



# Reducing Greenhouse Gas Emissions: A Guide for State DOTs

*NCHRP Project 25-56/ WebResource 1*

*presented to*

*TRB Webinar*

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# Agenda

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- Overview of the guide
- Background on climate change and GHGs
- Reducing GHGs from the transportation system users
- Reducing GHGs from transportation agency activities
- Implementing GHG reduction strategies
- Conclusions
- Q&A

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# Overview of the Guide

# The Guide – NCHRP WebResource 1


TRB's COOPERATIVE RESEARCH PROGRAMS

NCHRP WebResources An electronic product line of TRB's Cooperative Research Programs

## Reducing Greenhouse Gas Emissions: A Guide for State DOTs

OVERVIEW ▾ BACKGROUND ▾ FRAMEWORK ▾ FUNCTIONAL AREAS ▾ IMPLEMENTATION ▾ RESOURCES ▾ Search the Website

NCHRP WebResource 1  
PUBLISHED DATE - March 3, 2022



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This guide presents methods for State departments of transportation (DOTs) to reduce greenhouse gas (GHG) emissions from the transportation sector. The purpose of this guide is to

- Identify and describe tools, methods, and data sources that State DOTs can use to assess GHG emissions, evaluate GHG reduction opportunities, and develop action plans based on current and desired engagement levels.
- Provide self-assessment rubrics to help State DOTs understand how they can address GHGs through all stages of their activities across a range of functional

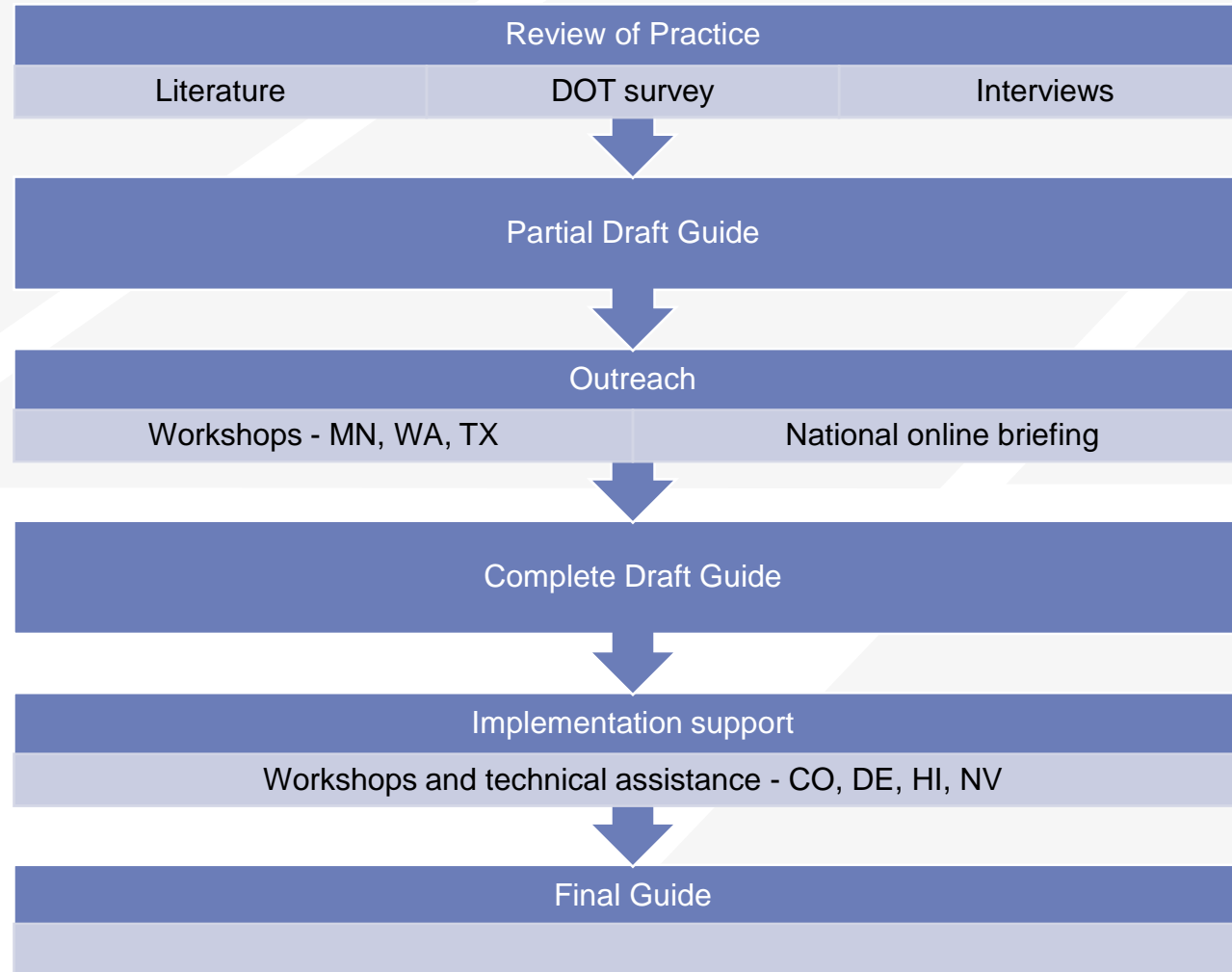
# Purpose of the Guide

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- Identify and describe **tools, methods, and data sources** that State DOTs can use to estimate GHG emissions from the transportation system and evaluate and implement GHG reduction opportunities
- Help State DOTs understand how they can address GHGs through **all stages of their activities**
- Help State DOTs respond to and support **State, local, and/or Federal GHG requirements or initiatives**



# Guide Development Process



# Guide Contents

## Background

- Purpose of Guide (1.0)
- GHG Basics (2.0)
- Planning for Uncertainty (3.0)
- GHGs Across the Agency (4.0)

## Institutional Alignment and Framework

- Policy (5.0)
- Institutional Considerations and Alignment (6.0)
- Partnerships (7.0)
- Communications (8.0)
- Performance Monitoring, Evaluation, and Reporting (18.0)
- Putting it All Together (19.0)

## Functional Areas

- Internal Assessment and Planning (9.0)
- Transportation Systems Planning (10.0)
- Programming (11.0)
- Project Development and Preliminary Design (12.0)
- Environmental Review (13.0)
- Final Design and Construction (14.0)
- Maintenance (15.0)
- System Management and Operations (16.0)
- Regions/Districts (17.0)

## Data and Tools

- References (Appendix A)
- GHG Analysis Tools (Appendix B)
- Examples (Appendix C)
- Electrification Resources (Appendix D)

# Section-by-Section Contents

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- What's included?
- Why address GHGs at this level?
- Level of effort
- Complementarity/consistency with other transportation goals
- Who—roles and responsibilities
- Inventory development and forecasting
- Goal and target setting
- Strategy identification
- Strategy evaluation
- Implementation
- Monitoring, evaluation, and reporting
- Self-assessment tool



# How to Use the Guide

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**I want to know more about climate change, GHG emissions, and why a DOT should care**



**Start with Section 2.0, GHG Basics**

**I want to see some examples of how DOTs have considered GHG reduction potential from transportation**



**See Section 3.0 for overall scenario analysis examples; Sections 9.0–15.0 also include some topic-specific examples**

**I'm charged with implementing a sustainability or climate change program and want to know how to get all the parts of our DOT working on this**



**Start with Section 6.0 (Institutional Considerations); also see Sections 5.0 and 7.0 (Policy, Partnerships) and 18.0 (Putting it All Together)**

# How to Use the Guide (continued)

**I work in a specific functional unit (planning, construction, etc.) and want to know what our unit can be doing to reduce GHGs**



**See the section for your functional unit in Sections 9.0–16.0, including self-assessment tools at the end of each section**

**I want to learn what tools and resources are available to support GHG inventory and strategy analysis**



**See the references in Appendix A and the table of GHG analysis tools and description of tools in Appendix B; or the functional unit sections (9.0–16.0) for specific topics**

**I want to know more about how we can track emissions and communicate progress and successes to the public**



**See Section 8.0 (Communications) and 17.0 (Performance Monitoring)**

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# Background on Climate Change and Greenhouse Gas Emissions

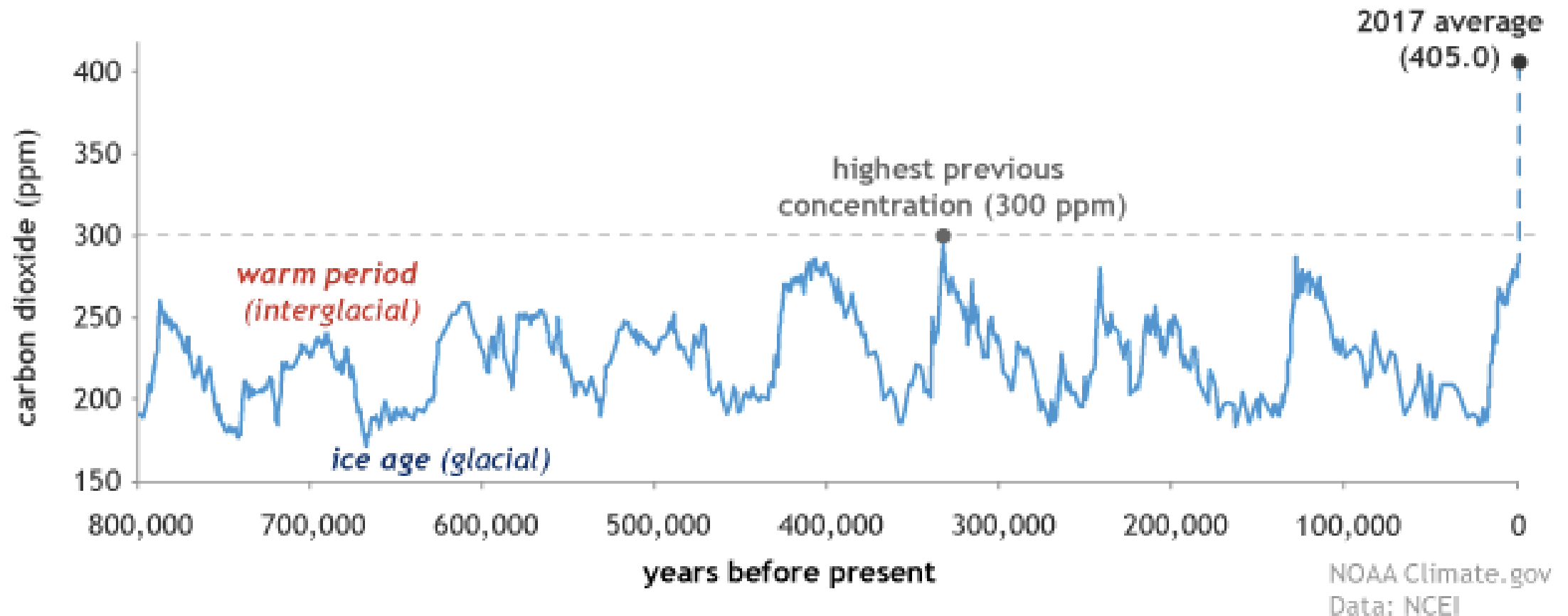
# Greenhouse Gases

Pollutant	Lifetime (Years)	100-year Global Warming Potential	% Increase in Atmosphere, 1750 – 2011/2013	Approximate Contribution to U.S. 2016 Transportation Inventory (%)
Carbon dioxide (CO <sub>2</sub> )	n/a	1	41%	96.1%
Methane (CH <sub>4</sub> )	12	28	152 – 170%	0.9%
Nitrous oxide (N <sub>2</sub> O)	121	65	20%	
Fluorinated gases	varies	4 – 1,430		2.4%

