

# Climate Change and Energy

Information, Challenges, and Strategies for  
Vermont Agency on Transportation

May 16, 2011

# Workshop Purpose

- To provide overview information on climate change and energy
- To provide foundation for state DOTs and partner agencies to respond to climate change and energy challenges
- To foster collaborative discussions on possible next steps



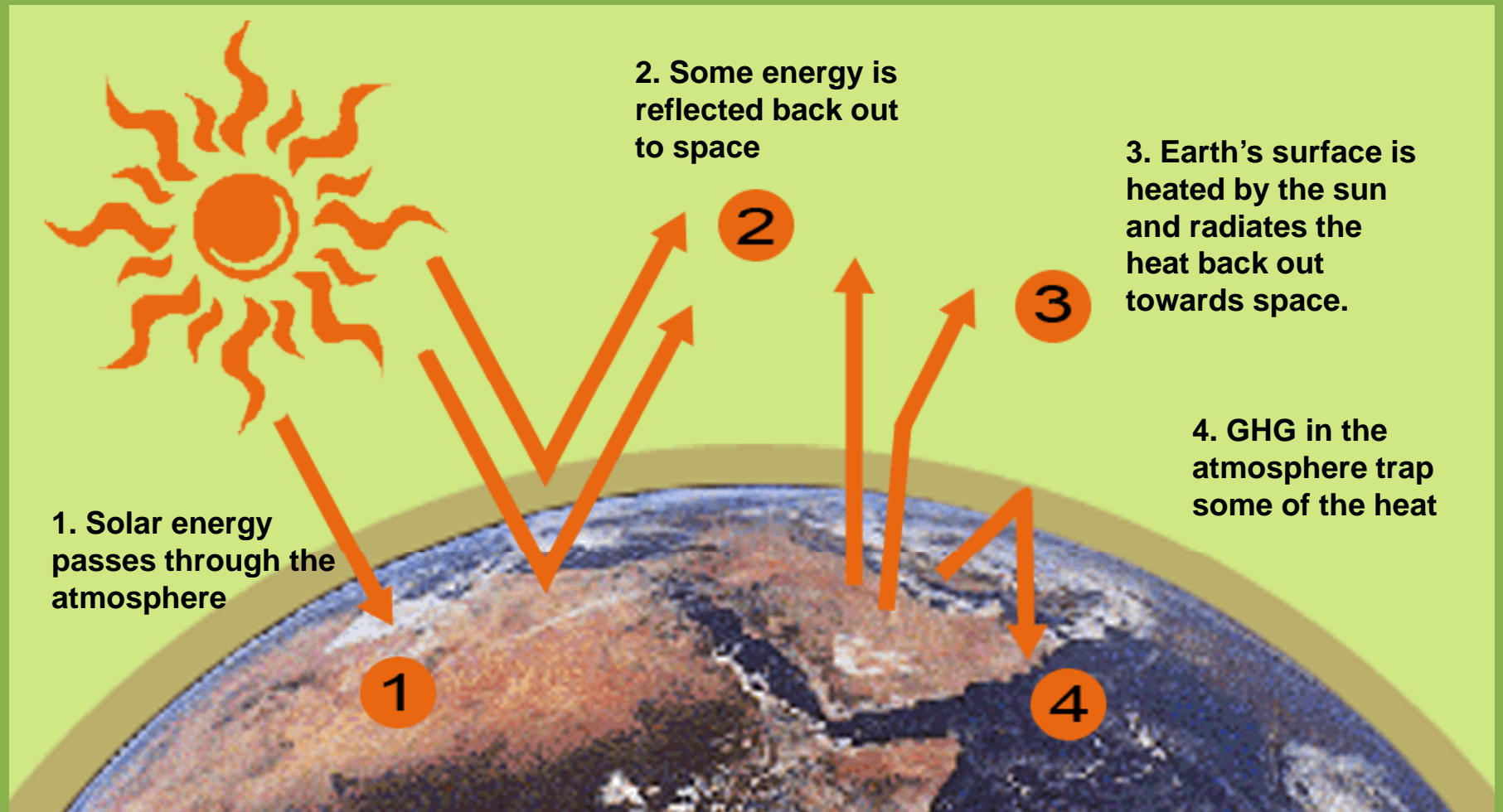
# Workshop Overview

- I. Climate Change/Energy: Science, Sources, Trends
- II. The Importance of Climate Change for Transportation
- III. Climate Adaptation for Transportation
- IV. Reducing GHG Emissions from Transportation – Strategies, Planning, and NEPA
- VI. Next Steps for VTRANS and VTRANS Partner Agencies

# I. Climate Change/Energy: Science, Sources, Trends



# Greenhouse Effect





# Climate Change

The United Nations Framework Convention on Climate Change (UNFCCC) defines Climate Change as:

*“A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.”*



# Growing Evidence

- 14% increase in human GHG since 1990 – USA
- 26% increase in human GHG since 1990 – world
- GHG levels are at highest in 1000s of years
- 2000-2009 was the warmest decade on record worldwide
- Heat stored in oceans has increased substantially
- Sea surface temperatures have been higher during the past three decades than at any other time since large-scale measurement began in the late 1800s.
- **In recent years, a higher percentage of precipitation in the United States has come in the form of intense single-day events.**
- 8 of top 10 years for extreme one-day precipitation events occurred since 1990.
- **The occurrence of abnormally high annual precipitation totals has increased.**
- Intensity of tropical storms in the Atlantic, Caribbean, and Gulf has risen noticeably over the past 20 years.
- 6 of the 10 most active hurricane seasons have occurred since the mid-1990s.

*Source: EPA, Climate Change Indicators in the U.S., May 2010*

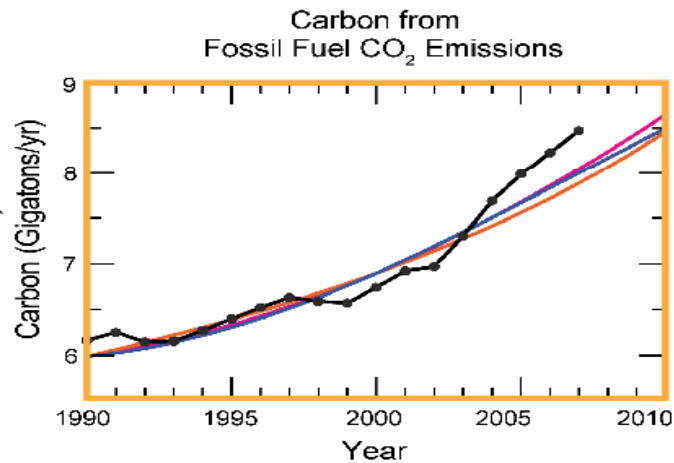
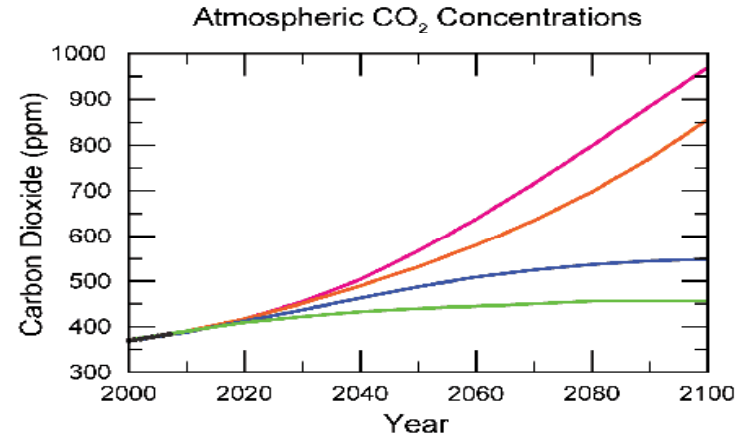
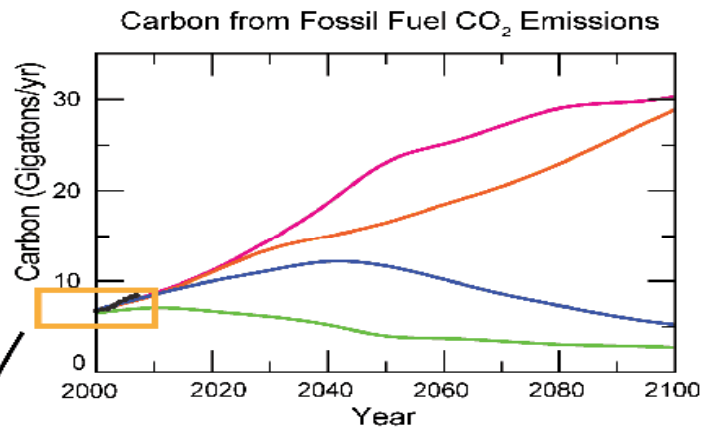
# Growing Evidence (continued)

- Sea level worldwide has increased at a rate of roughly 0.6" per decade since 1870.
- Sea level increase has accelerated to more than 1"/decade in recent years.
- Oceans have become more acidic over the past 20 years, and studies suggest that the ocean is substantially more acidic now than it was a few centuries ago. Rising acidity is associated with increased levels of carbon dioxide dissolved in the water, and affects sensitive organisms such as corals.
- **Sept 2007 had least Arctic sea ice of any year on record, followed by 2008 and 2009.**
- **Arctic sea ice in 2009 was 24 percent below the 1979-2000 historical average.**
- Glaciers in U.S. and around the world have generally shrunk since the 1960s and the rate at which glaciers are melting appears to have accelerated over the last decade.
- **Glaciers worldwide have lost more than 2,000 cubic miles of water since 1960.**
- Average length of the growing season in the lower 48 states has increased by about two weeks the since beginning of the 20th century.
- **North American bird species have shifted their wintering grounds northward by an average of 35 miles since 1966, with a few species shifting by several hundred miles.**

*Source: EPA, Climate Change Indicators in the U.S., May 2010*



# GHG Scenarios



- Even higher emissions scenario (A1FI)<sup>91</sup>
- Higher emissions scenario (A2)<sup>91</sup>
- Lower emissions scenario (B1)<sup>91</sup>
- Stabilization 450 ppm
- Observations

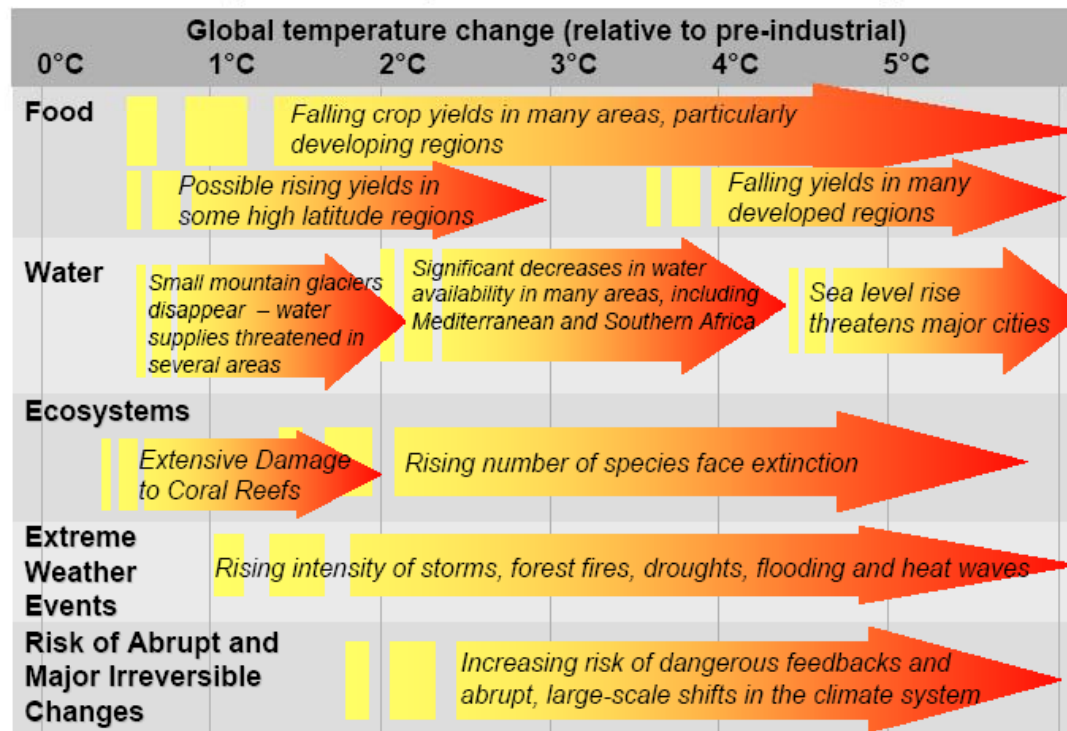
# How widespread are climate change concerns?

