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TRANSPORTATION MACROECONOMIC ACCOUNTING MODELS: VISION AND NON-LIGHT DUTY ENERGY AND GREENHOUSE GAS (GHG) EMISSIONS ACCOUNTING TOOL (NEAT)

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VAN033

OVERVIEW

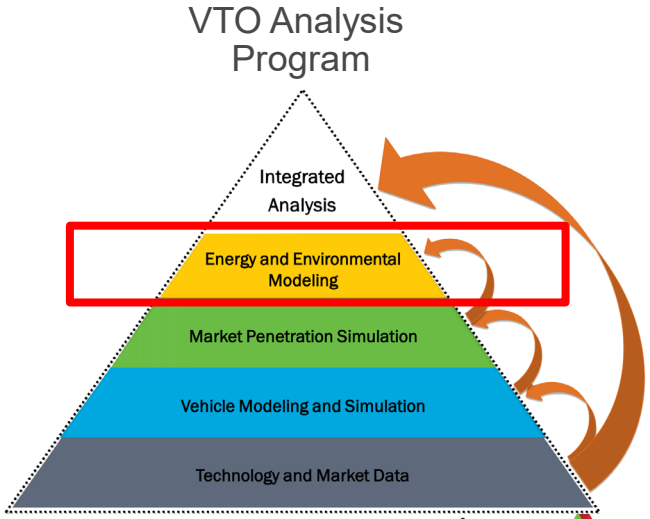
Timeline	Barriers Addressed
• Project start date: 10/01/2019 • Project end date: 09/30/2022 • Percent complete: 80%	• Indicators and methodology for evaluating environmental sustainability • Evaluating energy and emissions benefits of vehicle/fuel systems • Overcoming inconsistent data, assumptions, and guidelines
Budget	**Partners**
• Total Project Funding: $750 K • Funding for FY22: $250 K	National labs: • NREL (Alicia Birky)

RELEVANCE AND OBJECTIVES

Need analytical modeling capabilities to compare and evaluate fleet impact of vehicle and fuel technologies by employing consistent, systematic approaches and methodologies.

Objectives: VISION/NEAT have been developed to provide estimates of the potential energy use, oil use, and carbon emissions impacts of advanced light-duty vehicles (LDVs), medium-duty vehicles (MDVs), heavy-duty vehicles (HDVs), and freight modes, as well as alternative fuels, at the national level.

- **Annually update and calibrate VISION/NEAT** models with projections from the Energy Information Administration's Annual Energy Outlook (AEO) reference case and the Department of Transportation's Freight Analysis Framework (FAF)
- **Enhance the medium- and heavy-duty (MDHD) modeling capabilities**
- **Quantify the impact of light-duty vehicle upsizing**
- **Quantify regionally-resolved emissions from electric vehicles adoption by county**.



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APPROACH: VISION/NEAT FLEET IMPACT MODEL STRUCTURE

Systematically assess energy and emissions effects of vehicle technology deployment scenarios

MODEL INPUTS
User can define

- Market share
- Fuel efficiency
- VMT by year
- VMT by vehicle
- Survival function
- Fuel blends
- Economic factors
- Ton-miles

MODELS' CALCULATIONS

- Vehicle stock
- VMT per vehicle
- VMT per technology
- Emissions and total embodied energy per Btu of fuel

MAJOR OUTPUTS

- Energy use and GHG emissions by vehicle tech, vehicle type and fuel type
- Energy use and GHG by freight mode

	VEHICLE CLASS	TECHNOLOGY AND FUEL
HIGHWAY VEHICLES	**VISION—On Road** Cars, Light Trucks	**4 ICEVs** Gasoline, Diesel, E85, CNG **3 HEVs** Gasoline, Diesel, E85 **3 PHEVs** 2 Gasoline Types, Diesel **3 EVs** EV100, EV200, EV300 **1 FCEV**
HIGHWAY VEHICLES	Class 3–6 Trucks	Gasoline, Diesel, CNG, Ethanol, EV, Diesel PHEV, Gasoline PHEV, and FCEV
HIGHWAY VEHICLES / LONG-HAUL FREIGHT	Class 7–8 Vocational	Gasoline, Diesel, LPG, CNG, BEV, PHEV (gasoline, diesel), and FCEV
HIGHWAY VEHICLES / LONG-HAUL FREIGHT	Class 7–8 Day Cab	Diesel, LPG, CNG, BEV, Diesel PHEV, and FCEV
HIGHWAY VEHICLES / LONG-HAUL FREIGHT	Class 7–8 Sleeper	Diesel, LPG, CNG, BEV, Diesel PHEV, and FCEV
LONG-HAUL FREIGHT	**NEAT—Off Road**	Diesel Biodiesel Renewable diesel Jet fuel Electricity Hydrogen

