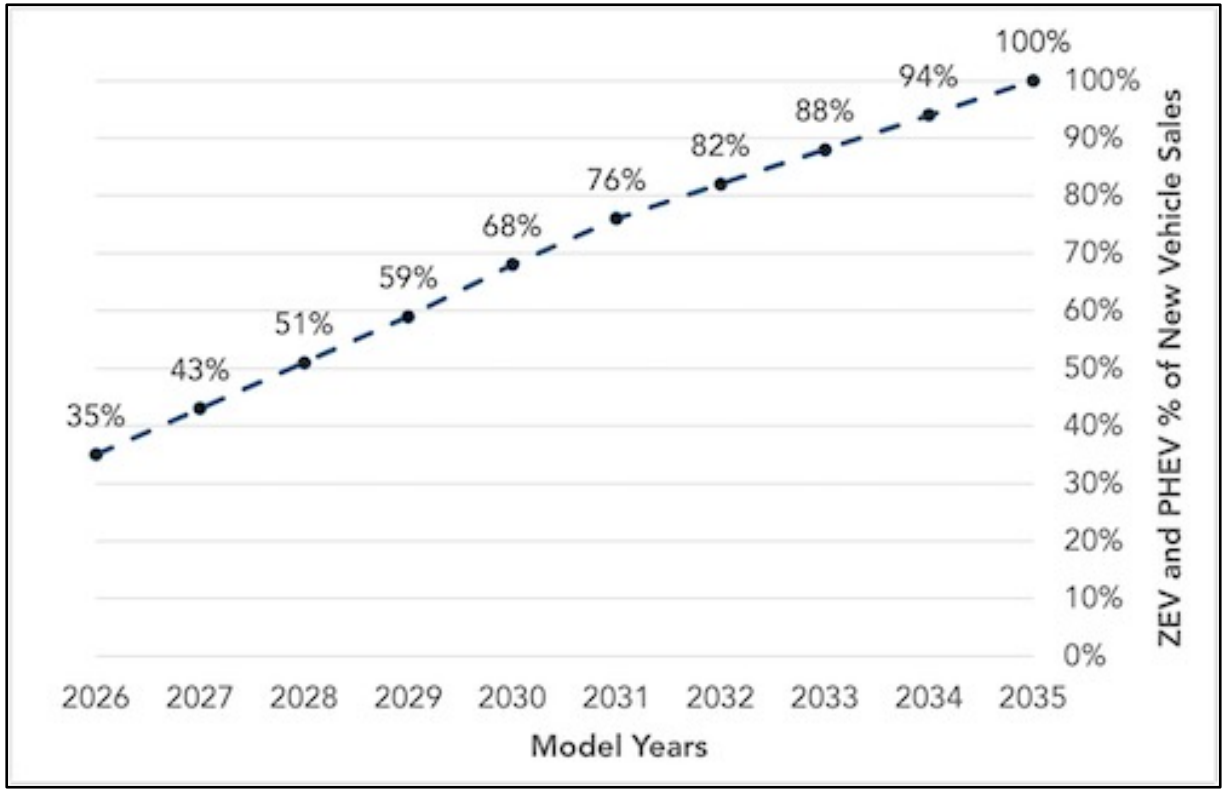
reductions from EPA Rule baseline (reductions from BAU scenario):								
MY2026 Implementation								
yearID	regCalssID	NOx	CO2	Energy	Total PM2.5	VOC	SO2	NH3
2025	All	0	0	0	0	0	0	0
2026	All	**0.006**	**0.014**	0	**0.005**	**0.003**	0.016	0.016
2027	All	**0.016**	**0.036**	0	**0.011**	**0.009**	0.038	0.038
2028	All	**0.029**	**0.065**	0	**0.020**	**0.018**	0.065	0.065
2029	All	**0.047**	**0.099**	0	**0.030**	**0.029**	0.098	0.098
2030	All	**0.069**	**0.139**	0	**0.042**	**0.043**	0.135	0.135
2031	All	**0.095**	**0.186**	0	**0.056**	**0.059**	0.177	0.177
2032	All	**0.125**	**0.236**	0	**0.070**	**0.076**	0.219	0.219
2033	All	**0.158**	**0.289**	0	**0.085**	**0.094**	0.262	0.262
2034	All	**0.195**	**0.345**	0	**0.100**	**0.114**	0.306	0.306
2035	All	**0.235**	**0.404**	0	**0.116**	**0.135**	0.348	0.348
2036	All	**0.277**	**0.458**	0	**0.131**	**0.157**	0.387	0.387
2037	All	**0.318**	**0.505**	0	**0.144**	**0.178**	0.421	0.421
2038	All	**0.359**	**0.545**	0	**0.155**	**0.199**	0.450	0.450
2039	All	**0.399**	**0.579**	0	**0.165**	**0.222**	0.475	0.475
2040	All	**0.436**	**0.607**	0	**0.173**	**0.246**	0.495	0.495