- Over 2000 leading scientists worldwide contributed to IPCC report
- 33 U.S. states have developed climate change action plans
- U.S. military is actively preparing for climate change
- U.S. Climate Action Partnership includes 23 major corporations and 5 nongovernmental groups which have called for U.S. Congress to enact strong GHG targets to achieve significant reductions in GHG:

[AES](#), [Alcoa](#), [Alstom](#), [Boston Scientific Corporation](#), [Chrysler](#), [The Dow Chemical Company](#), [Duke Energy](#), [DuPont](#), [Environmental Defense Fund](#), [Exelon Corporation](#), [Ford Motor Company](#), [FPL Group](#), [General Electric](#), [General Motors](#), [Honeywell](#), [Johnson & Johnson](#), [Natural Resources Defense Council](#), [The Nature Conservancy](#), [NRG Energy](#), [PepsiCo](#), [Pew Center on Global Climate Change](#), [PG&E Corporation](#), [PNM Resources](#), [Rio Tinto](#), [Shell](#), [Siemens Corporation](#), [Weyerhaeuser](#), [World Resources Institute](#).

# Impacts of Climate Change

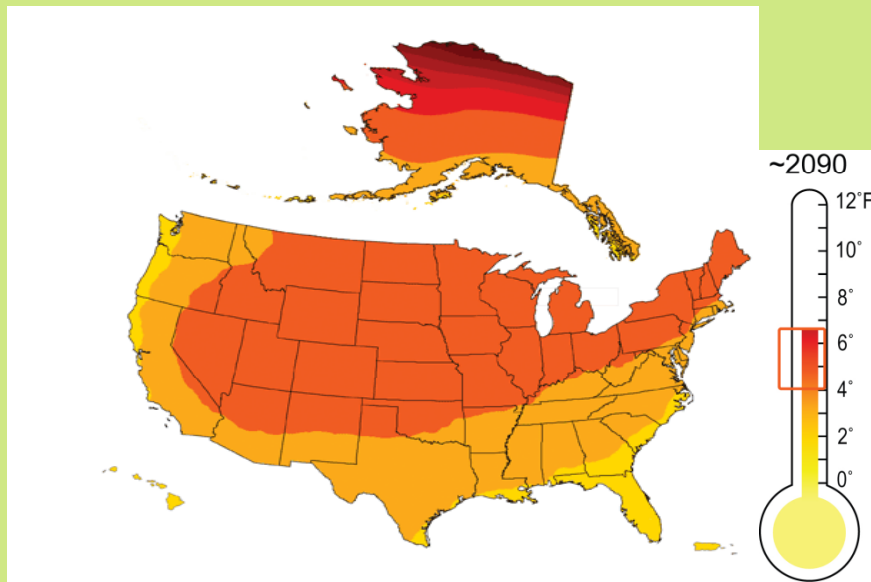
## Projected impacts of climate change



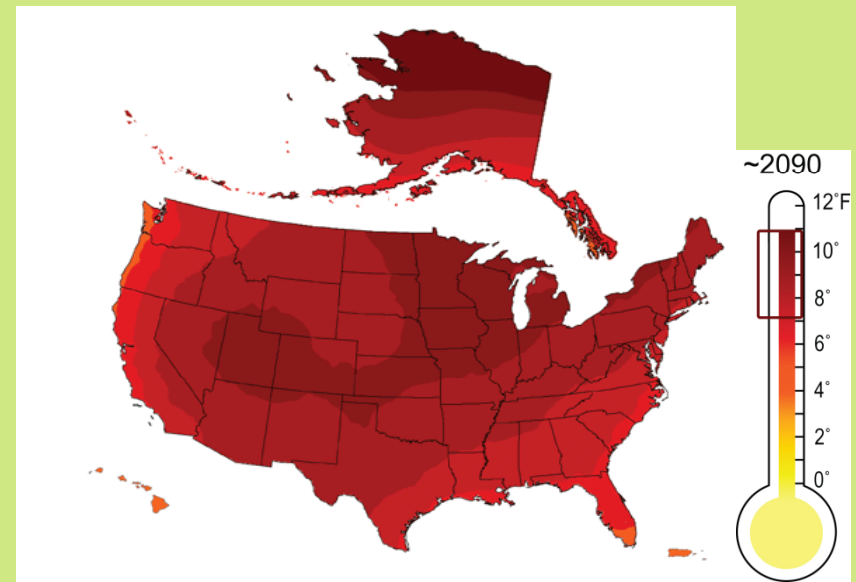
# Temperature Changes (°F)

(compared to 1961-1979 Baseline)

Low Scenario End-of-Century  
(2080-2099 average)



High Scenario End-of-Century  
(2080-2099 average)



Source: Virginia Burkett, USGS (USGCRP 2009)

# Precipitation Changes

(Change in Spring Precipitation – by 2090, showing areas of highest confidence in model prediction)

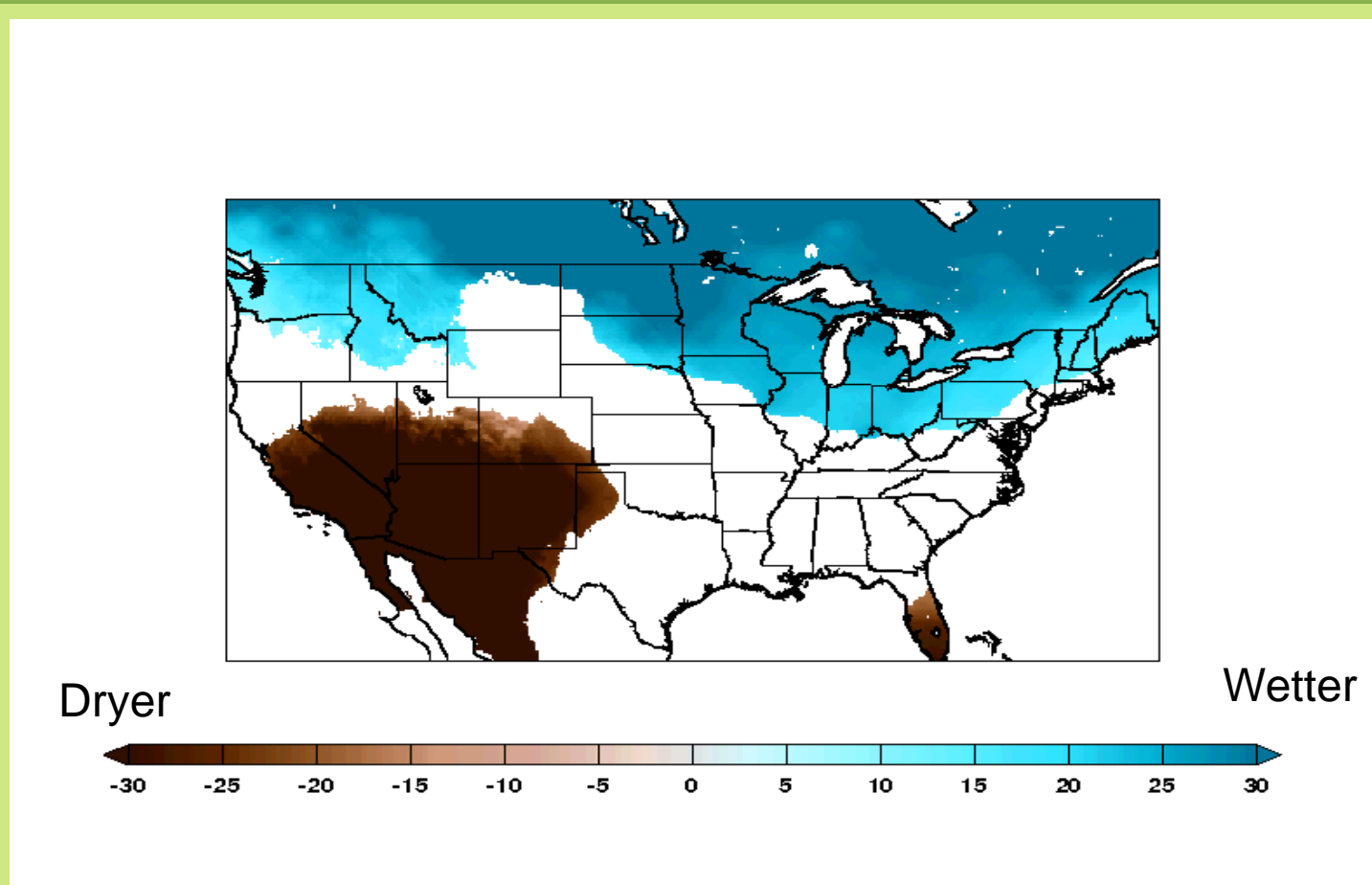
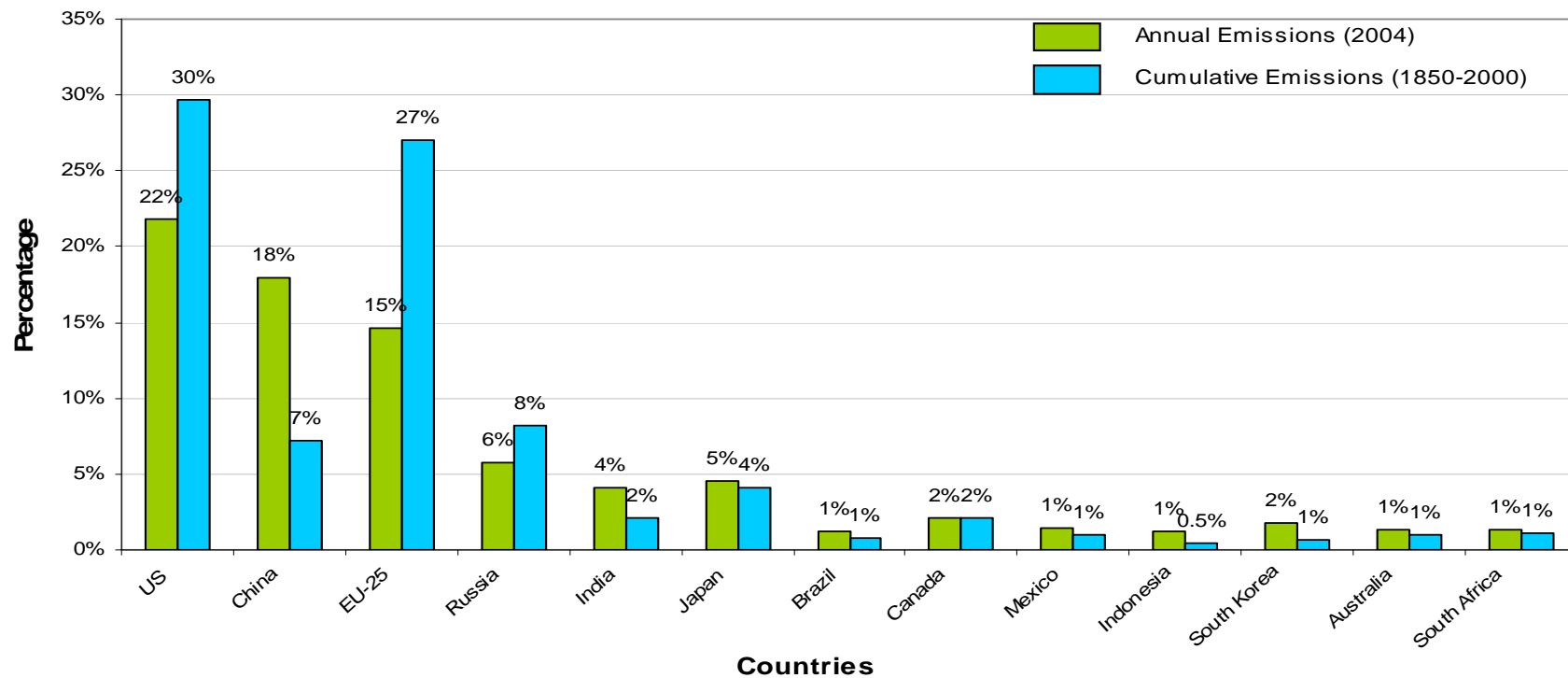