FREIGHT MODES
Domestic marine
Air freight
Rail
Pipeline
Trucks

FUEL PATHWAYS

- Crude oil to gasoline and diesel
- Natural gas to CNG, LNG, F-T diesel
- Soybeans to biodiesel
- Corn, sugarcane, switchgrass to ethanol
- Coal, nuclear, renewables to electricity
- NG, coal, biomass to H_2

ABBREVIATIONS

BEV	Battery Electric Vehicle
CNG	Compressed Natural Gas
E85	Ethanol-Gasoline blend
EV	Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
F-T	Fischer-Tropsch
H_2	Hydrogen
HEV	Hybrid Electric Vehicle
ICEV	Internal Combustion Engine Vehicle
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
NG	Natural Gas
PHEV	Plug-In Hybrid Electric Vehicle
VMT	Vehicle Miles Traveled

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APPROACH: REGIONAL EMISSIONS BENEFITS

Estimating County-Level Emissions Benefits of PEV Adoption Using VISION

Data Sources

- National and State-Level **PEV Targets**
(e.g., 50% of sales by 2030)
- **FHWA Highway Statistics:** State Vehicle Registration
- **EIA AEO:** Vehicle Efficiency

- **US EPA MOVES3:** County-Level VMT

- **Cambium and GREET:** Local emission intensity

Method

- **Estimate** PEV Sales Share for Each State from 2020 to 2050
- **Estimate** State-Level Energy Consumption in VISION

- **Allocate** State-Level Energy Consumption to the County Level based on County-Level VMT

- **Calculate** County-Level Emissions Benefit based on Local Emissions Intensity

Deliverables

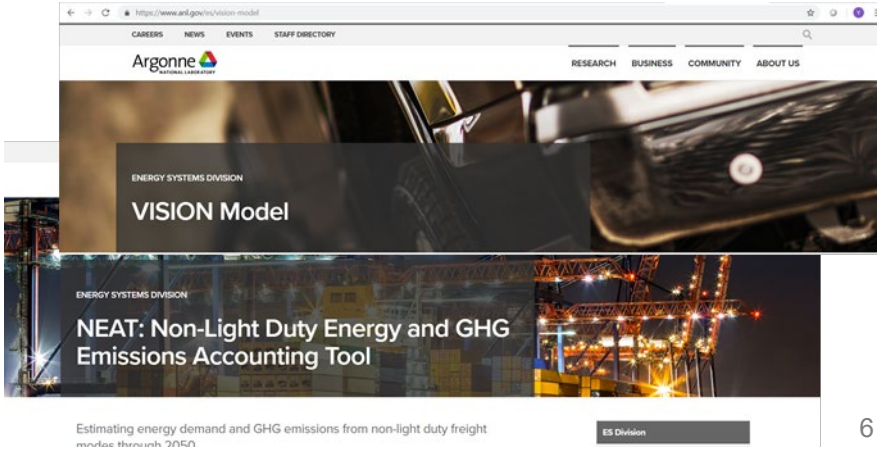
- County-Level Emissions Benefits
- Presentations
- Publishable Reports and Papers

ACCOMPLISHMENTS

Models are annually updated, calibrated and released to the users

- Argonne has been developing the VISION/NEAT models since 2000 with annual expansions; Over 400 users
- **Annually updated** using energy/emissions rates from GREET®
- **Allow users to define mobility parameters** such as annual VMT per vehicle, vehicle survival functions, etc.*
- **Available to public** at https://www.anl.gov/es/vision-model

- **Developed VISION-online** to improve user experience
  - Car/LT market shares
  - Car/LT fuel economy
  - PHEV range
  - Utility scenarios