Developing ACC II Adjustments

- CARB provided emissions reductions for most of the pollutants being analyzed for both the proposed rule and the final rule
  - Estimated reductions not provided for SO_2 or NH_3; change in in-use ZEV fractions used as a surrogate
- Those reductions applied to MOVES-based BAU scenario
  - Adjustments made to account for different in-use ZEV fractions between CARB baseline and EPA no-action scenario
- CARB ZEV sales targets used to estimate sales/population in states
  - Our ZEV estimates represent a “lower-bound” scenario reflecting use of available regulatory flexibilities (20% lower than nominal sales percentages) through 2030

Mandated ZEV Sales

- ACC II includes ZEV sales mandates: 35% of new LDVs starting in model year 2026, increasing to 100% for model year 2035



Developing the ACC II Lower Bound Scenario

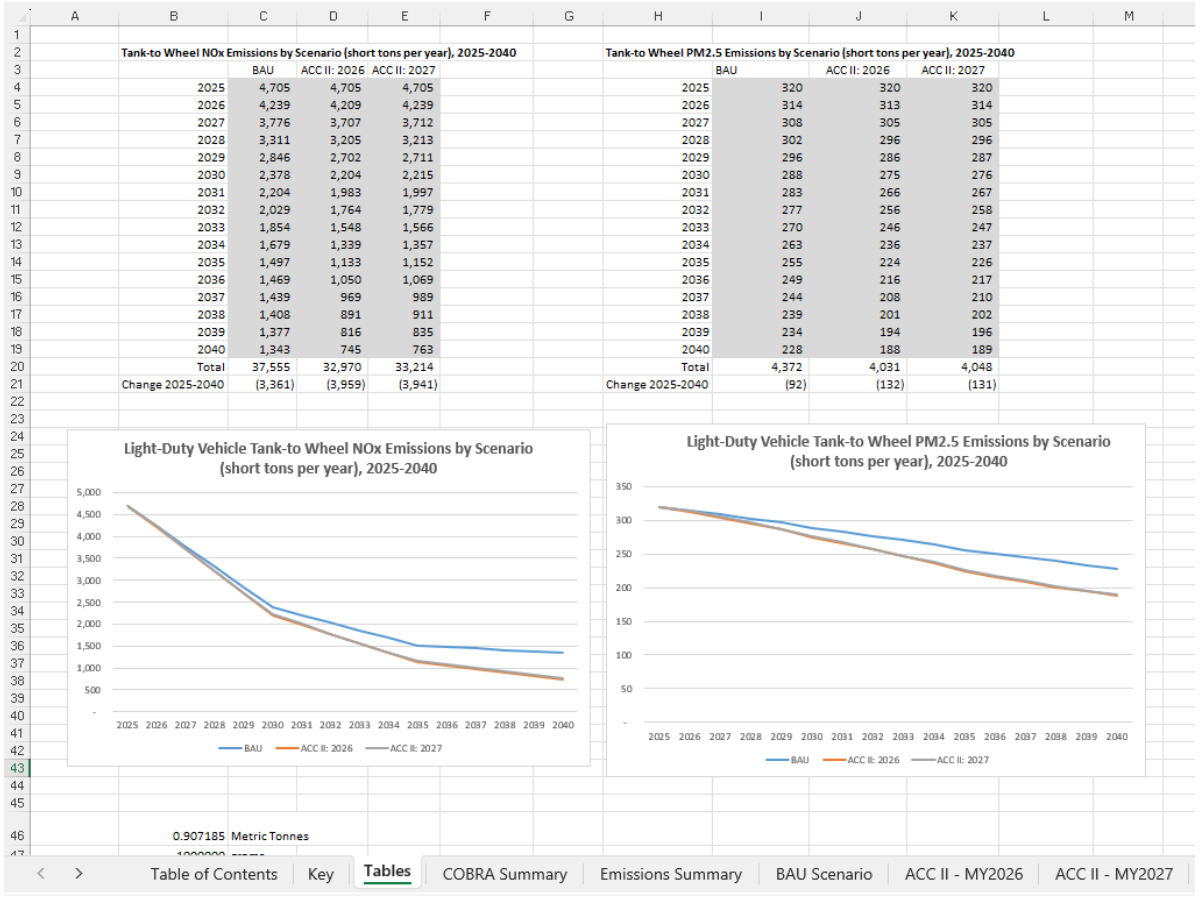
- OEMs have several compliance flexibilities available to them in the ACC II program, including:
  - Environmental justice vehicle values (up to 5% between MYs 2026-2031)
  - Early compliance vehicle values (up to 15% in the first three implementation years)
  - Converted ZEV and PHEV values (up to 15% between MYs 2026-2030 or cumulative option)
  - Pooled ZEV and PHEV values (up to 25% in MY 2026, phases down 5% annually, and phases out completely after MY 2030)
  - Proportional FCEV values (10% or, if less, OEM's "FCEV percentage share" in MYs 2026-2030)