Figure courtesy of Mike Wehner, DoE and Katharine Hayhoe, Texas Tech for USGCRP, 2009



# GHG Sources – by Country

## Comparison: Annual\* & Cumulative\*\* CO<sub>2</sub> Emissions



Source: \* Annual Emissions for the year 2004 from IEA (2006) CO<sub>2</sub> Emissions from Fossil Fuel Combustion

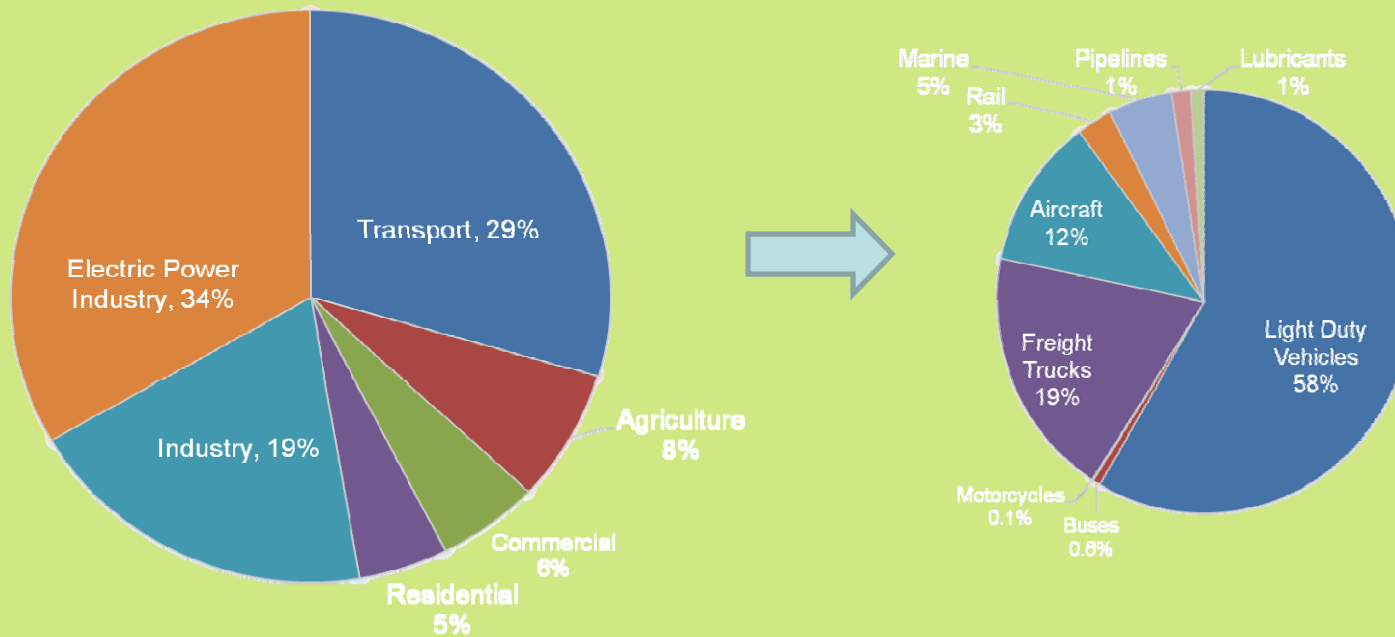
\*\* Cumulative Emissions from 1850-2000, CAIT WRI

# GHG Targets

- Scientists recommend **60-80% GHG reduction below 1990 level by 2050 to avoid worst impacts**
- Many states and countries have adopted similar targets
- President Obama and several bills in Congress: **80%** GHG reduction below 2005 by 2050
- VT targets are to reduce GHG by:
  - 25% below 1990 by 2012
  - 50% below 1990 by 2028
  - 75% below 1990 by 2050, if practical

# Transportation's Share of U.S. GHG

Source: U.S. DOT Report to Congress, 2010



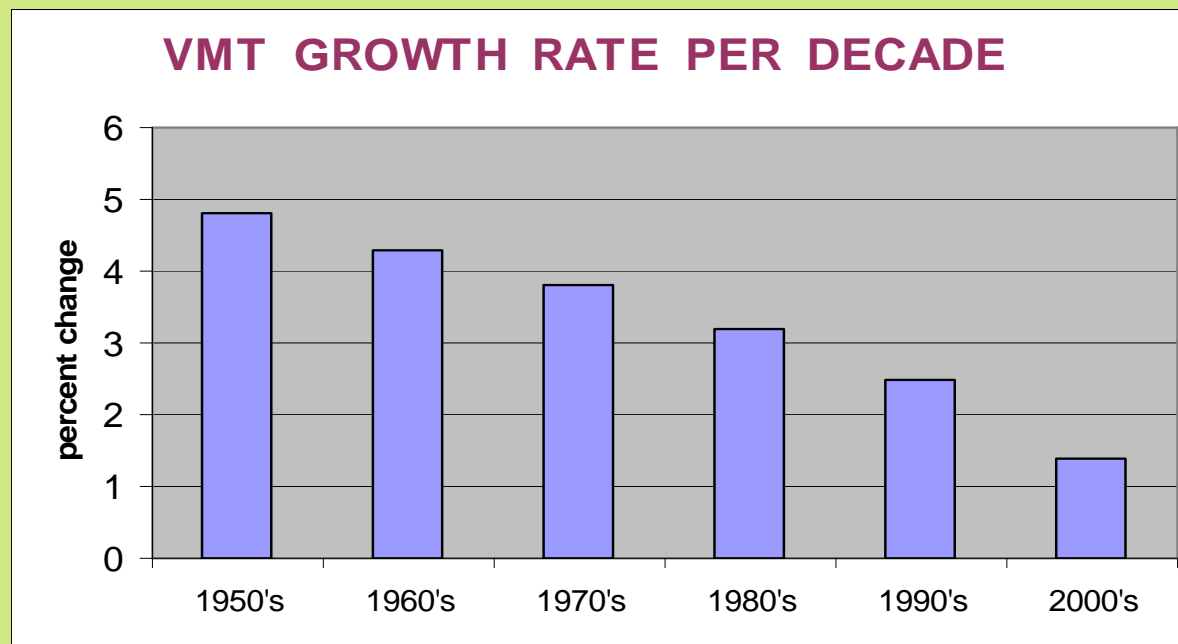
# U.S. Transportation GHG Trends

Source: U.S.DOT Report to Congress, 2010

	<b>Change, 1990-2006</b>
<b>All U.S. GHG Sources</b>	<b>15%</b>
U.S. Transportation	27%
Light Duty Vehicles	24%
Freight Trucks	77%
Commercial Aircraft	4%

# U.S. VMT Growth Rates are Declining

- VMT growth has been steadily declining since the 1950s
- VMT growth slowed to about 1.5% in early 2000s
- VMT growth was actually negative in 2008, pattern of upward growth in 2009
- VMT is affected by population, economy, transportation prices, demographics, land use