ACCOMPLISHMENTS: FURTHER SEPARATE CLASS 7&8 TRUCK BY SEGMENT

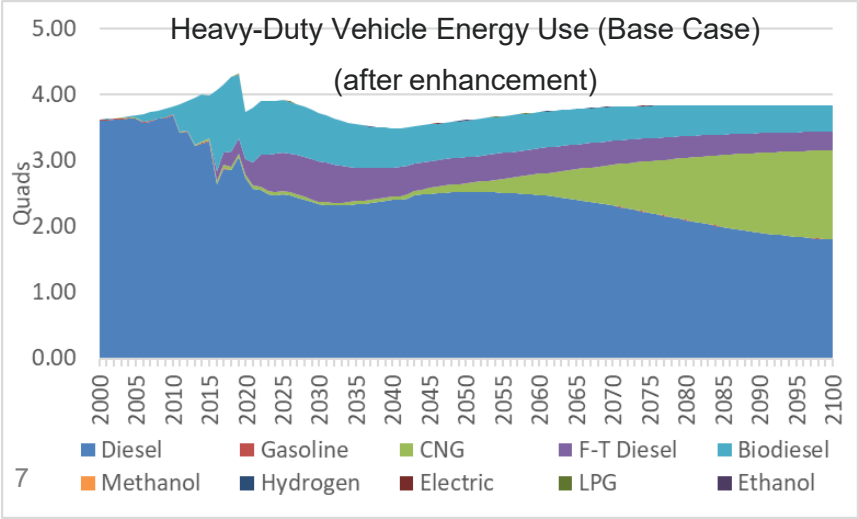
Annual Update and Enhancement

Enhance the medium- and heavy-duty (MDHD) modeling capabilities to align with:

- Emerging technologies and trends, the growing DOE MDHD R&D portfolio,
- EPA / NHTSA regulations in MDHD sector
- EIA's NEMS model and improve the correction factors in VISION, which are used to calibrate the model to match EIA projections (Correction Factor = EIA projections/VISION projections)

Previous Segments
Class 7&8 Single Unit (SU)
Class 7&8 Combination

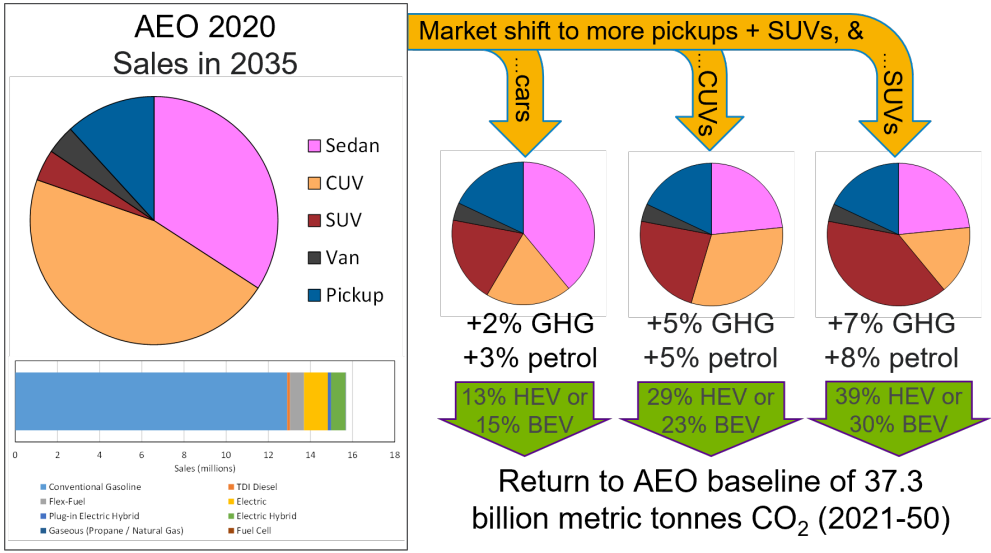
Current Segments
Class 7&8 SU (Vocational)
Class 7&8 Day Cab
Class 7&8 Sleeper



ACCOMPLISHMENTS: IMPACT OF VEHICLE UPSIZING

Evaluate the emissions and energy of different mixes of cars and light trucks, and investigate mitigation strategies