- These flexibilities have different conditions for usage, and manufacturers find themselves in varying positions in terms of need, product offerings, market share – we estimate OEMs will utilize a combination of these flexibilities to lower the industrywide annual requirement by 20% in MYs 2026-2030

MY2026 or MY2027 Implementation Modeled

MY2026 Implementation	MY2027 Implementation
Massachusetts	Colorado
New York	Connecticut
Oregon	Delaware
Vermont	Maine
Virginia	Maryland
Washington	Minnesota
	New Jersey
	New Mexico
	Nevada
	Rhode Island

Emissions Analysis Spreadsheets



Tank-to Wheel NOx Emissions by Scenario (short tons per year), 2025-2040

	BAU	ACC II: 2026	ACC II: 2027
2025	4,705	4,705	4,705
2026	4,239	4,209	4,239
2027	3,776	3,707	3,712
2028	3,311	3,205	3,213
2029	2,846	2,702	2,711
2030	2,378	2,204	2,215
2031	2,204	1,983	1,997
2032	2,029	1,764	1,779
2033	1,854	1,548	1,566
2034	1,679	1,339	1,357
2035	1,497	1,133	1,152
2036	1,469	1,050	1,069
2037	1,439	969	989
2038	1,408	891	911
2039	1,377	816	835
2040	1,343	745	763
Total	37,555	32,970	33,214
Change 2025-2040	(3,361)	(3,959)	(3,941)

Tank-to Wheel PM2.5 Emissions by Scenario (short tons per year), 2025-2040

	BAU	ACC II: 2026	ACC II: 2027
2025	320	320	320
2026	314	313	314
2027	308	305	305
2028	302	296	296
2029	296	286	287
2030	288	275	276
2031	283	266	267
2032	277	256	258
2033	270	246	247
2034	263	236	237
2035	255	224	226
2036	249	216	217
2037	244	208	210
2038	239	201	202
2039	234	194	196
2040	228	188	189
Total	4,372	4,031	4,048
Change 2025-2040	(92)	(132)	(131)

0.907185 Metric Tonnes

Table of Contents | Key | Tables | COBRA Summary | Emissions Summary | BAU Scenario | ACC II - MY2026 | ACC II - MY2027