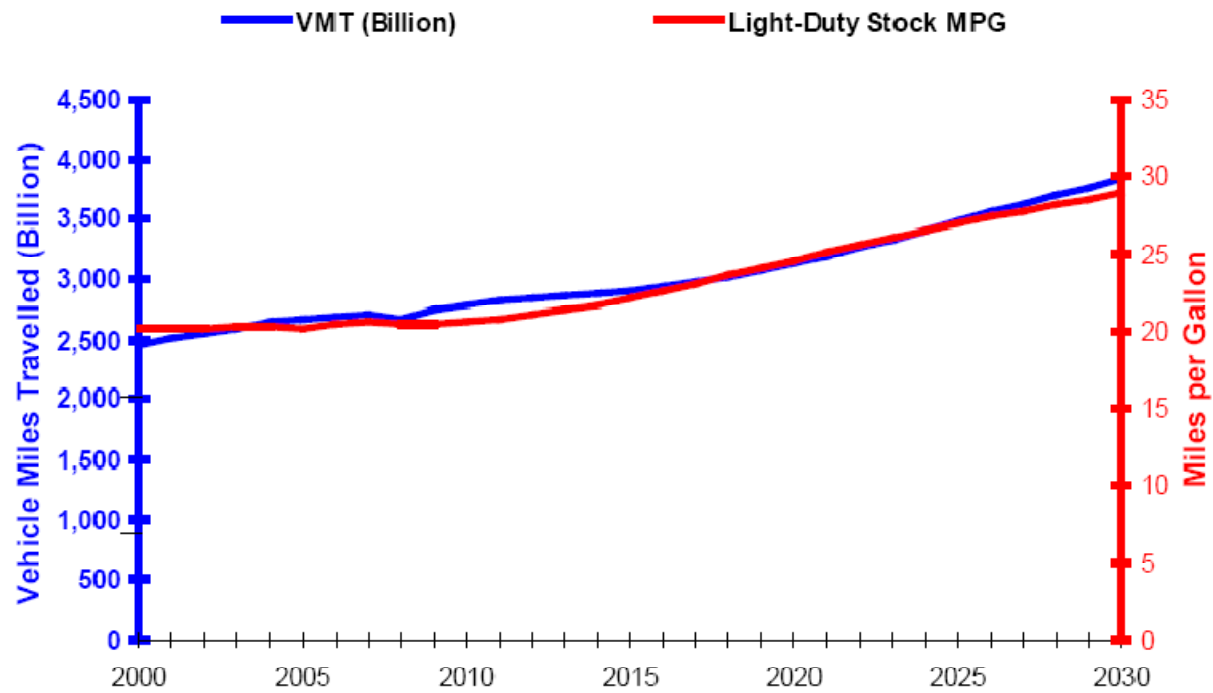


Source: Alan Pisarski and Cambridge Systematics



# DOE expects VMT and MPG both to rise

## Light Duty Vehicle Miles Travelled (2 of 3)

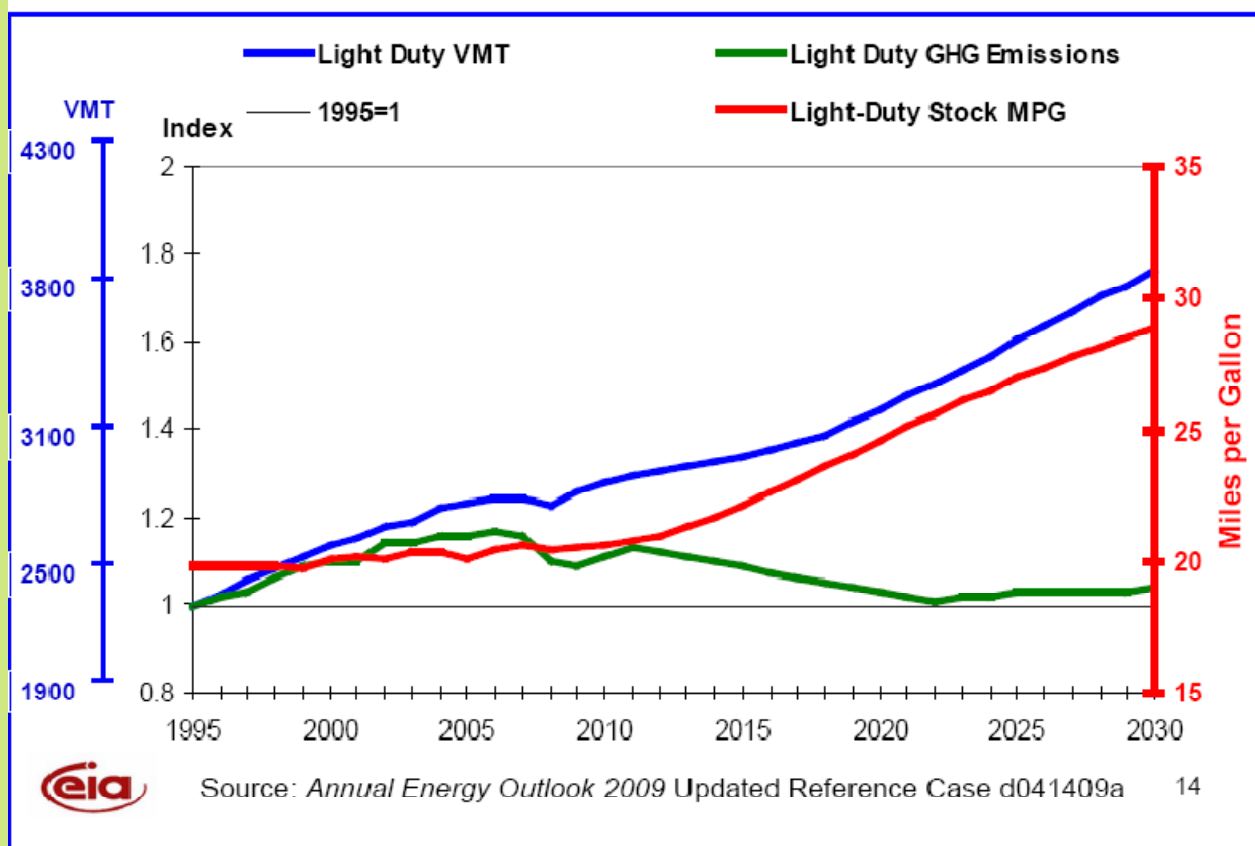


Source: Annual Energy Outlook 2009 Reference Case d041409a

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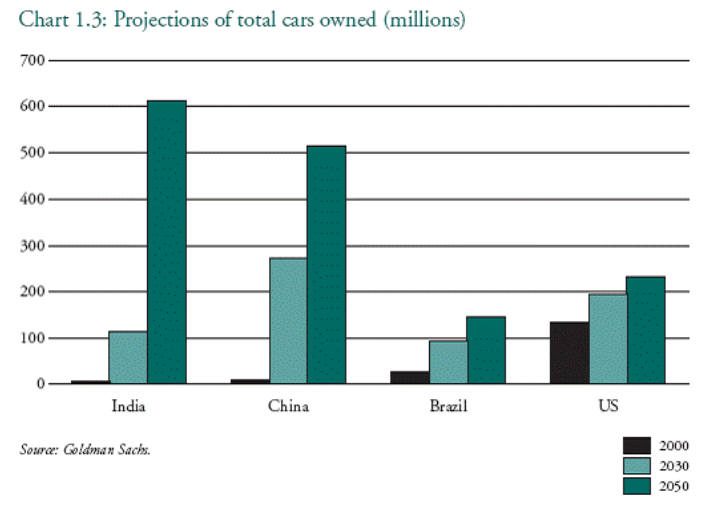
As VMT and MPG rise, GHG is nearly flat

### Light Duty VMT, MPG, and GHG Emissions (3 of 3)



# Worrisome Global Trends in Vehicle Ownership

- Today, car ownership in the U.S. is greater than in India, China, and Brazil combined.
- By 2050, car ownership in those countries will be 5x greater than in the U.S.



Source: The King Review, Table 1.1 and Goldman Sachs, “The BRICs and Global Markets: Crude, Cars and Capital: Goldman Sachs Global Economics Paper No 118, 2004.

# Consider Energy Security

- Even if climate change went away, energy security is a growing concern
- ~\$1 billion/day = U.S. payments to other countries for imported oil
- Consider what \$365 billion/year could do if invested in U.S. economy (or deficit reduction) .....
- Largest transfer of wealth in human history?
- 70% of U.S. oil consumption is from transportation
- Reducing transportation energy consumption = reduced GHG, lower transportation costs, greater wealth retained in U.S., reduced vulnerability to hostile nations

# Energy Security and Climate Change

- Most of the strategies to reduce transportation energy consumption also reduce GHG emissions:
  - High MPG vehicles
  - Low-carbon fuels
  - Reduced VMT growth
  - Reduced congestion
  - Eco-driving
  - Energy efficient construction and maintenance practices and materials
  - And more.....
- And they save money for budget-strapped DOTs and households



# Energy Costs -- Wal-Mart Perspective

***“We know we need to get ready for a world in which energy will only be more expensive.”***

Wal-Mart will cut 20 MMT of GHG from its supply chain by the end of 2015 — equivalent to removing >3.8 million cars from the road for a year.

Wal-Mart is already requiring suppliers to cut packaging, selling “Walmart-label” CFL bulbs in Mexico, and labeling clothes as cold-water wash.

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Should state DOTs take a page from Wal-Mart’s book?

## II. The Importance of Climate Change for Transportation



# Four Climate/Energy Issues for Transportation

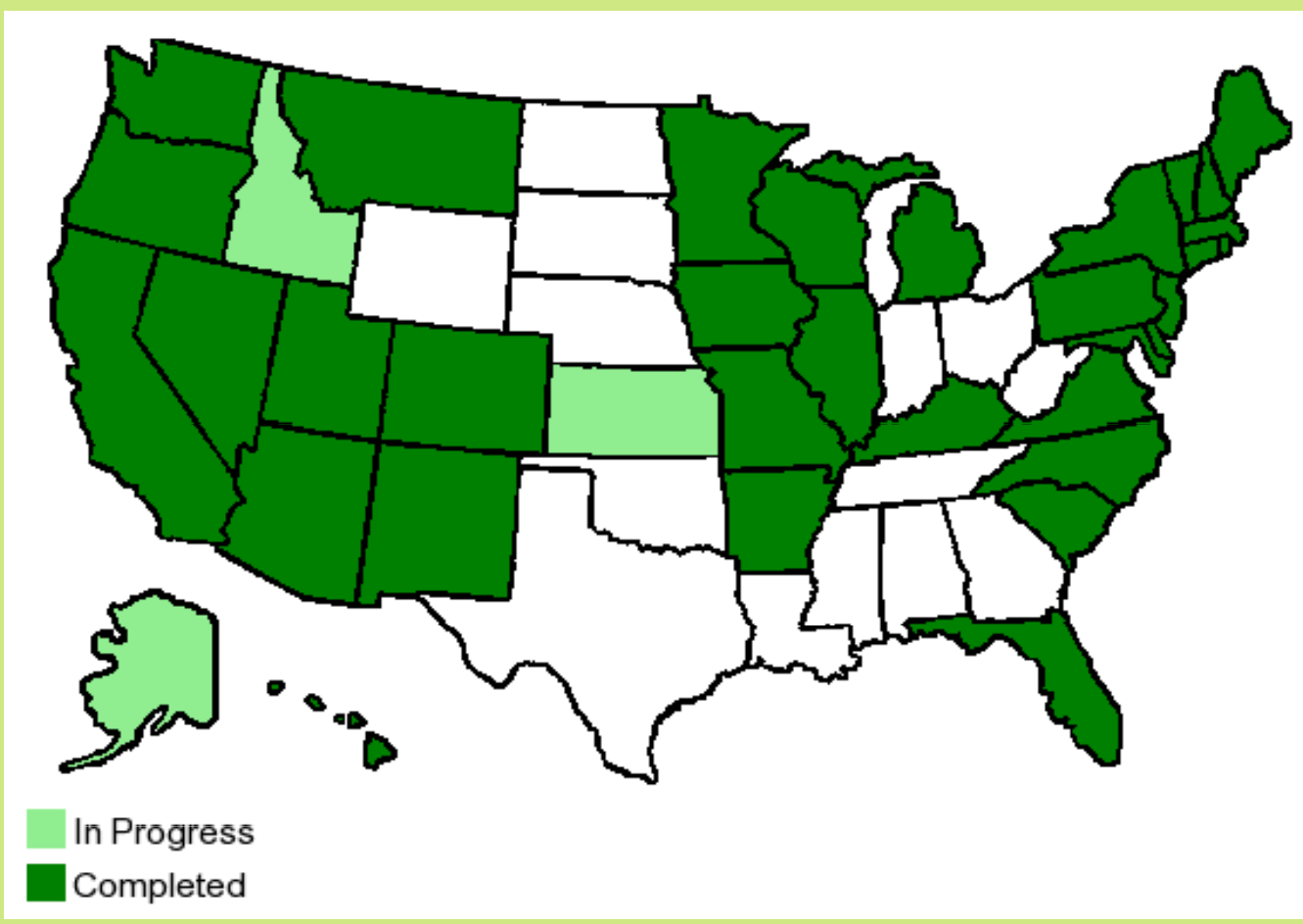
1. Climate adaptation: Physical impacts of climate change on transportation facilities, systems and operations
2. GHG mitigation: State and federal policies calling for GHG reductions
3. Energy: Higher costs and energy volatility for agencies, households, and all levels of government
4. Transportation revenue: Declining revenue as U.S. shifts to alternative energy and high MPG vehicles