MTCO<sub>2</sub>e = Metric Tons Carbon Dioxide Equivalent

# CO<sub>2</sub> in the Atmosphere

CO<sub>2</sub> during ice ages and warm periods for the past 800,000 years

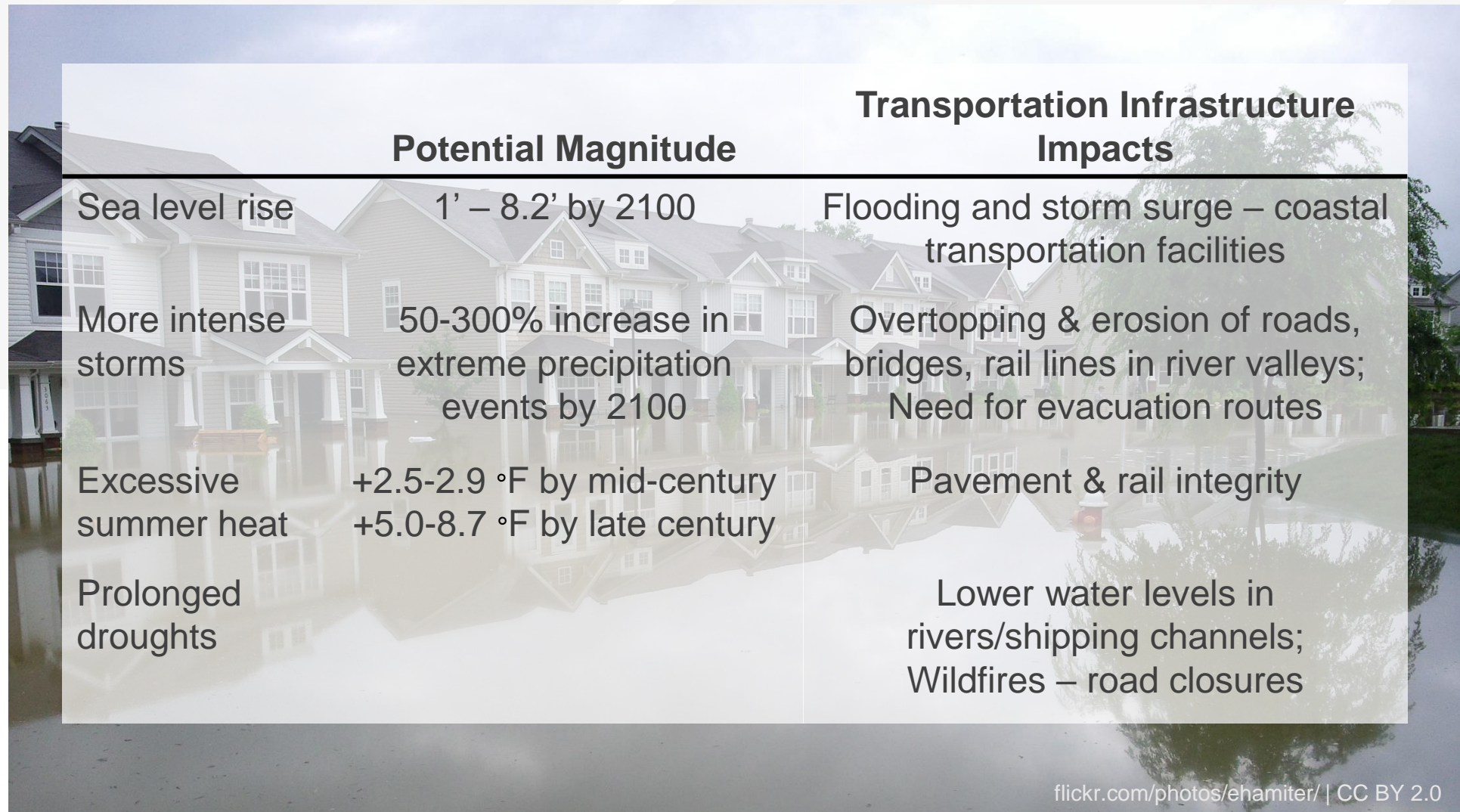


# GHGs vs. Criteria Pollutants

	Greenhouse Gases	Criteria Pollutants and Precursors
Include:	CO <sub>2</sub> , N <sub>2</sub> O, CH <sub>4</sub> , HCFCs	VOC, NO <sub>x</sub> , PM, CO, SO <sub>2</sub> , Lead
Nature of Effects	Trap heat in the atmosphere, causing the atmosphere to warm and various changes to weather and climate <ul style="list-style-type: none"> <li>• <i>May have indirect human health effects</i></li> </ul>	Mainly effects on human health (mortality & morbidity) Some ecological effects (e.g., acid deposition)
Scale of Effects	Global	Local or regional
U.S. Regulation	Emission rates regulated from some sources (e.g., g/mi in vehicle exhaust) Atmospheric concentrations and total emission levels <u>not</u> regulated	Standards for atmospheric concentrations set under Clean Air Act Emission rates of direct pollutants and some precursors regulated

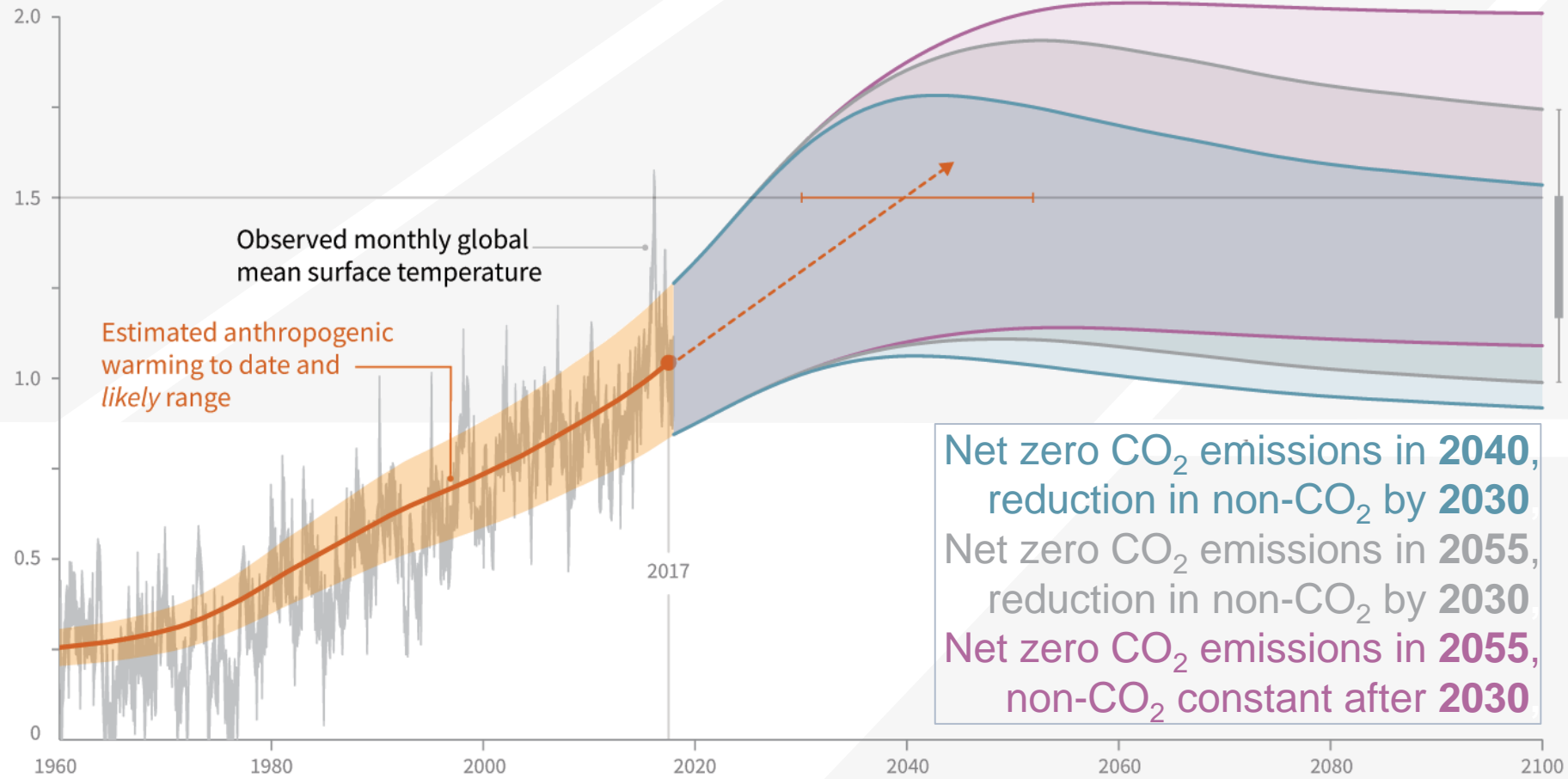


# Climate Change Impacts



	Potential Magnitude	Transportation Infrastructure Impacts
Sea level rise	1' – 8.2' by 2100	Flooding and storm surge – coastal transportation facilities
More intense storms	50-300% increase in extreme precipitation events by 2100	Overtopping & erosion of roads, bridges, rail lines in river valleys; Need for evacuation routes
Excessive summer heat	+2.5-2.9 °F by mid-century +5.0-8.7 °F by late century	Pavement & rail integrity
Prolonged droughts		Lower water levels in rivers/shipping channels; Wildfires – road closures