Worksheet	Description of Contents
Key	Overview of scenarios, programs evaluated, and information on vehicle types
Tables	Tables of emissions, VMT, and population by year reflecting EVs sold under the ACC II program
COBRA Summary	Detailed COBRA modeling results (Vehicles = LDV vehicles, EGU = electric generation, REF = petroleum refining, STR = petroleum storage, TRN = petroleum transport)
Emissions Summary	Emissions summary for all scenarios
BAU Scenario	Business as Usual Scenario
ACC II - MY2026	ACC II program starting in model year 2026
ACC II - MY2027	ACC II program starting in model year 2027
Federal GHG Rule	Emissions reductions and fleet technology penetration from EPA's 12/30/21 LDV GHG rule, used to define BAU
ACC Emissions Benefits	CARB estimates of emissions benefits for the ACC II program
Fleet ZEV Fractions	Calculated fractions of ZEVs under the different scenarios
CARB ZEV Counts	CARB projections of convention/ZEV population
ZEV Efficiency	Calculation of relative energy efficiency of ZEVs
ZEV Population	Interim table for calculation of ZEV fractions
ZEV Sales	Estimates of ZEV sales, based on MOVES3 new vehicle sales rates
Combined MOVES Output	County-scale MOVES3 output for 2017, 2030, and 2040; interpolated MOVES3 output for 2020, 2025, 2035 (source data for scenario worksheets)
County Scale Output 2017-2040	Imported MOVES County-scale output
Default Output 2017-2040	Imported MOVES Default-scale output
Output Interpolation	Factors derived for using MOVES Default output to interpolate County values for 2020, 2025, 2035
GREET Factors	GREET electricity and petroleum production emissions rates used in the scenarios
State Grid Data	State-specific renewable energy projections used to calculate state GREET factors
Regional GREET Factors	GREET electricity factors for all areas analyzed as part of this project

ACC II Emissions Benefits

- Vehicle-only emission reductions relative to BAU:
  - 40% - 54% for NO_x
  - 16% - 22% for $PM_{2.5}$
  - 57% - 76% for CO_2e
- Net (well-to-wheel) emission reductions with vehicle reductions, petroleum reductions and grid increases taken into account:
  - 9% - 120% for NO_x
  - 2% - 57% for $PM_{2.5}$
  - 54% - 100% for CO_2e

State	Starting Model Year*	Vehicle Only			Well-to-Wheel		
		NO_x	$PM_{2.5}$	CO_2e	NO_x	$PM_{2.5}$	CO_2e
CO	2027	54%	22%	76%	71%	34%	100%
CT	2027	42%	17%	59%	93%	45%	84%
DE	2027	43%	17%	60%	78%	18%	66%
MA	2026	44%	17%	61%	98%	41%	84%
MD	2027	43%	17%	62%	81%	14%	69%
ME	2027	42%	17%	59%	54%	47%	81%
MN	2027	49%	20%	70%	40%	16%	80%
NJ	2027	41%	16%	58%	89%	44%	77%
NM	2027	42%	18%	65%	50%	29%	80%
NV	2027	40%	17%	60%	9%	2%	54%
NY	2026	45%	18%	62%	120%	49%	89%
OR	2026	41%	16%	57%	84%	46%	82%
RI	2027	41%	16%	58%	97%	57%	83%
VA	2026	47%	19%	66%	94%	41%	87%
VT	2026	42%	17%	59%	104%	47%	84%
WA	2026	42%	17%	58%	77%	43%	84%

ACC II Emissions Benefits: Well-to-Wheel

- Well-to-wheel estimates vary widely due to
  - Different age distributions and growth rates (rate of fleet turnover)
  - Baseline conventional vehicle emissions rates
  - Grid emissions rates & renewable energy targets
- This analysis does not represent a full lifecycle analysis, and these projections focus on the emissions *reductions* from the rule. The analysis does not include the upstream petroleum emissions associated with the remaining ICE vehicles in the fleet, or total emissions from the petroleum and electrical generation sectors.

ACC II Emissions Benefits: Well-to-Wheel

- As a result of this approach, three states had estimated reductions of 100% or greater:
  - WTW CO_2e: Colorado
    - Highest vehicle miles traveled growth between 2025 and 2040 (24%)
    - Highest growth in LDT population (79%)
    - Transitioning the fast-growing LDT fleet from conventional to ZEV vehicles results in large reductions in petroleum-related emissions, but only modest increases in grid emissions (Colorado projects an 80% renewable grid in 2040).
  - WTW NO_x: New York and Vermont
    - Very clean electrical grids in 2040 (97% to 100% renewable)
    - Emissions rates for the conventionally fueled LDV fleet in 2040 are lower than the emissions rate for petroleum production, on a gram-per-million-Btu basis.
    - Displacing these very clean vehicles with electric vehicles relying on near-zero or zero-emitting electricity results in negative total well-to-wheel NO_x emissions.