# What are Other State DOTs Doing on Climate Change?

- California: <http://www.dot.ca.gov/docs/ClimateReport.pdf>
- Maryland: [http://www.mde.state.md.us/assets/document/Air/ClimateChange/Appendix\\_C\\_%20MDOT\\_CLimate\\_Action\\_Process.pdf](http://www.mde.state.md.us/assets/document/Air/ClimateChange/Appendix_C_%20MDOT_CLimate_Action_Process.pdf)
- Oregon: <http://www.oregon.gov/ODOT/SUS/docs/EffortsOnClimateChange2008.pdf>
- Vermont: <http://www.aot.state.vt.us/planning/Documents/Planning/VTransClimateActionPlanfinal1.pdf>
- Washington: <http://www.wsdot.wa.gov/environment/climatechange/>
- New York: [http://www.nysdot.gov/nasto/repository/WS4d\\_Zamurs%20AASHTO\\_0.ppt](http://www.nysdot.gov/nasto/repository/WS4d_Zamurs%20AASHTO_0.ppt)
- Florida: [http://www.dep.state.fl.us/climatechange/files/action\\_plan/chap5\\_trans.pdf](http://www.dep.state.fl.us/climatechange/files/action_plan/chap5_trans.pdf).

# VT is Among 33 States with Climate Action Plans

Source: Pew Center on Climate Change



# Climate Change is a Matter of Vermont State Policy

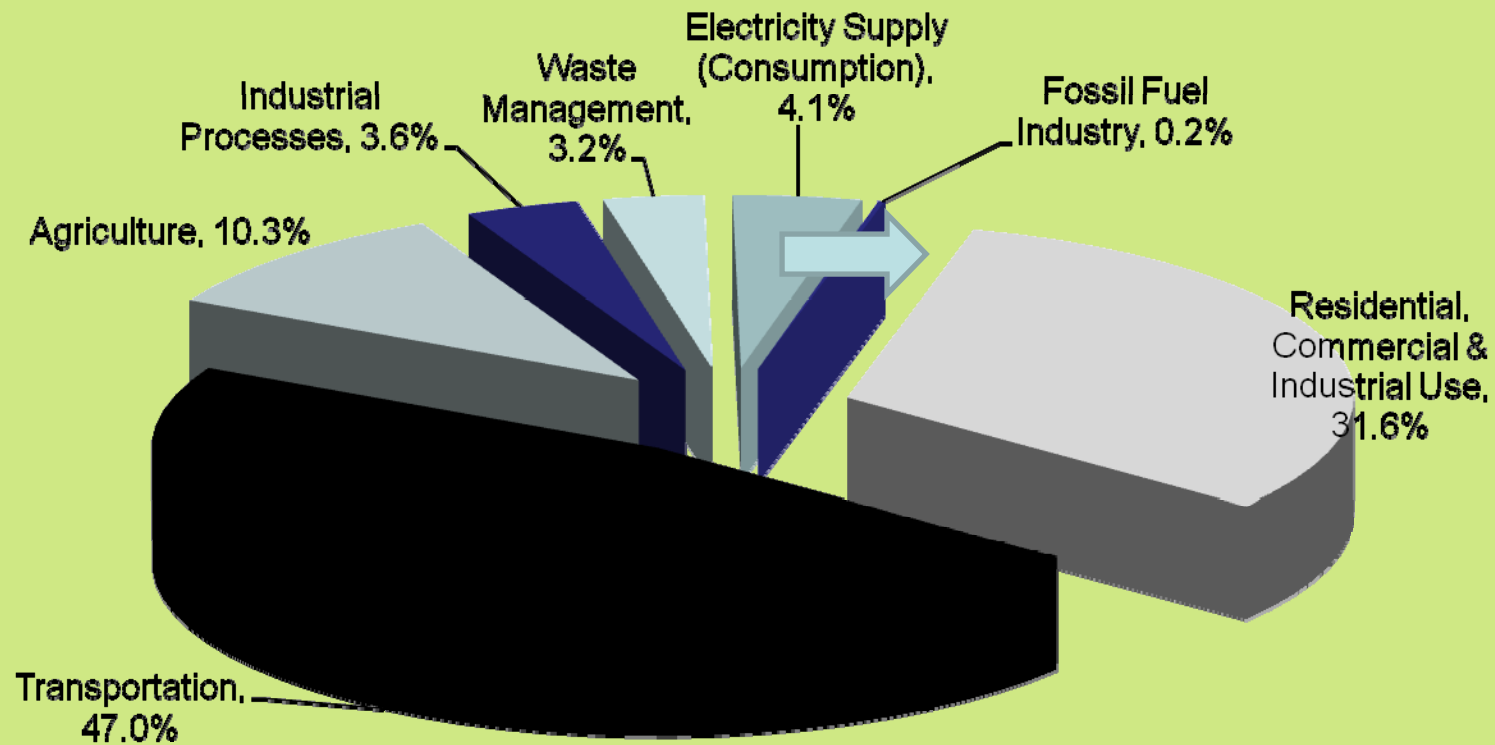
The state of Vermont recognizes there are real environmental and economic impacts from climate change.

Vermont has set GHG emission goals and taken steps to reduce GHG

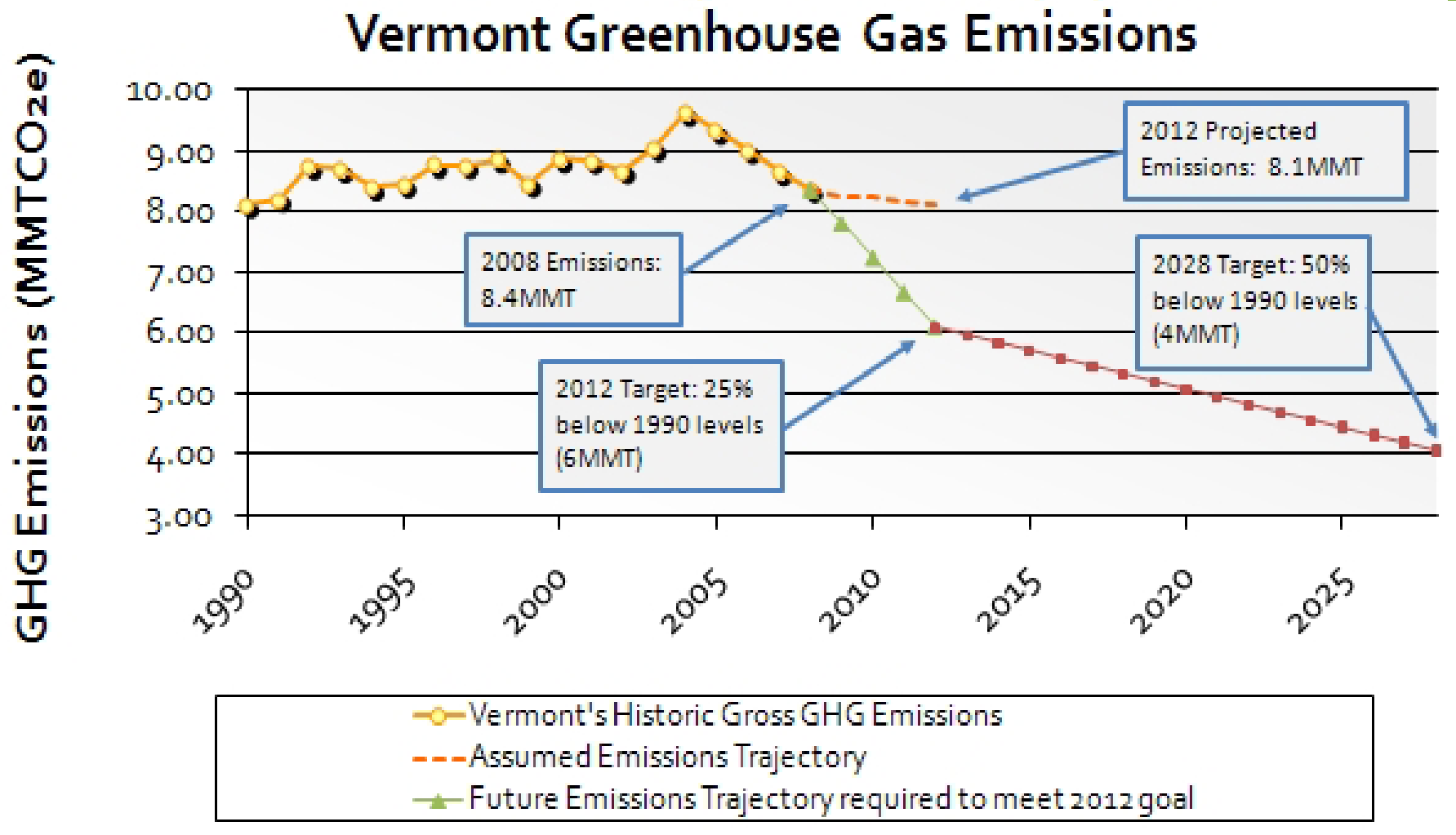
- Regional Agreements (NEGC/ECP, REGGI, TCI)
- 2007 Governor's Commission Report (available at: <http://www.anr.state.vt.us/air/Planning/htm/ccvtactions.htm> )

# 47% of VT GHG is from Transportation

## Vermont Greenhouse Gas Emissions



# Vermont GHG Trends & Targets



Source: VT Agency of Natural Resources 2010



# Sampling of State Climate Plans/Reports

State	Target Year	Reduction in Transportation GHG	Transportation Share of all GHG Reductions
<b>Vermont</b>	<b>2028</b>	<b>59%</b>	<b>34%</b>
New York	2020	18%	7%
Connecticut	2020	N/A	7%
Pennsylvania	2025	30%	8%
Arizona	2020	25%	9%
Minnesota	2025	27%	5%
Oregon	2025	25%	8%
New Mexico	2020	30%	8%
Colorado	2020	22%	6%
California	2020	28%	10%

# Transportation Strategies in State Climate Plans – Much Variation & Much to Question

State	Year	Vehicle	Low Carbon Fuels	Smart Growth and Transit	Other
<b>VT</b>	<b>2028</b>	<b>21%</b>	<b>14%</b>	<b>49%</b>	<b>17%</b>
CO	2020	40%	26%	22%	13%
SC	2020	14%	55%	29%	1%
CT	2020	51%	38%	8%	2%
ME	2020	53%	25%	21%	1%
OR	2025	80%	14%	6%	0%
NY	2020	59%	11%	27%	4%
PA	2025	53%	15%	<1%	28%
MN	2025	15%	35%	25%	25%
CA	2020	60%	24%	10%	6%