# CO2 Scenarios to Limit Warming



Graphic: IPCC SR15



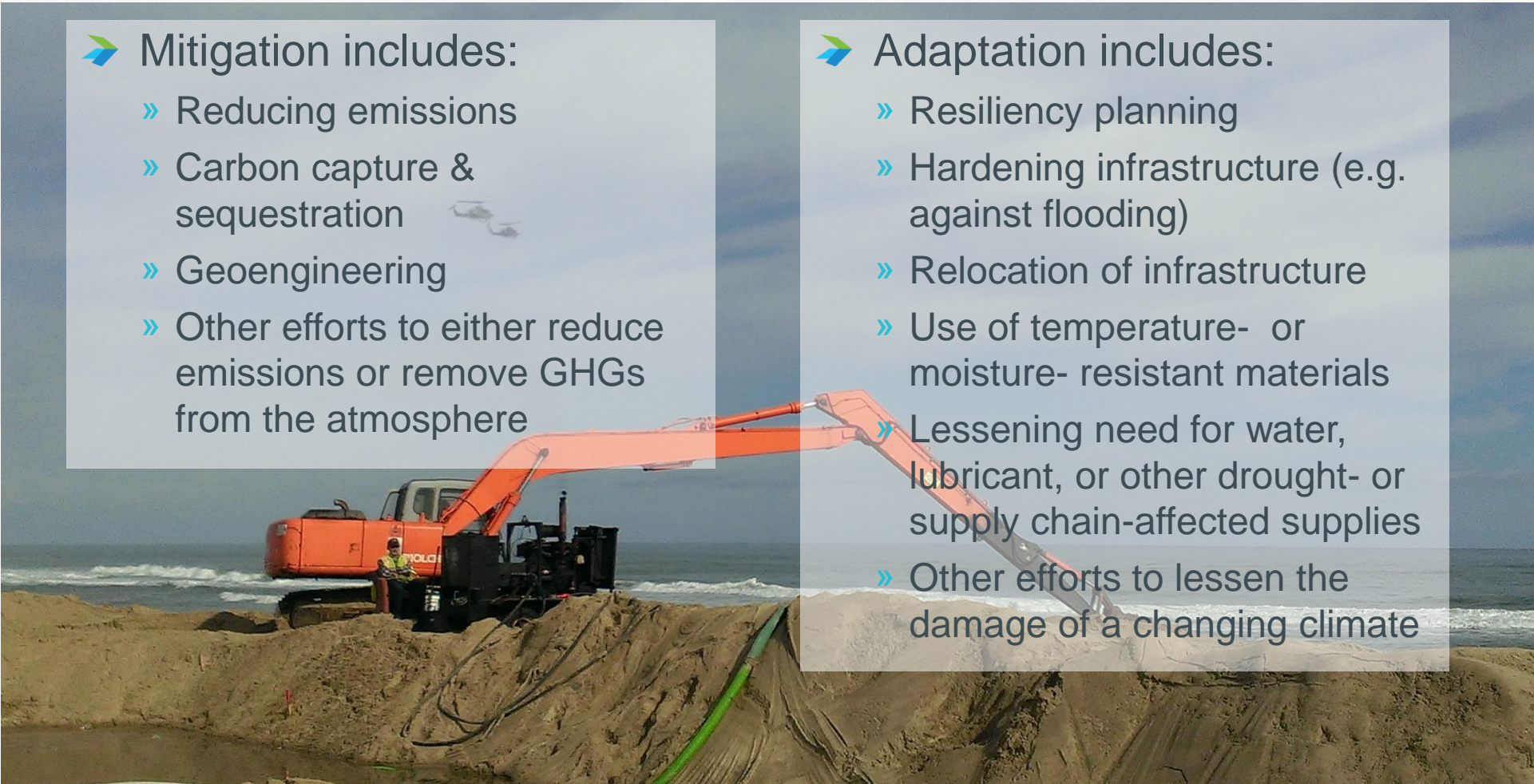
# Mitigation vs. Adaptation

## ➤ Mitigation includes:

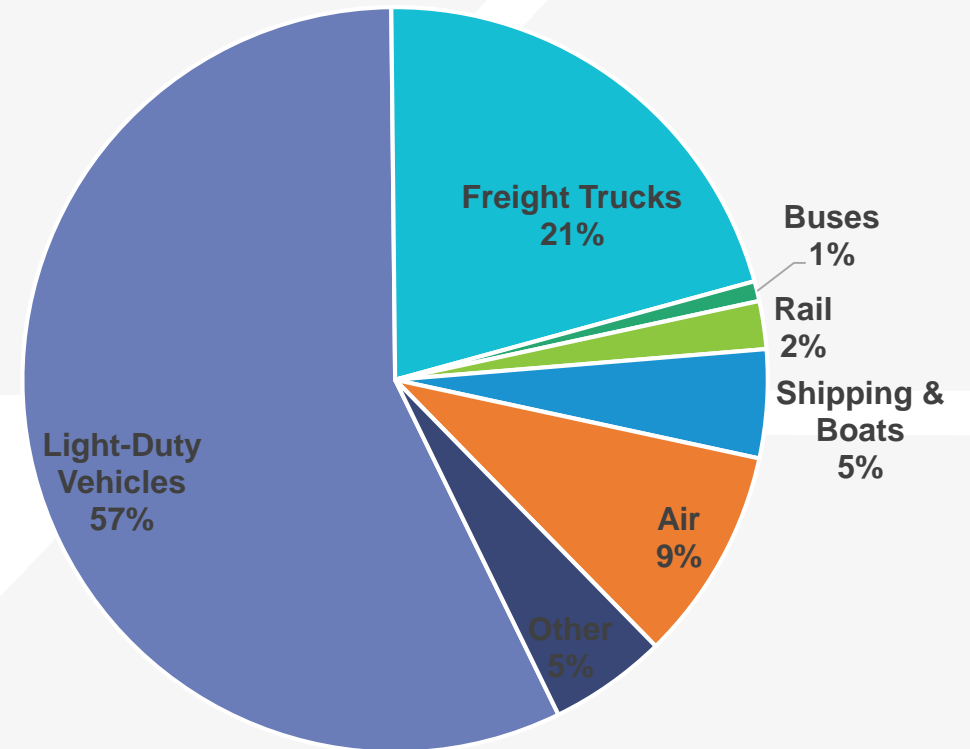
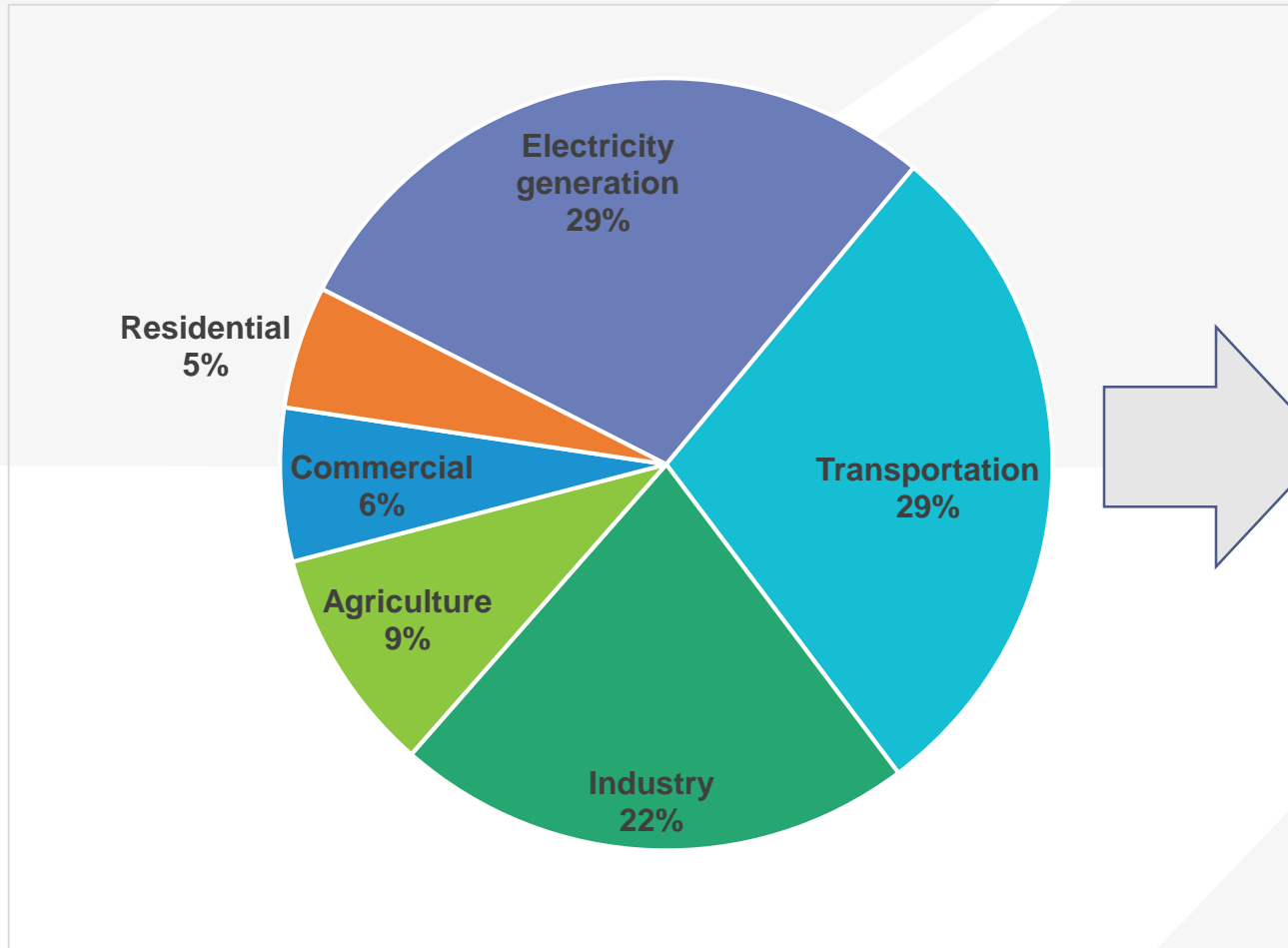
- » Reducing emissions
- » Carbon capture & sequestration
- » Geoengineering
- » Other efforts to either reduce emissions or remove GHGs from the atmosphere