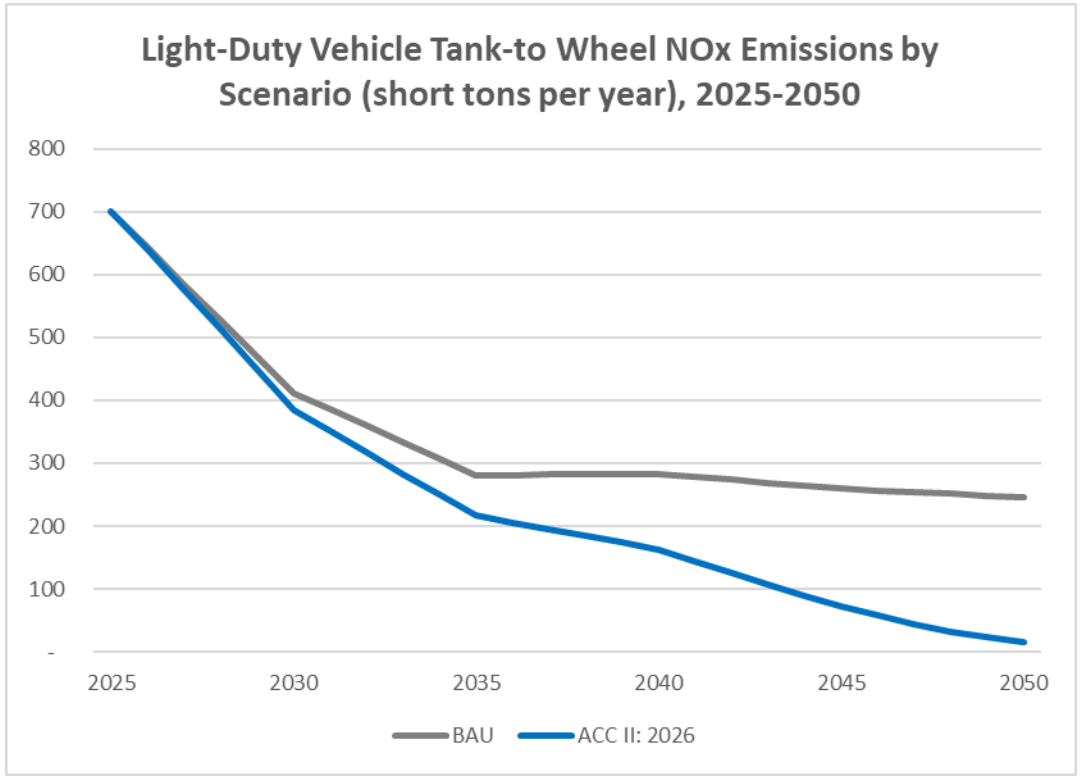
Incremental CO_2e Benefits of ACC II over BAU