# State Climate Action Plans/Reports

## Most state climate action plans/reports:

- Very “aspirational”\*
- Managed by state environmental agencies
- Steering Committees had few or no transportation agency reps
- State DOT involvement often at a technical advisory level

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\* For example, VT strategies are expected to reduce 2030 statewide VMT from 10.5 B to 3.9 B

# 2007 VT Climate Action Report

- Issued October 2007
- 6 member Commission + 31 plenary group members
- Organized around:
  - Energy Supply & Demand
  - Transportation & Land Use
  - Agriculture, Forestry & Waste Management
- 38 policy recommendations to meet VT targets to achieve these reductions below 1990:
  - 25% by 2012
  - 50% by 2028
  - 75% by 2050, if practical

# 2007 Vermont Climate Action Report – Relative Shares of GHG Reductions, 2008-2028

<b><i>Sectors Represented</i></b>	2008 - 2028	
	GHG Reductions (MMtCO <sub>2</sub> e)	Share of Reductions
Energy Supply and Demand	72.75	44%
Transportation and Land Use	40.31	24%
Agriculture, Forestry, & Waste Management	54.00	32%
	<i>Total</i>	167.06

# 2007 VT Climate Action Report – Transportation & Land Use Strategies

<u>TLU Strategy</u>	<u>GHG Reductions, 2028</u>
1. Compact & Transit Oriented Development	0.99 MMT
2. Alternatives to Single-Occupancy Vehicles	0.32 MMT
3. Vehicle Emissions Reduction Incentives	0.63 MMT
4. Pay-as-You-Drive Insurance	0.32 MMT
5. Alternative Fuels & Infrastructure (LCFS)	0.42 MMT
6. Regional Intermodal Transportation System -- Freight & Passenger	0.20 MMT
7. Commuter Choice/Commute Benefits	0.19 MMT
8. Plug-In Hybrids	(part of #5 above)
9. Fuel Tax Funding Mechanism	(to be examined later)
<b>TOTAL</b>	<b>3.07-3.64 MMT</b>
	(out of 10.37 MMT reduced for all sectors)

MMT = million metric tons of CO2 equivalent

# VTRANS Climate Change Action Plan

- Developed June 2008
- On VTrans website at:  
<http://www.aot.state.vt.us/planning/Documents/Planning/VTransClimateActionPlanfinal1.pdf>
- Three major focus areas:
  - Reducing GHG emissions from the transportation sector
  - Protecting Vermont's transportation infrastructure from the effects of climate change
  - Reducing Vtrans' operational impacts on climate change

# Observations of TRB Executive Committee

- Moving away from our dependence on oil and reducing GHG emissions will be the greatest challenge to decision-making for transportation policies, programs, and investments in the coming decades.
- Other sectors are moving on climate change policies faster than transportation
- States are adopting sweeping policies with little or no input from transportation agencies or experts

Source: Transportation's Role in Climate Change:  
TRB Executive Committee, June 2008



# III. Climate Adaptation for Transportation



# Why Transportation Agencies Should Plan for Adaptation

- Intense precipitation:
  - Roadway flooding
  - Culverts
  - Slope erosion
  - Soil stability
  - Maintenance needs
  - Bridge scour
  - Streambanks
  - Ditches
- Higher temperatures:
  - Pavement and rail buckling
  - Increased maintenance
  - Work crew limitations
  - Materials choices
  - Weight limits

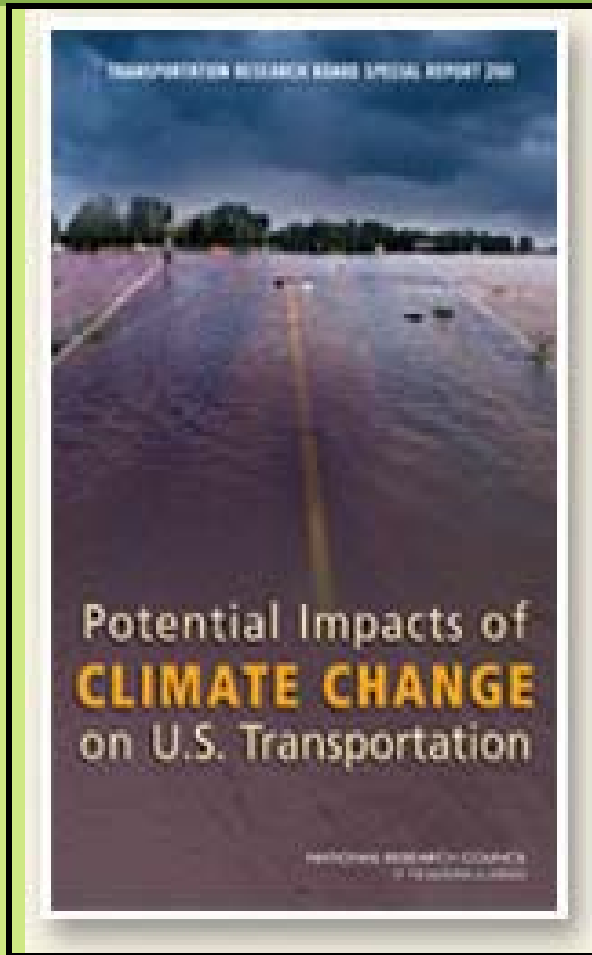


# Definition of Climate Adaptation

*“Actions by individuals or systems to **avoid, withstand, or take advantage of** current and projected climate changes and impacts. Adaptation **decreases a system’s vulnerability, or increases its resilience to impacts.**”*

*--Pew Center on Climate Change*

# U.S. -- TRB Special Report 290



## Potential Impact of Climate Change on U.S. Transportation (TRB Special Report 290)

**Transportation Research Board  
Division on Earth & Life Studies  
National Research Council**

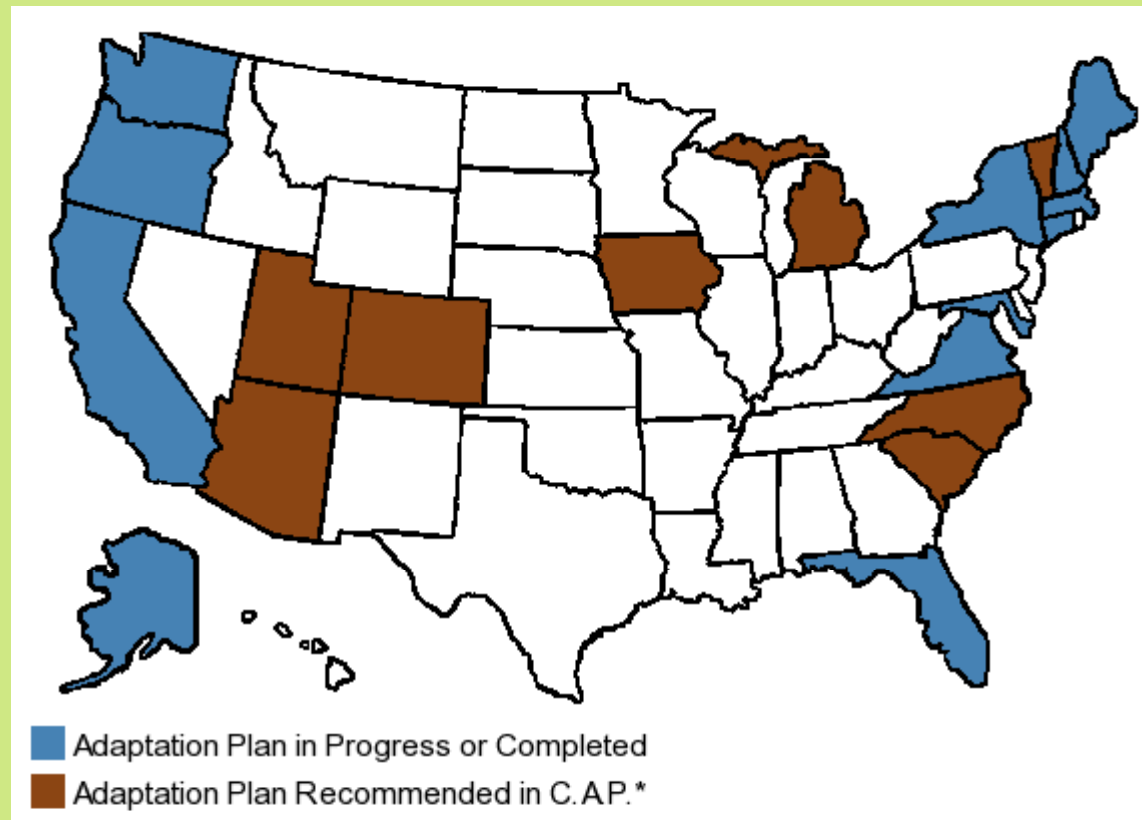
# TRB Special Report 290

- Climate change will affect every mode of transportation and every region in the United States, and the challenges to infrastructure providers will be new and often unfamiliar.
- State and local governments and private infrastructure providers will need to incorporate adjustments for climate change into long-term capital improvement plans, facility designs, maintenance practices, operations, and emergency response plans.

# TRB Special Report 290

- Design standards will need to be re-evaluated and new standards developed as progress is made in understanding future climate conditions and the options for addressing them.
- Transportation planners will need to consider climate change and its effects on infrastructure investments. Planning timeframes may need to extend beyond the next 20 or 30 years.
- Institutional arrangements for transportation planning and operations will need to be changed to incorporate cross jurisdictional and regional cooperation.