## ➤ Adaptation includes:

- » Resiliency planning
- » Hardening infrastructure (e.g. against flooding)
- » Relocation of infrastructure
- » Use of temperature- or moisture- resistant materials
- » Lessening need for water, lubricant, or other drought- or supply chain-affected supplies
- » Other efforts to lessen the damage of a changing climate

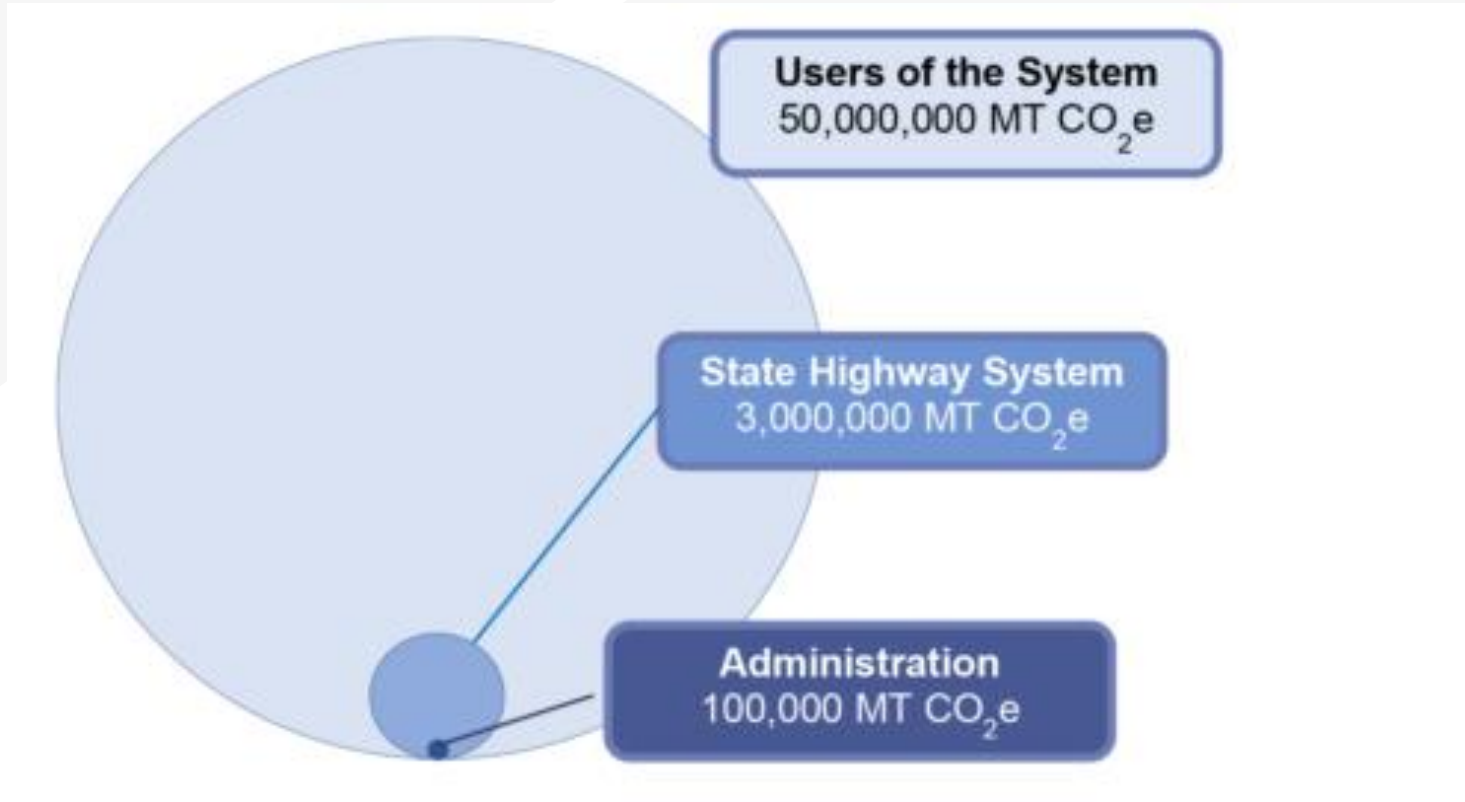


# Transportation's Contribution



Source: EPA. *Inventory of U.S. Greenhouse Gas Emissions and Sinks*; calculations based on U.S. DOE 2019 Annual Energy Outlook

# Transportation Sources – Sample State



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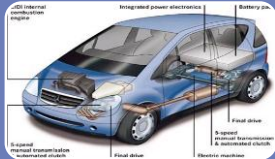
# Reducing GHGs from Transportation System Users



# Strategies for GHG Reduction



Low Carbon Fuels



Vehicle Fuel Efficiency



System Efficiency



Reduce Carbon Intense Travel Activity



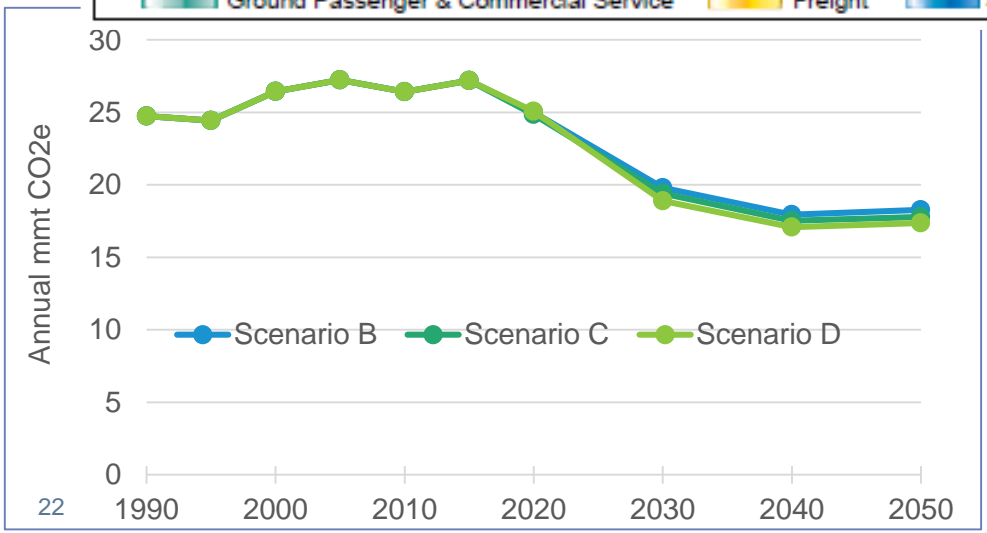
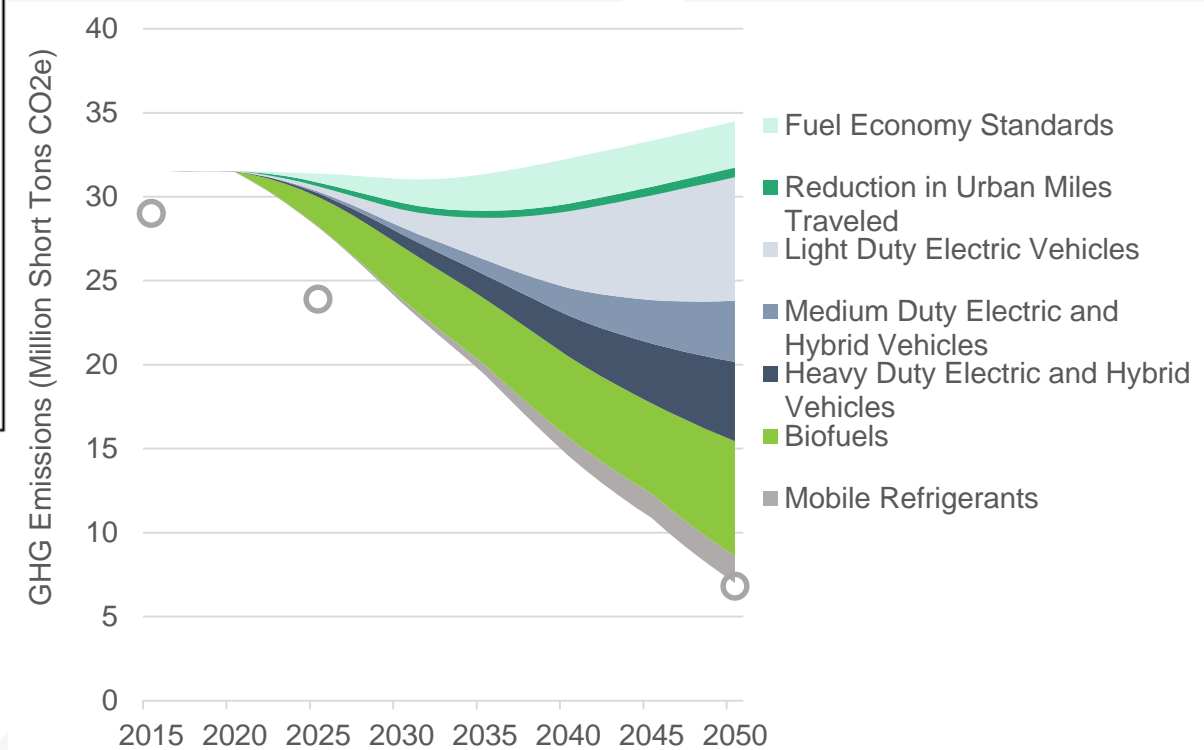
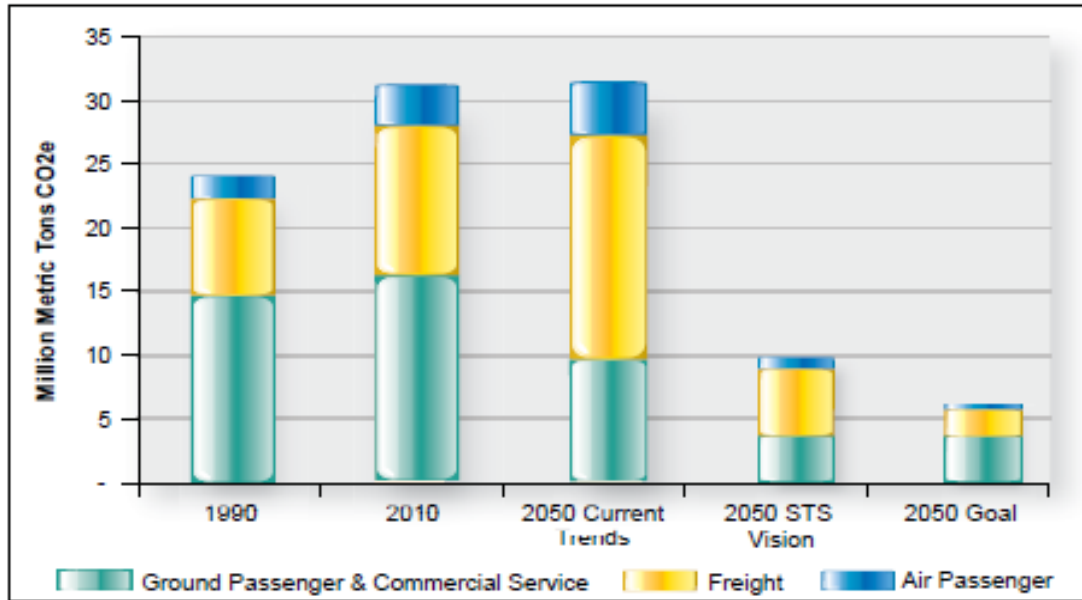
Reduce Emissions from Construction, Maintenance, Operations