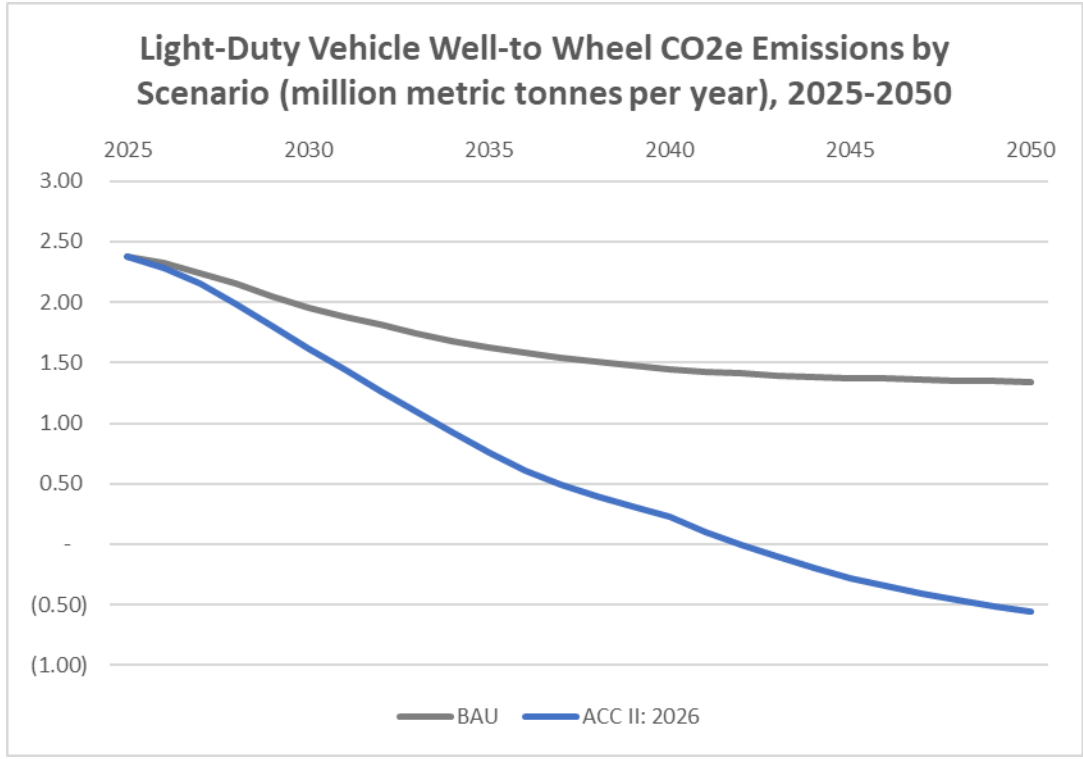
- At the suggestion of New Jersey, we calculated the incremental benefit of ACC II over BAU for CO_2e in each state (NJ shown below):

Year	BAU Scenario CO_2e Reductions from CY 2026, Million Metric Tons		Additional CO_2e Reductions if ACC II Sales Goals are Achieved	
	Tailpipe	Total (WTW)	Tailpipe	Total (WTW)
2030	3.1	3.5	2.7	3.3
2040	7.3	8.7	10.1	12.3
2050	7.9	9.8	16.2	20.8

Trends to 2050 (New Jersey and Vermont)

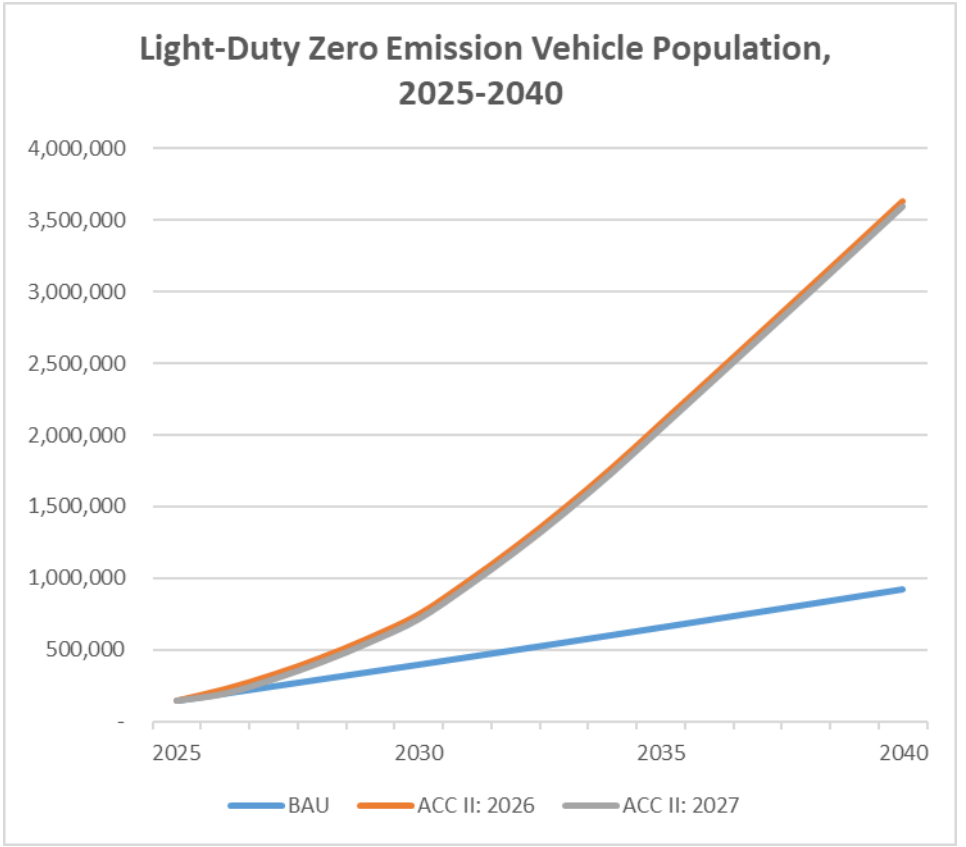
- New Jersey and Vermont requested projections out to calendar year 2050; reductions in 2050 are much larger than those in 2040 (Vermont shown):