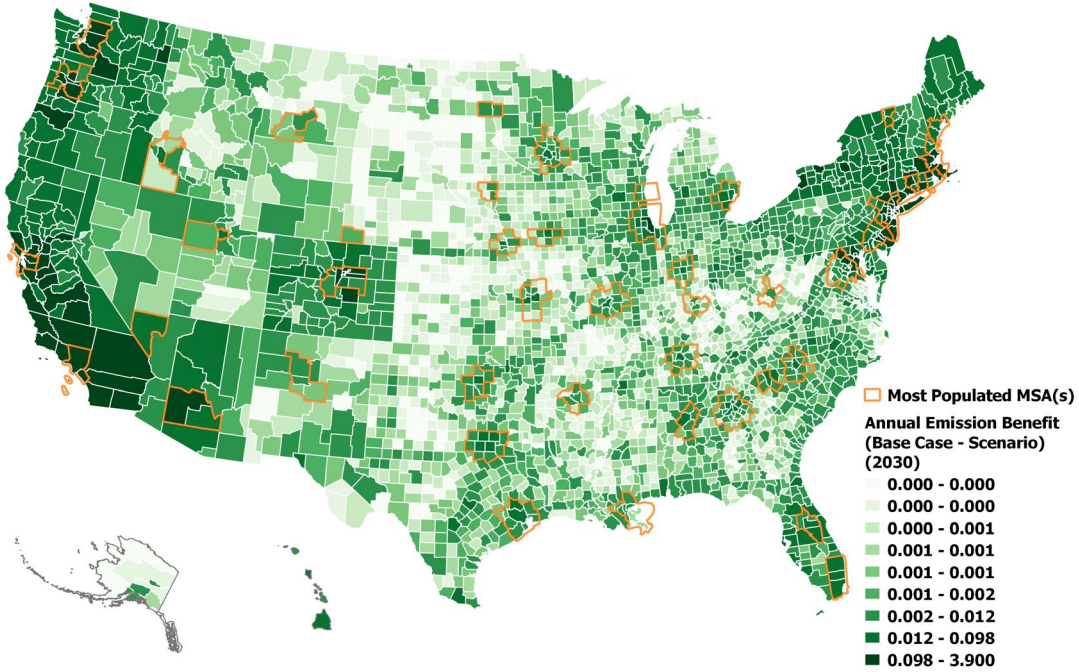
- EIA's Annual Energy Outlook 2020 has a lower share of light trucks than recent historical trends.
  - Developed 60 different scenarios for LDV based on AEO 2020, changing the mix of cars / crossovers / SUVs / pickups / vans.
- Quantified required share of different technologies needed to mitigate potential increase in vehicle size (in terms of emissions or petroleum consumption)
  - What fraction of sales needs to be EVs to offset increases in vehicle size (assessing both fuel consumption and vehicle-cycle emissions)?
  - Also considered lightweighting, aerodynamic drag reduction, rolling resistance, hybridization (micro-, mild-, and full), and engine downsizing



Publication won the Best Paper award of the 2022 TRB AMS10 committee

ACCOMPLISHMENTS: COUNTY-LEVEL WELL-TO-WHEEL EMISSIONS BENEFITS OF PEV ADOPTION

The following map shows a snapshot of annual emissions reduction in 2030 at the county level. It compares the base case emissions in 2030 with the scenario emissions in 2030.



Magnitude of the emissions reduction depends on multiple variables. In general,

Some regions show greater amounts of emissions reductions than other parts of the country:

- ZEV States (e.g. California and Oregon)
- Large metropolitan areas (e.g. Chicago and Detroit), and
- Populated states (e.g. Florida).

In contrast, other regions show relatively small amounts of emissions reduction:

- Remote and rural areas (e.g. North Dakota)
- Areas with relatively unclean grid (e.g. Indiana and Kentucky)

COLLABORATION AND PROPOSED RESEARCH

Collaboration

- NREL: assists on data sources and methodologies
  - Provided NEMS input data files
  - Provided analysis of VIUS VMT data
  - Collaborate on calibrating segmented scrappage and VMT to class totals
- ORNL: provides historical data on vehicle stock, sales and VMT

Proposed Research *(Note: Any proposed future work is subject to funding levels)*

- Update and maintain the model on an annual basis
- Continue estimating regional emissions reductions from EV adoption
  - Consider different conventional vehicles to be replaced
- Add off-road technologies to support the growing DOE off-road R&D portfolio
  - Add vehicles with the high potential for decarbonization, considering each equipment type's projected future powertrain market, horsepower rating
- Energy equity: assess the energy and emissions impact of promoting both new and used fuel-efficient vehicle adoption and usage

RESPONSES TO PREVIOUS YEAR REVIEWERS' COMMENTS

- Collaboration between National Laboratories is well-established, but more information needs to be provided….. For example, the reviewer would like to know if the baseline data shared through ORNL and NREL is updated annually….