Price Carbon

Transport Planning and Investment



# System-Level Scenario Planning Examples



Sources: Oregon DOT; Massachusetts DOT, Minnesota DOT

# Inventory Development and Forecasting

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- Fuel-based methods
- VMT/activity and emission factors (no travel demand model)
- Travel demand model & VMT-based emission factors
- Travel demand model & MOVES/ EMFAC emission factors
- GHG tools, e.g., EERPAT, VisionEval, PATHWAYS
- Mode-specific data sources (e.g., FAF, NTD)

# Tools and Data Sources: Systems Planning & Policies

Tool	Emission Rates/Factors	GHG Inventory Development	Construction and Maint. Activities	Highway Network and Operations	Transit Investment and Operations	Nonmotorized Improvements	Pricing Policies	Land Use and Smart Growth	TDM and Public Education	Shared Mobility	Freight Rail and Marine Strategies	Clean Vehicle and Fuel Strategies
MOVES/EMFAC	•	•										•
GREET	•											•
FHWA ICE		•	•									
VISION	•											•
MA3T	•											•
Travel Demand Model		•		•	•		•	•				
VisionEval/FFRPAT		•		•	•	•	•	•	•	•	•	•
Impacts 2050					•		•	•		•		
TRIMMS					•	•	•	•	•			
Transit GHG Emissions Est			•		•							
Land Use Scenario Tools						•		•				

# GHG in Programming – MassDOT Example

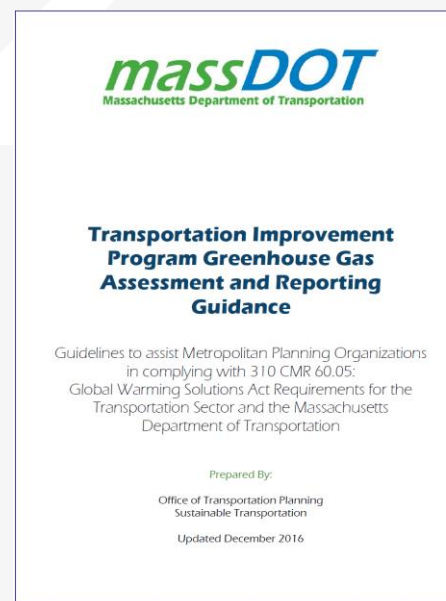
## Project-level Assessment

- All STIP and regional TIP projects subject to GHG assessment
  - » Assess direction (increase/decrease/no impact) and cause
  - » Quantitative assessment per guidelines
- Report each cycle
- MassDOT provides CMAQ spreadsheet project calculator tools

Source: MassDOT, Transportation Improvement Program Greenhouse Gas Assessment and Reporting Guidance (2017)

## Program-level Assessment

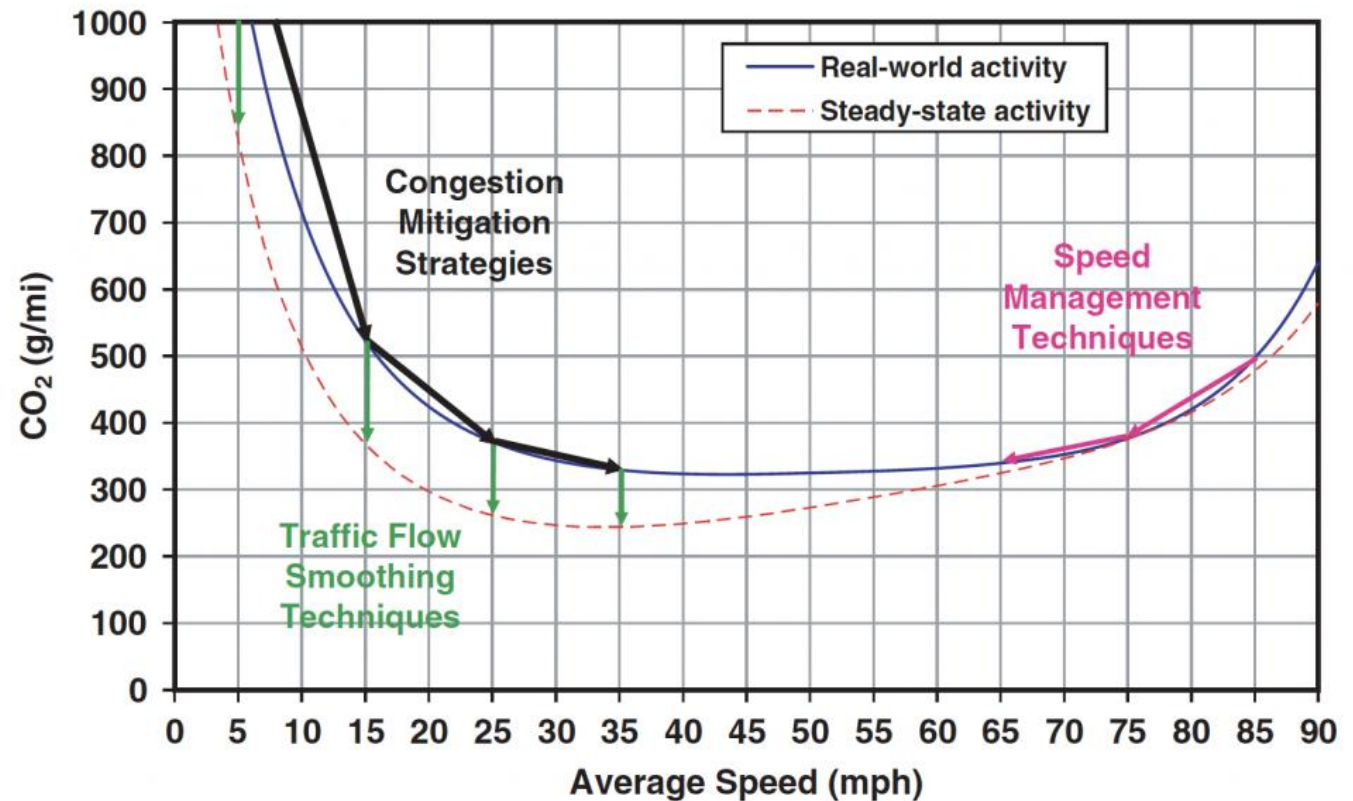
- TIPs and STIP require program-level GHG evaluation
- Evaluate for consistency with State GHG reduction targets



# Transportation System Management and Operations

## What's Included?

- Emissions from transportation system users as they are affected by operations strategies (TSM&O, ITS)



Source: Barth and Boriboonsomsin, 2008



# Project-Level GHG Evaluation Tools for Traffic

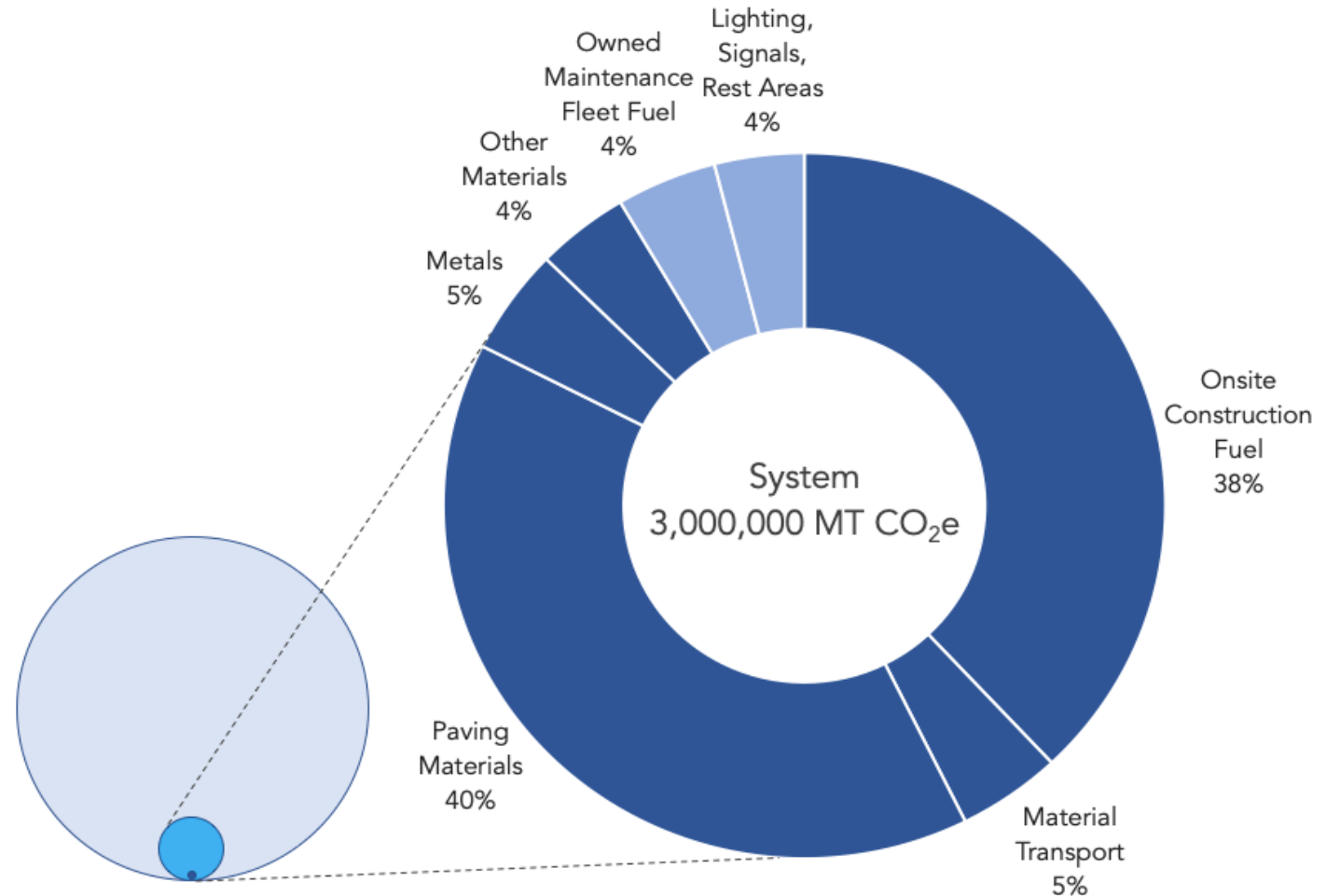
Tool	Emission Rates/ Factors	Traffic Flow/ Operations	Transit Investment and Operations	Nonmotorized Improvements	Freight Rail and Marine	Clean Vehicles and Fuels
MOVES/EMFAC	●	●				●
CMAQ Emissions Calculator Toolkit		●	●	●		●
CARB SB1 Grant Programs Emissions Calculator		●	●	●		●
Argonne—Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET)	●					●
U.S. EPA—Heavy-Duty Vehicle Emissions Calculator	●				●	●
U.S. EPA—Diesel Emissions Quantifier	●					●