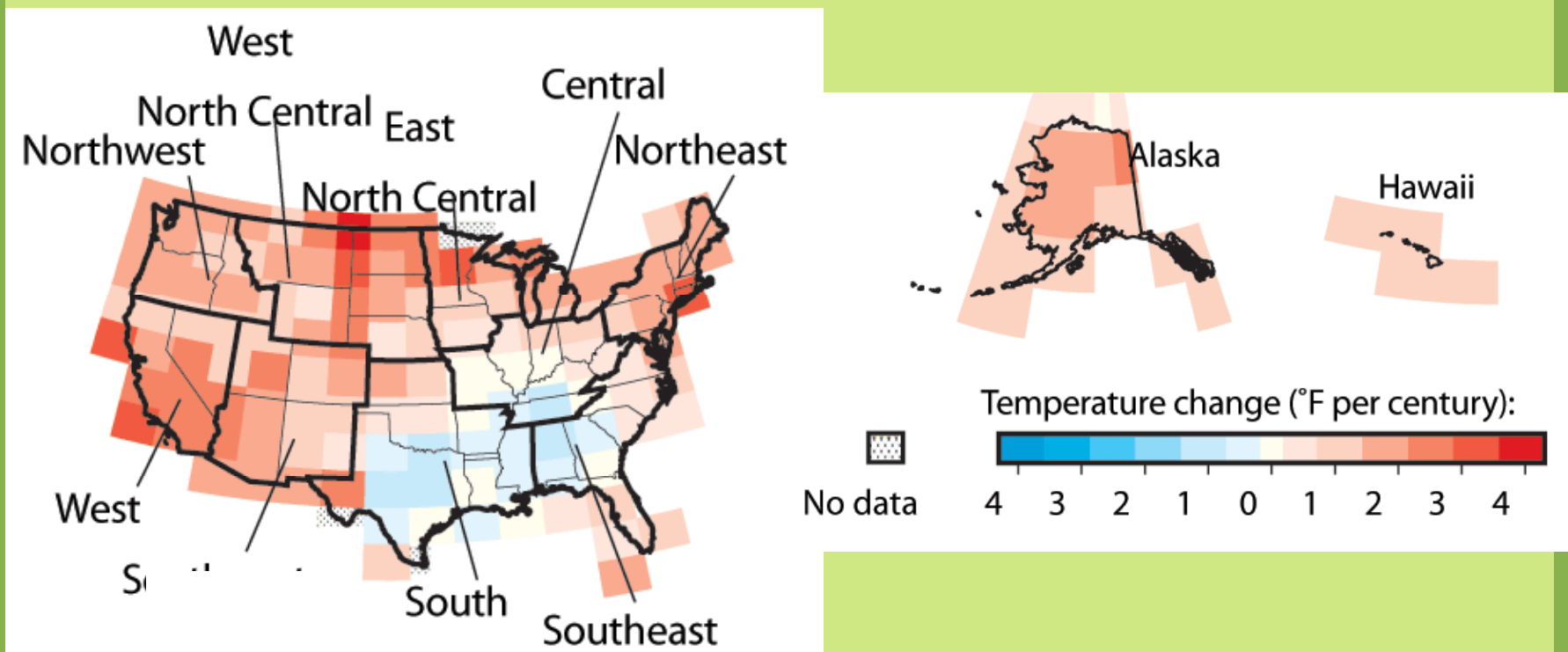
# U.S. -- State Climate Adaptation Plans





# U.S. -- Recent Temperature Changes

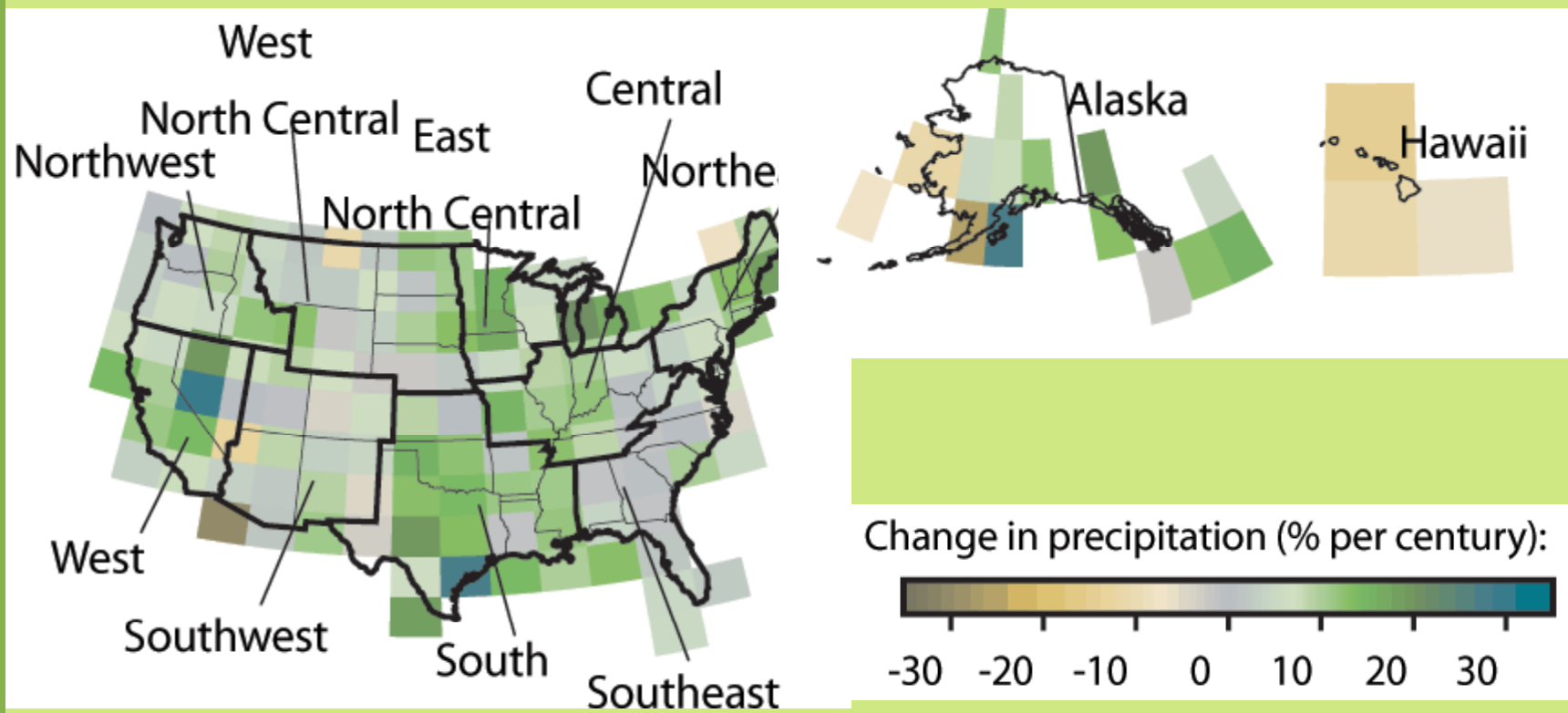
Annual Mean Temperature Anomalies, 1901-2005





# U.S. -- Recent Precipitation Changes

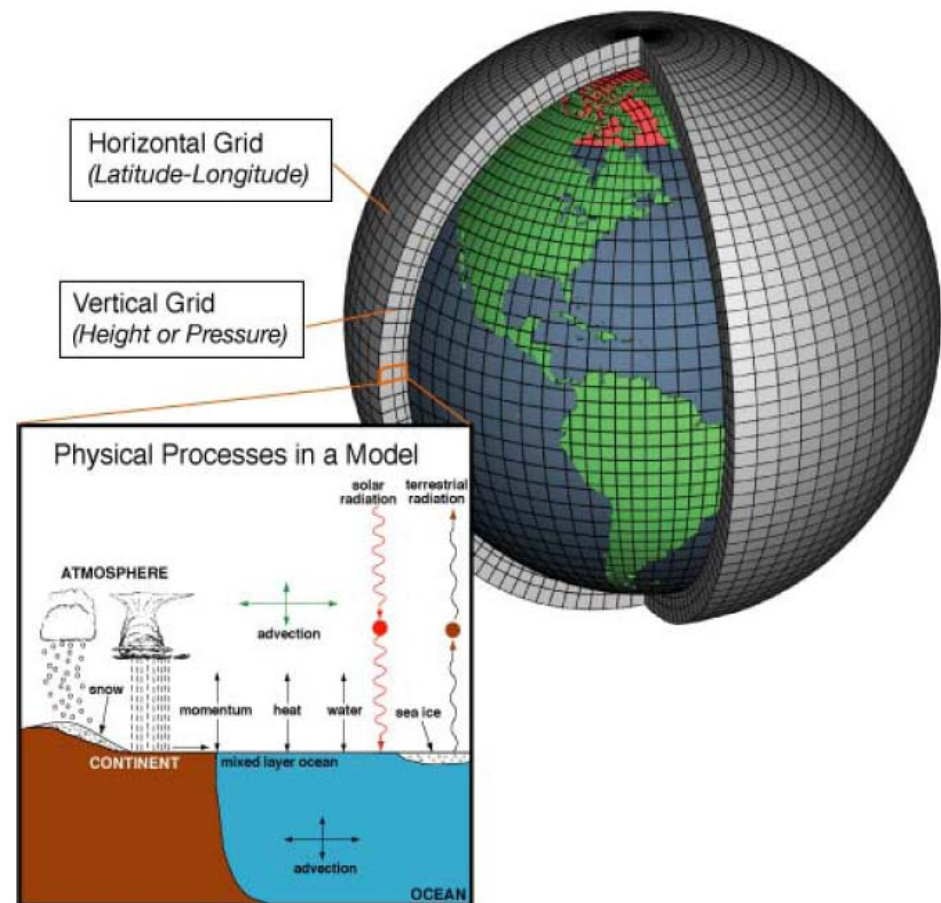
## Annual Precipitation Trends, 1901-2005



# Global Climate Model Basics

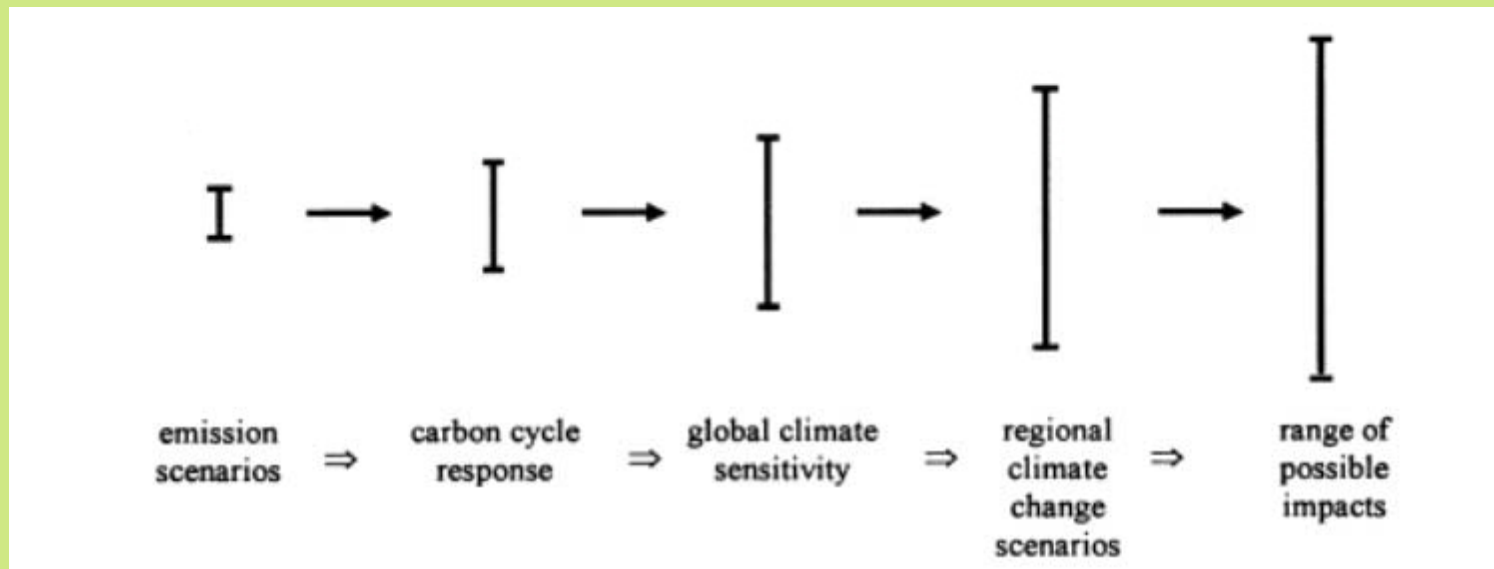
Global Climate Model (GCM): a set of computer codes that solve mathematical equations which emulate the Earth's climate system

Calculations performed at grid cell scale



# Global Climate Model Uncertainty

- Uncertainty is substantial in climate modeling and builds each step of the way



Source: *Climate Change Policy*, edited by Stephen H. Schneider, Armin Rosencranz, and John O. Niles.