Thank you for recognizing our collaboration with NREL. We provide more information on slide 10. The baseline data through ORNL and NREL is updated annually.

- Some additional modeling capabilities and granularity have been added to the VISION model which is desirable.

Agree. We have demonstrated how to use VISION for state-level (slide 9) and county-level (slide 15) analysis. The Excel spreadsheet model and VISION-online available for the public use is only for national analysis. We provide assistance to the users if they need to conduct regional-level analysis.

- ….It will be beneficial to continue improving the model documentation and public facing sharing

Agree. We have proposed to update the user guide in FY23 to include the new HDV capabilities.

- The work is very relevant to DOE objectives like enhancing tools that estimate GHG emissions and energy use of alternate vehicle technologies with macroeconomic approaches….. The project supports overall DOE objectives by providing core analytical tools.

Thank you for the recognition. We will continue to update and improve the model, as well as to support our users.

SUMMARY

- **Objectives:** develop analytical modeling capabilities to compare and evaluate fleet impact of vehicle and fuel technologies by employing consistent, systematic approaches and methodologies.
- **Outcomes:** publicly available models for users to compare scenarios. Energy and emissions impact analysis of advanced technologies deployment.
- **Methods:** Annually updated and calibrated to match with projections from AEO and FAF. Adopts latest energy and emissions rates from GREET model. FY22 focus on conducting regional WTW emissions reduction analysis using VISION.
- **Results:** 1) Release the models on Argonne's websites and support other DOE programs, 2) Scenario analysis shows adjusting the sales shares of LDV by size class can change estimates of energy consumption by over 10% compared to AEO reference case, 3) Regionally-resolved emissions analysis illustrates the geographic variation in emissions benefits from PEV adoption
- **Publications:** Model user guide and reports to document data and methodologies
- **Milestones:** Successful quarterly and annual milestones delivered on-time and within budget – improving over time as more data becomes available

TECHNICAL BACK-UP SLIDES

APPROACH – REGIONAL EMISSIONS BENEFIT

Research Plan for Improved Results

Research Plan:

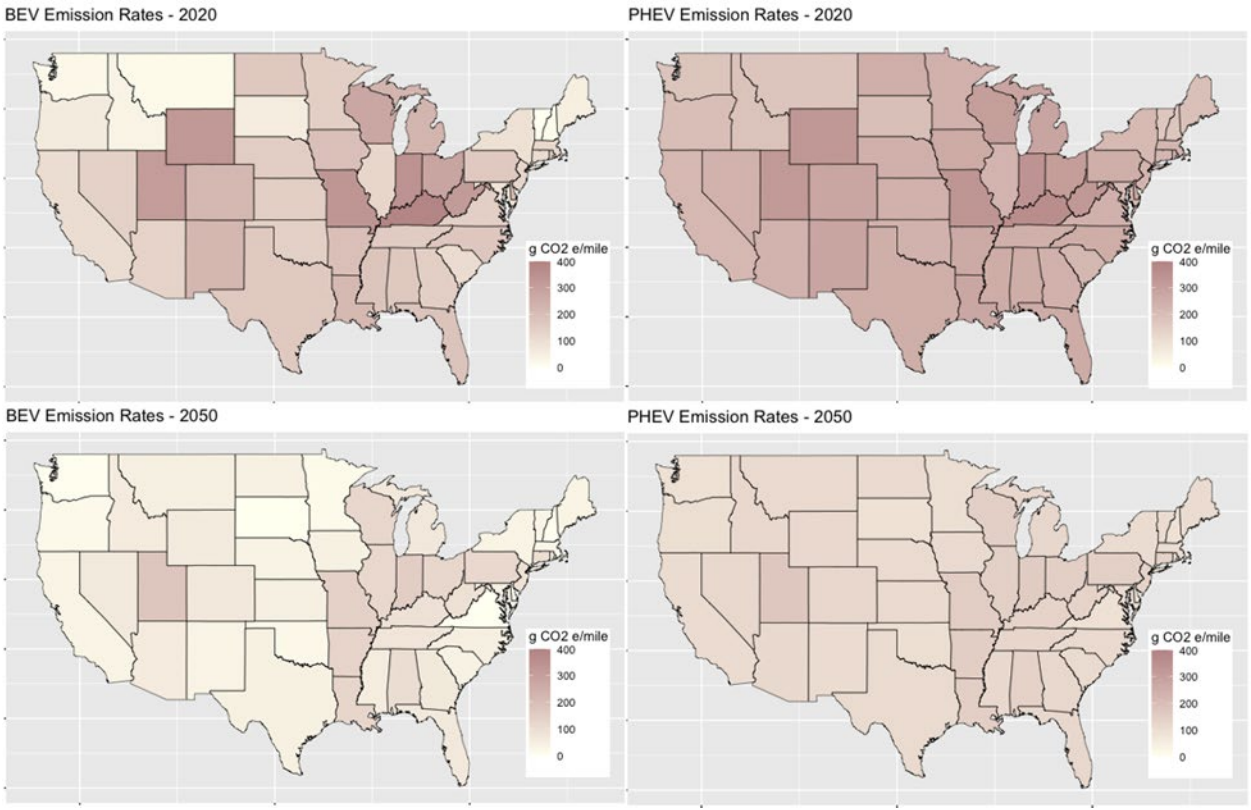
- Summarize PEV goals in details for every state (ZEV and non-ZEV);
- Estimate regional carbon intensities in GREET using local grid mixes from NREL's Cambium;
- Separate major metropolitan area(s) from each state for separate analyses;
- Calculate state-level VMT for gasoline, BEV, and PHEV in VISION for scenario and base case and allocate to counties, and
- Use the county-level VMT and regional carbon intensities to calculate emissions benefits.