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# Reducing GHGs from Transportation Agency Activities

# Construction and Maintenance - What's Included?

- Selection of materials
- Reuse of deconstructed materials
- Equipment and fuel standards for the construction equipment
- Construction staging and detour routes
- Purchase of offsets



# Construction and Maintenance GHG Reduction Strategies

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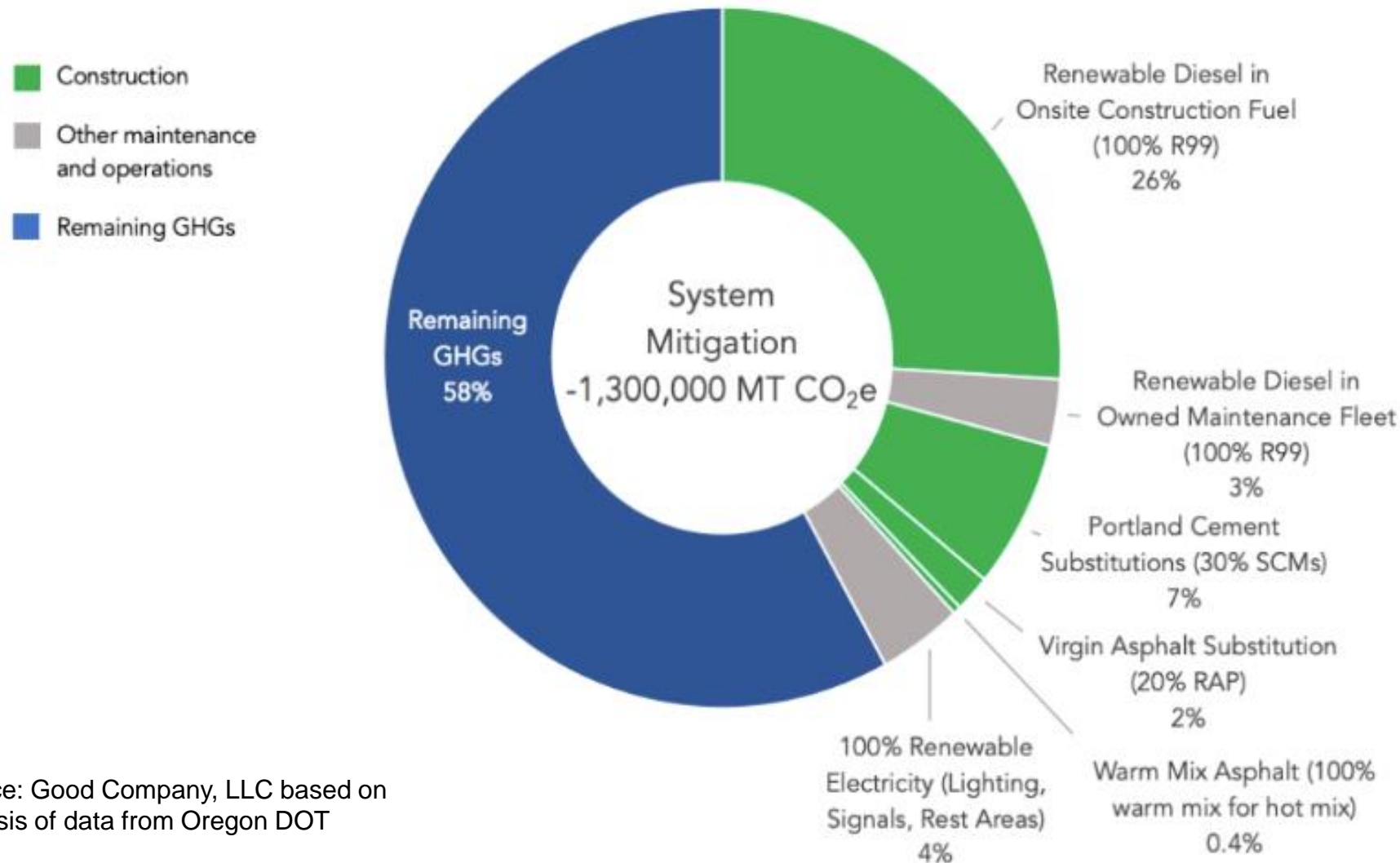
## Final Design

- Ensure that bid specs reflect alternatives analysis best outcome
- Encourage reuse of deconstructed materials
- Encourage use of locally sourced materials
- Explore variants in mixes or material composition and availability
- Specify low carbon fuels, newer engines, idle reduction, and electric equipment as possible

## Construction

- Ensure contractors have a ready supply of recycled materials
- Ensure that any reuse agreements are followed or recycle materials
- Allow longer cure times for concrete
- Include carbon intensity number or feedstock source when specifying bio or renewable diesel
- Spec detour routes and construction staging to minimize delays and VMT

# Construction & Maintenance Mitigation Strategies – Illustrative Impacts



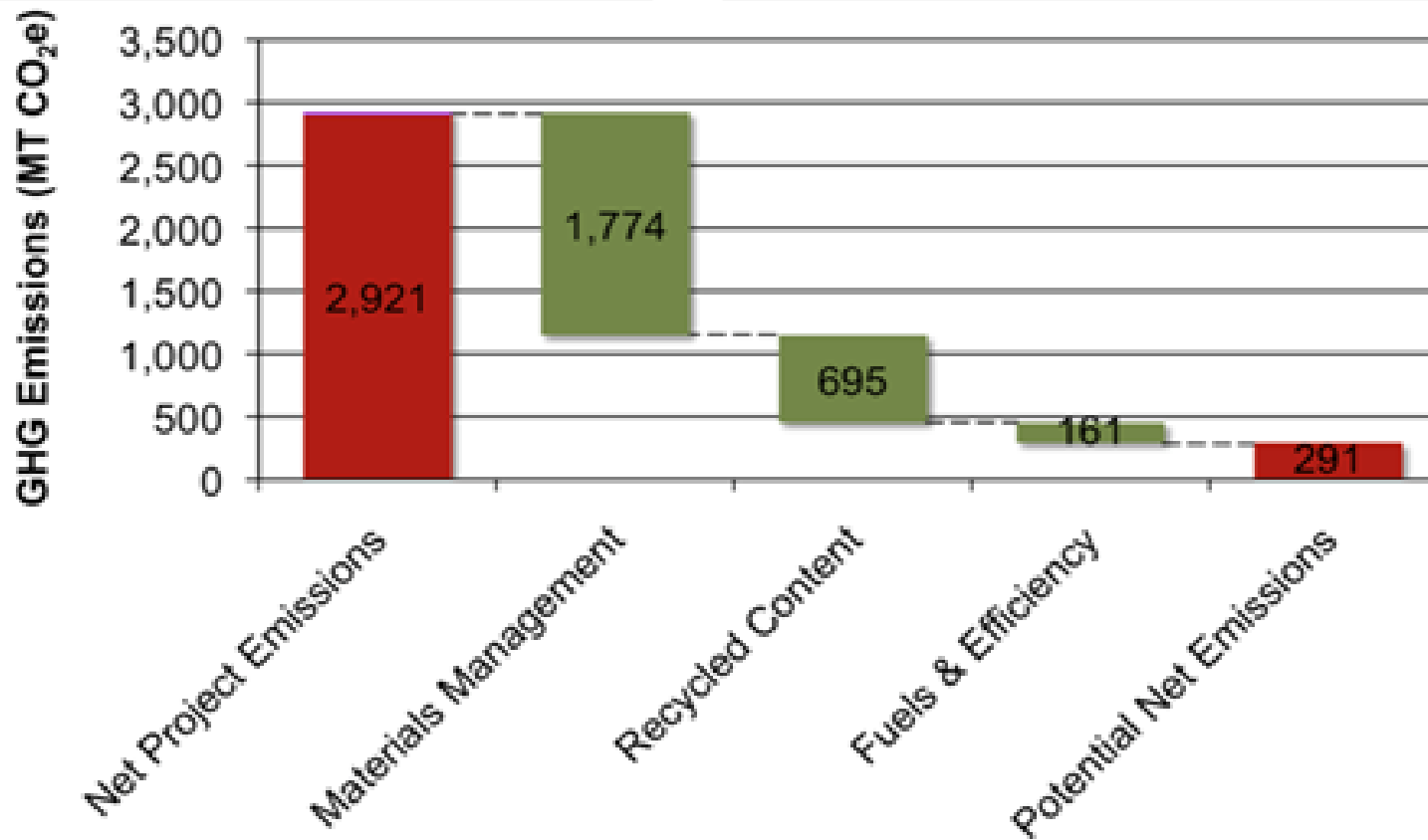
Source: Good Company, LLC based on analysis of data from Oregon DOT