ZEV Sales and In-Use Projections

- Used EPA (BAU) and CARB (ACC II) projections of ZEV sales fractions along with MOVES estimates of LDV population and sales to calculate
  - ZEV population
  - ZEV in-use VMT fraction
- eVMT fractions for PHEVs were based on CARB estimates
- Massachusetts ZEV population projections shown at right



COBRA Modeling – Model Basics

- Once emissions analysis was completed, STI used EPA's CO–Benefits Risk Assessment (COBRA) screening model to estimate the economic value of the health benefits associated with the emissions changes.
- COBRA uses a reduced form air quality model, the Source-Receptor (S–R) Matrix, to estimate the effects of emission changes on ambient PM.
- COBRA assesses changes in emissions of $PM_{2.5}$, SO_2, NO_X, NH_3, VOCs, and organic aerosols; the precursors are processed to estimate changes in $PM_{2.5}$ concentrations. For this analysis, COBRA is most sensitive to changes in $PM_{2.5}$ emissions.
- The model translates the ambient PM changes into human health effects and monetizes them.

COBRA Modeling – Modeling Methodology

- ACC II emissions impacts for each sector and state compared to a Business as Usual (BAU) scenario in 2040
  - Light-duty vehicles, electricity generation, petroleum refining, petroleum storage, petroleum transportation
- Emissions are allocated across counties and processes according to COBRA default ratios
  - Default COBRA county level emissions taken from National Emissions Inventory
- Output cases and costs are aggregated at the state level
- Out of state impacts are calculated as a result of dispersion modeling of activity within target state

ACC II Health Benefits

- All states show a net CY2040 health benefit in COBRA; vehicle and petroleum emissions reductions more than offset impacts of grid emissions increases, even in states with relatively “dirty” grids
  - Net benefit ranged from $13 million (VT) to $1.5 billion (NY)
- Highest impact seen in areas with highest population density
  - More people potentially exposed to pollution, and likely higher VMT
  - If EGU sector is present in highest populated counties, larger burdens will be experienced
- Downwind states affected more by EGU sector than others
  - EGU emission points are higher than LDV and are transported further

ACC II/EPA 2027 Proposal Comparison

- Using emissions inventory projections provided by EPA, we compared the relative benefits of ACC II and EPA's proposed Multi-Pollutant Emissions Standards for MY2027+ LDV/MDV
- Emissions reductions calculated from EPA's No Action and Proposal vehicle emissions inventories
- Compared to our BAU representing EPA's 2021 LDV GHG rule

Calendar Year 2040 Emissions Reductions from BAU (Vehicle-only)				
	NO_x	$PM_{2.5}$	CO_2e	VOC
ACC II/MY2027	55%	22%	75%	31%
EPA 2027	22%	23%	35%	22%

ACC II Project Documentation

- Summary spreadsheets available for each state
- Fact sheets also available for each state, as well as a summary fact sheet for all states
- Detailed technical report with documentation of methodology, data sources, and assumptions
- Main landing page for all materials, including summary spreadsheets and fact sheets for each state: https://theicct.org/benefits-ca-advanced-clean-cars-ii-reg-data/
- Direct link to technical report: https://theicct.org/publication/benefits-of-state-level-adoption-of-california-acc-ii-regulations/