Improvement in Results:

- State-specific PEV penetration goals will improve the reliability of state-level PEV projections
- Separating metro areas can account for their higher PEV stock and VMT compared with other regions;
- Regional carbon intensities can improve the accuracy of county-level emissions benefits estimation.

ACCOMPLISHMENTS: EMISSIONS RATES FOR BEVS AND PHEVS BY STATE IN 2020 AND 2050

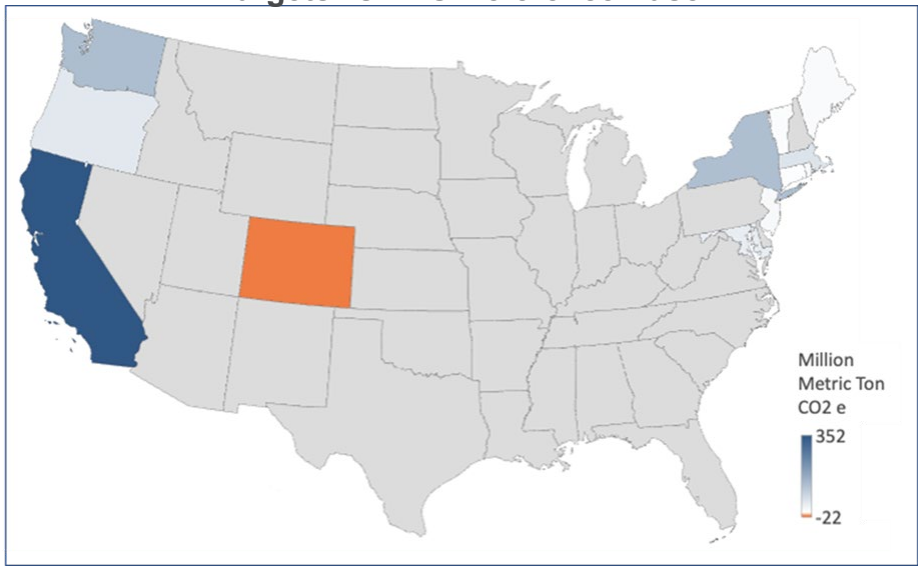
- Emissions per mile for BEVs and PHEVs in 2020 and 2050: show both improvements in the grid and in the average vehicle efficiency



ACCOMPLISHMENTS: REDUCTION IN WTW EMISSIONS RELATIVE TO THE AEO REFERENCE CASE DUE TO ACHIEVING ZEV SALES TARGET

- WTW emissions reductions depend on the PEV adoption targets and the grid mix
  - NREL Cambium grid emissions rates indicate a larger reduction than when estimated using AEO grid mix

National Total GHG Emissions under All Scenarios (Million Metric Tons)

Scenarios		Sales Mix		
		With ZEV mandates	Without ZEV mandates	Difference
Grid Mix	NREL Cambium	17,007	17,616	-609
	AEO Reference Case	17,924	18,100	-176
	Difference	917	484	

Cumulative GHG reduction (2020-2050): ZEV Targets vs AEO Reference Case