# Tools & Data Sources: Construction & Maintenance

Data Source/Tool	Material Factors	Fuel Factors	Calculation Platform
FHWA Infrastructure Carbon Estimator (ICE)	✓	✓	✓
GreenDOT	✓	✓	✓
Pavement Life Cycle Assessment Tool (PaLATE)	✓		✓
U.S. Environmentally Extended Input- Output Model	✓	✓	✓
U.S. EPA Waste Reduction Model (WARM)	✓		✓
National Precast Concrete Association Environmental Product Declarations	✓		
FHWA Environmental Product Declarations	✓		
National Asphalt Pavement Association's Environmental Product Declarations	✓		
Portland Cement Association Environmental Impact Reporting	✓		
Individual producers' Environmental Product Declarations	✓		
Argonne - AFLEET		✓	✓
Heavy-Duty Vehicle Emissions Calculator		✓	✓
U.S. EPA Diesel Emissions Quantifier		✓	✓
CARB Carbon Intensity Factors		✓	



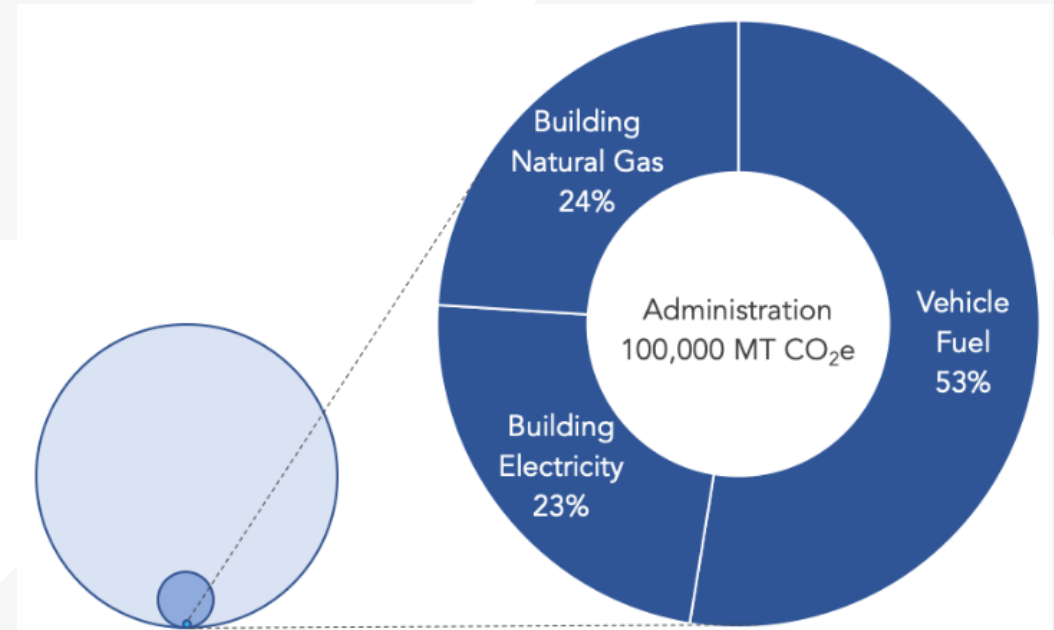
# Bridge Replacement Project - Example



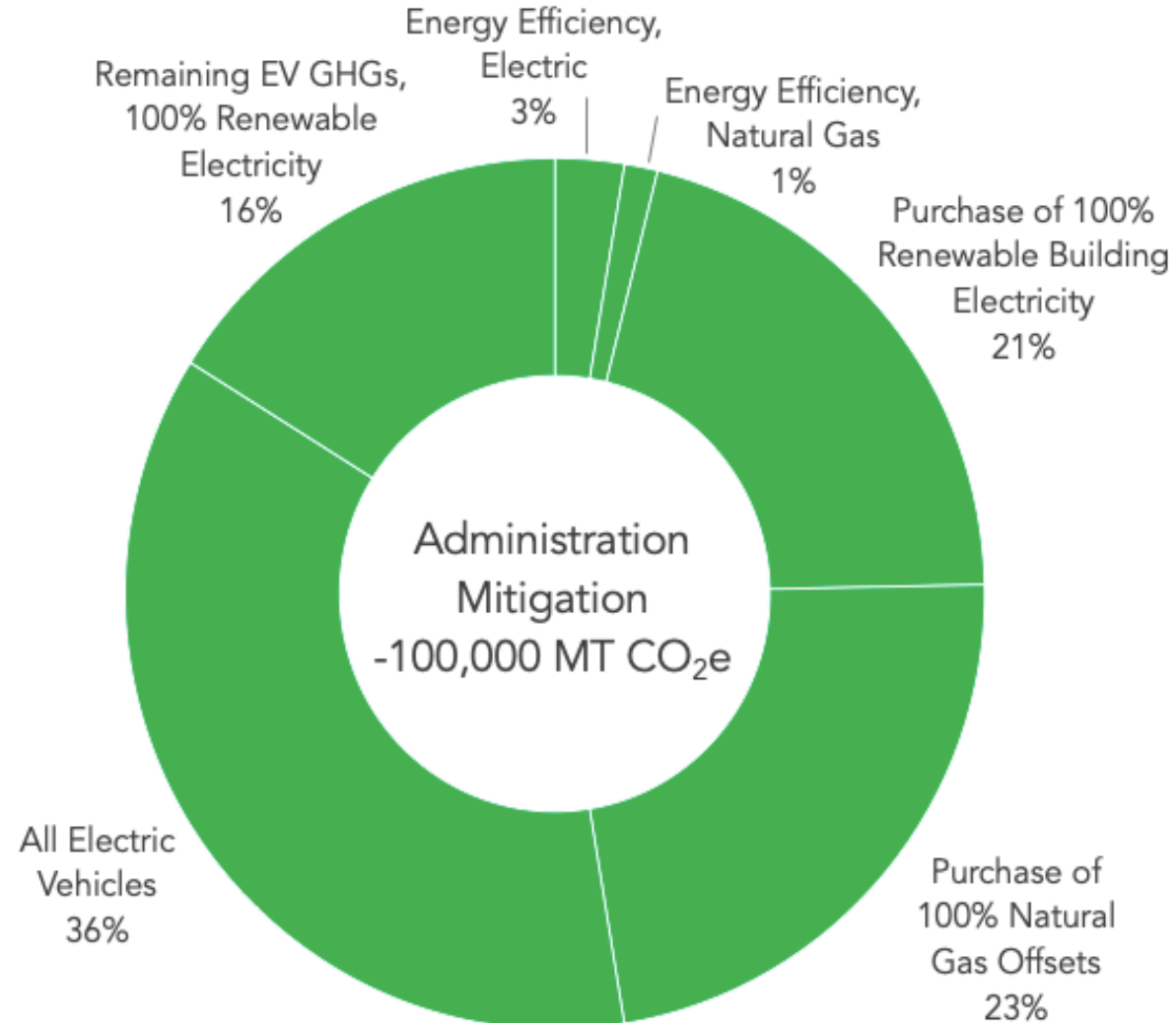
Source: Good Company/Portland Bureau of Transportation

# Central Administration - What and Why?

- GHG emissions from the buildings, supplies, and travel associated with DOT office functions
  - » Electricity and space heating fuel
  - » Employee travel and commuting- telecommute
- Small magnitude of emissions compared to system users, but DOT has high level of influence
- Cobenefits:
  - » Cost savings
  - » Staff comfort
  - » Reduced air pollution
  - » “Lead by example”



# Central Administration – GHG Mitigation Strategies



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# Implementing GHG Reduction Strategies

# The GHG Action Spectrum

GHG Step	Functional Area									
	Execs and Whole Agency	Planning	Program- ming	Env Analysis	Design	Construc- tion	Mainten- ance	Opera- tions	Admin- istration	Districts
Policy	✓	✓		✓						
Institutional Alignment	✓	✓		✓			✓	✓	✓	✓
Partnerships	✓	✓		✓			✓	✓	✓	✓
Inventory	✓	✓		✓		✓	✓	✓	✓	✓
Communication & Public Engagement	✓	✓		✓	✓					✓
Strategy Identification	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Strategy Assessment	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Implementation	✓		✓	✓	✓	✓	✓	✓	✓	✓
Monitoring and Evaluation	✓	✓		✓			✓	✓	✓	✓

# DOT Functional Areas – Typical GHG Interests

Functional Area	GHG Interests / Responsibilities
<b>Executive</b>	Agency leadership, coordination, resourcing, prioritization Liaison with governor's office, budget, sister agencies, political establishment
<b>Administration</b>	Buildings, weatherization, and energy efficiency Electricity source Heating source
<b>Planning</b>	Transportation system goals, objectives, strategies Transportation system inventory, forecasting, and strategy evaluation Modal & project investment priorities
<b>Programming</b>	Project selection based on planning objectives, constrained by funding
<b>Environment</b>	Agency expert on environmental matters Liaison with environmental agencies Emissions data/analysis

Functional Area	GHG Interests / Responsibilities
<b>Design</b>	Materials selection and specification Plants/trees Detour planning Fuel specifications
<b>Construction</b>	Deconstruction/demolition material recovery Fuels
<b>Maintenance</b>	Fleet and fuels Repair materials and specifications Maintenance procedures
<b>Operations</b>	ITS & traffic controls Managed lanes Freight (intermodal access, truck parking, inspections...) Transit Tolling/congestion pricing EV charging and alt fuel access
<b>Districts</b>	Operational units of DOTs

# Institutional Considerations - Five Roles

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- Preparing and supporting leadership for understanding, goal setting and action on GHG policy making
- GHG program leadership and staffing
- Providing mechanisms for internal coordination
- Managing partnerships and public outreach
- Leveraging synergies with related programs and initiatives

# Levels of Engagement

Level	Policy	Practice – Internal	Practice - System	Data & Analysis
Level 1	New to the topic; few or no formal actions to address GHG.			
Level 2	Has established general policies, goals, and/or objectives related to GHG.	Agency emissions considered.	No formal consideration of transportation system emission reduction.	No or limited/partial GHG inventory.
Level 3	Has established specific policies, goals, and/or objectives related to GHG.	Applies quantitative project or program evaluation criteria to agency emissions.	Qualitative project or program evaluation criteria.	Has developed GHG inventory and/or forecast.
Level 4	Serious multiagency effort.	Strategic planning: has evaluated GHG reduction strategies, linked strategies to plans and programs, and conducted quantitative assessment.		Has developed inventory, forecast, specific data and tracking methods, and established specific policies and goals related to targeted GHG reductions.



# Self-Assessment Worksheets

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## ➤ Staff Responsibilities

- » Who is responsible for what topics?

## ➤ Level of Engagement

- » How engaged is your agency now, and how engaged you might want to be in the next few years?

## ➤ GHG Strategies

- » Which strategies your agency is undertaking now, and which ones you might want to be undertaking in a few years?

## ➤ Action Plan

- » What actions will you take to implement the strategies you identified above to advance your agency's practice on GHG issues?

# Self-Assessment - Level of Engagement

Now	In 3 Years?	Has your agency defined institutional roles and responsibilities related to GHG emissions reduction?	Level
_____	_____	No roles defined.	1
_____	_____	Assigned leadership/lead role for GHG activities, but not a comprehensive set of roles and coordination mechanisms. Primary focus on agency emissions.	2
_____	_____	Assigned leadership and some supporting roles for GHG activities, but limited/ incomplete coordination mechanisms. Focus includes system emissions.	3
_____	_____	Assigned complete set of leadership and supporting roles for GHG activities, covering all functional areas, and with comprehensive coordination mechanisms including internal and external coordination. Focus mainly on system emissions and includes agency purchases and operations.	4

# Charter and Task Force

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## GHG Task Force Charter

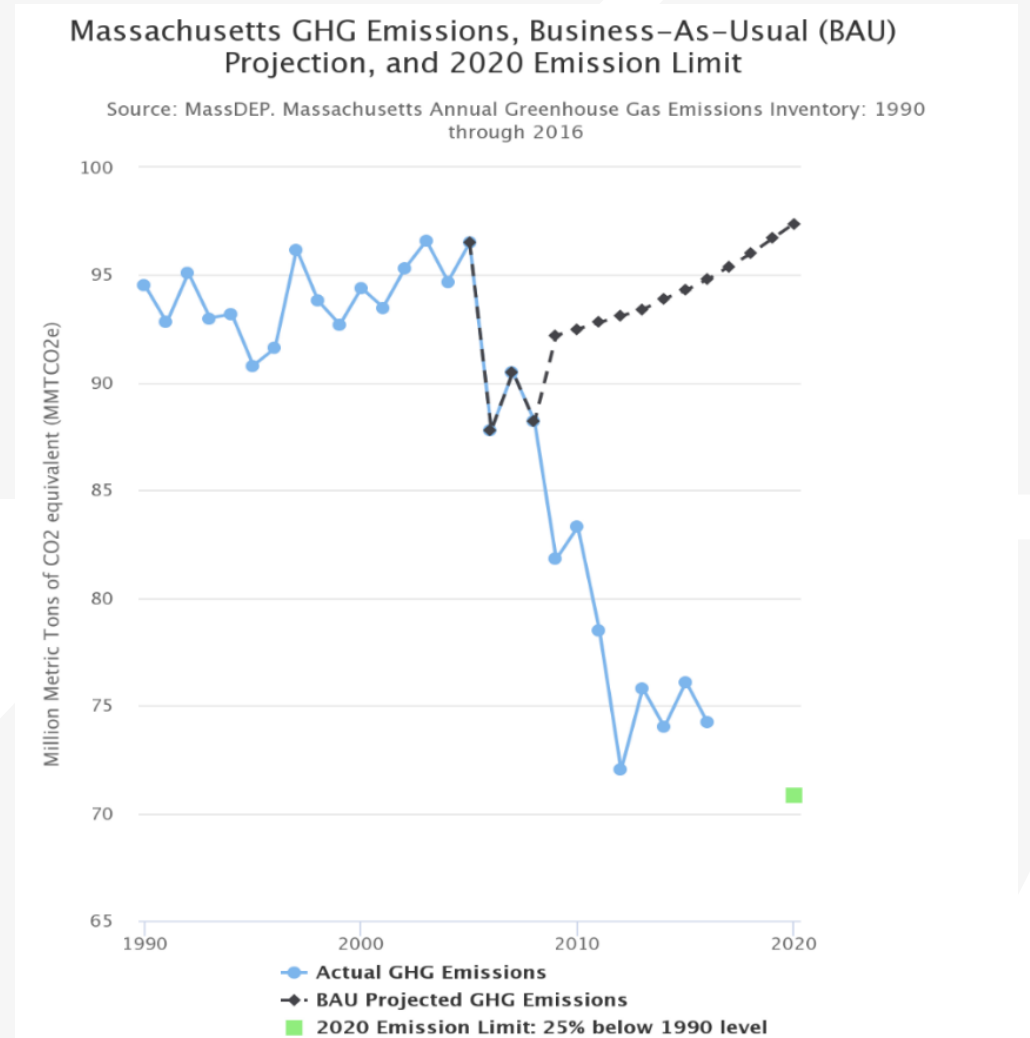
- Date
- Purpose
- Membership
- Meetings
- Reporting
- Deliverables

## Model GHG Task Force Kickoff Meeting Agenda

- Introductions/orientation
- GHG executive charter
- Interim GHG policy
- Discussion
- Unit by unit reaction
- Initial assignments
- Unit self-assessments
- Housekeeping
- Concluding remarks

# Monitoring, Evaluation, and Reporting

- “What gets measured, is what gets done”
- Requirements? (Legislative or executive)
- 3 types of metrics
  - » Process
  - » Product
  - » Outcome
- Internal and external reporting
- Periodic review and revision of targets



# Management Cycle



<b>Plan</b>	Set policy	Establish targets	Make assignments
<b>Do</b>	Develop procedures	Train staff	Implement
<b>Check</b>	Report	Consolidate reports	Evaluate performance
<b>Act (Improve)</b>	Check-in with partners	Explore alternatives	Revise procedures

# Common Climate Change Partners

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- Environmental/air quality agency
- Energy agency
- Utility regulators
- Commerce/economic development agency
- Agriculture agency
- Health agency
- Governmental services agency
- Housing agency
- State budget office
- MPOs and regional planning agencies
- Transit agencies
- Cities and counties
- NGOs
- Academics/universities
- Private sector/trade groups

# Communications

## What's Included

- Internal communications within the State DOT
- External communications with other State and local agencies
- External communications with the public



Maryland is a Leader in Reducing Greenhouse Gas Emissions  
*What the state's Greenhouse Gas Reduction Plan means for you*

Maryland is taking aggressive, sustained action to achieve the goal of reducing greenhouse gas emissions in a manner that also protects Maryland's economy and jobs. University of Maryland research has shown that the impacts from climate change in Maryland could be significant. Maryland is putting teeth, not just words, into achieving real reductions in greenhouse gas emissions.

#### MARYLAND'S PLAN

Maryland has set some of the strongest greenhouse gas reduction targets in the nation. The General Assembly passed the Greenhouse Gas Emissions Reduction Act (GGRA) of 2009, which required Maryland to develop a plan to reduce greenhouse gas emissions by 25 percent from 2006 levels by 2020.

The legislation also required actions to achieve this goal that promote balance between environmental benefits and economic prosperity. The state developed the comprehensive, multi-sector, multi-agency plan with input from more than a dozen state agencies and non-governmental organizations. This plan was released in 2010 and lays out a blueprint that, when fully implemented in 2020, will achieve the 25 percent reduction goal with positive job and economic benefits.

The 2012 plan also outlines Maryland's commitment to implement smart environmental and economic strategies, such as increasing clean energy use that helps customers save energy and money. For example, Maryland participates in the broader Regional Greenhouse Gas Initiative, a cooperative effort by nine states in the Northeast and Mid-Atlantic region that aims to reduce carbon emissions from the electric generation sector. Maryland's EnPOWER program sets efficiency targets for utilities and provides resources and incentives citizens can use for energy conservation and efficiency.

Maryland's balanced approach to climate change includes improvements to the economy, new and retained jobs and continued progress in reducing greenhouse gas emissions.

#### THE GREENHOUSE EFFECT EXPLAINED

Gases in the atmosphere, such as water vapor and carbon dioxide, act like a natural blanket to warm the Earth and prevent some of the earth's heat from radiating back into space. This process helps preserve a delicate balance that makes our planet livable; without this natural greenhouse effect, our planet would be too cold for humans to survive.

However, too much carbon dioxide and other greenhouse gases caused by human activities upset this balance. Gases released from burning fossil fuels for energy and transportation are thickening the blanket-like effect, which warms the Earth's surface above the normal range of temperatures, causing a rapid change in global and regional climate patterns. Scientists call this climate change.

Maryland is likely already experiencing some of the impacts of climate change — such as extreme heat waves, sea-level rise and more heavy downpours and flooding — and they are expected to become more intense and occur more frequently. These changes will affect our property, crops, economy and health.

## Lessons Learned

- Lay out the GHG process and share within the DOT before things get too far along
- Let everyone know what other offices were doing
- Pull in stakeholders early in the process
- Build buy-in from the public
- Reach out and set up meetings to make life easier for others
- Data sharing is imperative

# Conclusions



# What Can a DOT Do to Support GHG Goals?

Lesson Learned	DOT Role
Most emission reductions will come from clean vehicle and fuel technologies	Support EV/AFV infrastructure, clean transit & fleets
Demand reduction and systems efficiency strategies can get us another ~5-20%	Implement ITS/efficient traffic operations Support alternative modes
Additional 2-3% reduction potential from DOT construction materials, fuels/fleets, & buildings	Use low-carbon, recycled/reused materials where feasible Switch to clean fuel light and heavy vehicles
GHG reduction targets of 75-80% by 2050 are challenging and will require widespread electrification + clean grid	Collaborate with other state, regional, and local agencies to do everything within collective power
Most strategies require implementation at multiple levels (state, regional, local)	

# Contacts and Further Information

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- Guide (WebResource 1): <https://crp.trb.org/uat/nchrp25562/>
- Project report (Web-Only Document 308):  
<https://nap.nationalacademies.org/catalog/26523/methods-for-state-dots-to-reduce-greenhouse-gas-emissions-from-the-transportation-sector>
- Chris Porter, Principal Investigator, [cporter@camsys.com](mailto:cporter@camsys.com)
- Funding to assist with implementation may be available from NCHRP. If interested, contact Ann Hartell, NCHRP Senior Program Officer, [ahartell@nas.edu](mailto:ahartell@nas.edu)