# Global Climate Model Uncertainty

(continued)

- Uncertainty in precisely how all aspects of the climate system work together
  - Result: Different models use different assumptions and produce somewhat different outputs even if given the same input data
- Some major global climate patterns have not yet been accurately modeled (e.g. El Nino)
- Uncertain climate system feedback loops
  - Methane releases from melting permafrost and arctic lake & sea bottoms?
  - Increased precipitation and snowpack in Siberia causing colder winters in the Eastern U.S. and Europe?

# 2010 FHWA Climate Change Effects Report

- Provides climate projections for state DOTs
  - NOTE: Science is progressing, expect information to improve over next 3-5 years
- Based on low and high GHG emission scenarios
- Projected *changes* by region:
  - Annual, Seasonal Temperature (change in °F)
  - Seasonal Precipitation (% change)
  - Where information exists: Sea level rise & storm activity
- Contains 9 regions (6 in continental U.S. + Alaska, Hawaii, & Caribbean)
- NOAA, USGS, & DOE assisted FHWA
- Available on FHWA climate change website

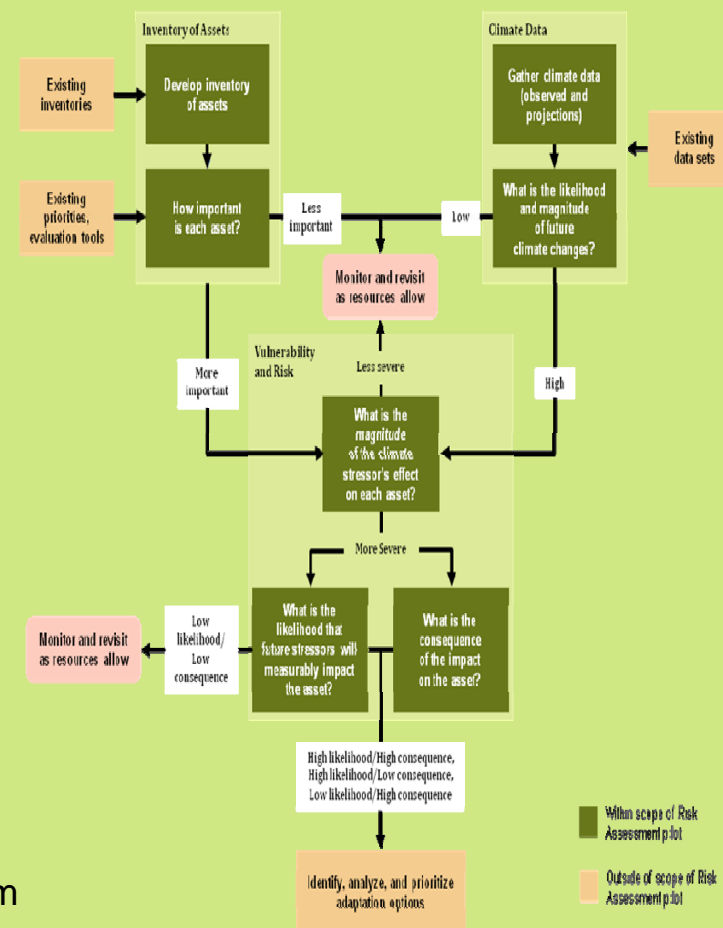
# New FHWA Climate Vulnerability/Risk Assessment Model

- Goal: Help transportation decision makers identify assets:
  - most exposed to the threats from climate change; and/or
  - could result in the most serious consequences as a result of those threats
- Draft model completed in 2010
- 5 pilots now underway to test model: WS, NJ, HI, VA, CA
- Finalize model for wider use

# FHWA Climate Vulnerability/Risk Assessment Model

1. Develop inventory of infrastructure assets
2. Gather climate data
3. Assess risk and vulnerability of assets to projected climate change
4. Analyze, prioritize adaptation options
5. Monitor and revisit

[www.fhwa.dot.gov/hep/climate/conceptual\\_model62410.htm](http://www.fhwa.dot.gov/hep/climate/conceptual_model62410.htm)



# Environmental Reviews Need to Consider Climate Impacts on Project

- In NEPA process, sponsor should consider project vulnerability to future climate change
- US ACE may raise new issues in wetland permitting due to climate impacts
- USCG may raise climate impacts in bridge permitting
- DOI may raise issues & require more analysis for ESA, due to uncertainty of climate impacts on species



# More Intense Storms: Potential Responses

- Changes in bridge height, foundation, and superstructure
- Larger hydraulic openings for bridges over waterways
- Changes in suspended/cable-stay bridges to withstand severe wind and turbulence
- Changes in materials specifications
- Changes in culvert design, capacity, and location
- Changes in slope design
- Changes in pavement drainage systems



# More Intense Storms: Potential Responses (continued)

- Heavier/lengthier armoring of river and stream banks and ditches to prevent erosion
- Greater pavement crowns to move runoff off pavement quicker
- Additional in-system detention to meter runoff outflow
- Changes in bridge design elements to reduce bridge scour
  - i.e. piers in the river, spread footings, use more sheet piling left in place
- Terraced vegetated slopes
- More robust pavement markings to be visible in wet/night conditions
- Larger capacity pumps/pump stations for below grade roads, to prevent flooding

# More Intense Storms: Potential Responses (continued)

- Stronger specifications for protection of work under construction
- Specs to require contractor response plans for work zones impacted by high intensity storms
- Improved Roadway Weather Information Systems
- Improved traveler information systems to warn of outages/risks



# Hotter Drier Summers: Potential Responses

- More night/cooler weather work to prevent damage such as slab curling, premature cracking, loss of air entrainment in concrete pavements, rutting and flushing in asphalt pavements
- Design tougher, more resilient, lower maintenance roadways, bridges, facilities and roadsides
- Design lower maintenance bridge expansion
- Design seed/vegetation mixtures that create a denser, deep-rooted vegetation mat that is more erosion resistant
- Eliminate monoculture roadside vegetation designs that may not survive extended drought periods or invasive species attack

# Hotter Drier Summers: Potential Responses (continued)

- Protect work in progress from effects of higher temperatures for both short term and long term durability
- Stronger specifications for Dust Control/Wind Erosion
- Materials whose performance is less variable in weather extremes
- Modify vegetation planting periods to ensure optimal growth and survival
- Work crew limitations in extreme heat periods
- Closer monitoring of moisture in aggregate piles
- More monitoring/response for pavement rutting
- More monitoring/response for rail buckling



# Summary

- **All modes** of transportation threatened
- **Affects all transportation functions** – planning, programming, environment, location, design, construction, operations, emergency planning – and budgeting
- **Low lying coastal areas especially vulnerable**
- **Risk assessment and prioritization** is key
- Transportation planners need to **be aware of and adapt to climate change impacts** on our transportation infrastructure
- Looming in future: where **not to build or re-invest?**



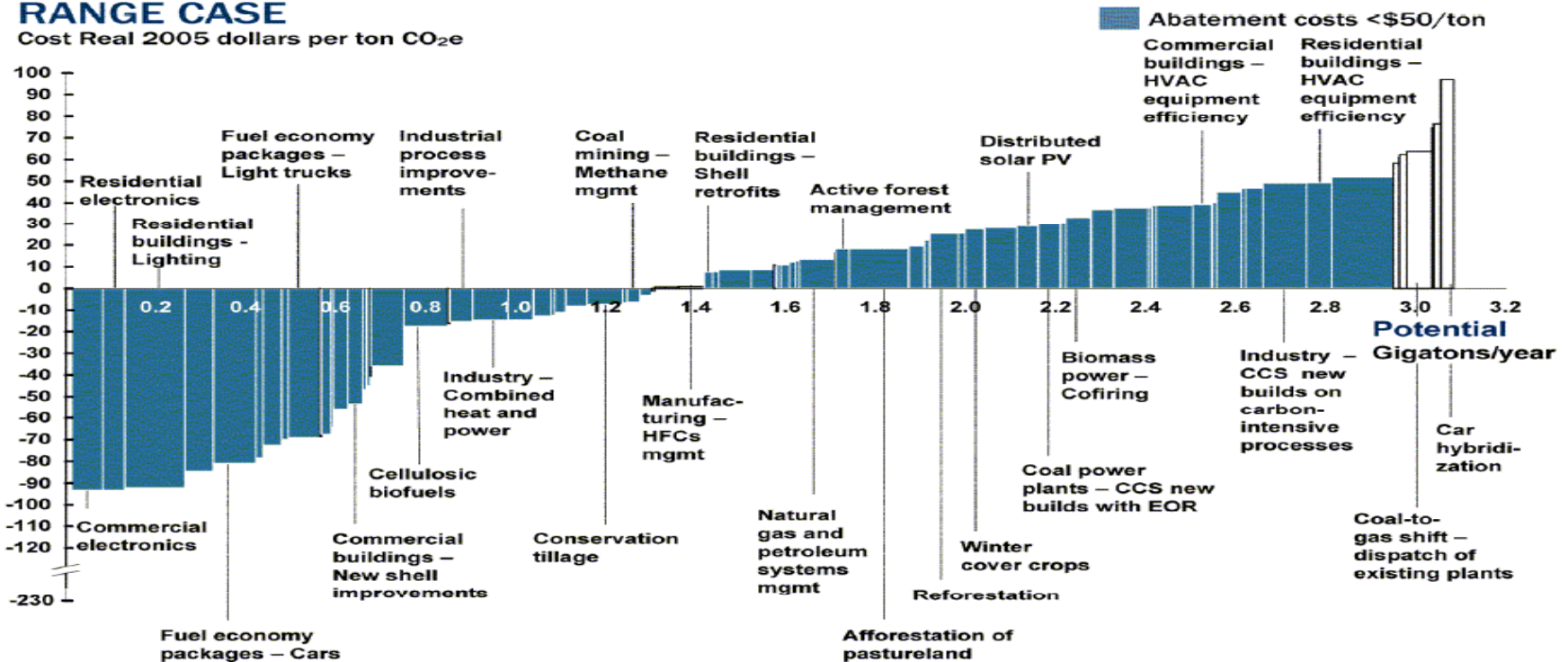
# IV. Reducing GHG Emissions from Transportation – Strategies, Planning, and NEPA



# CONTEXT/ALL SECTORS: McKinsey Finds Available Technologies can Reduce 3 Billion Tons GHG/Year at < \$50/ton (this is 31% of GHG economy-wide in 2030)

## GHG REDUCTION OPPORTUNITIES WIDELY DISTRIBUTED - 2030 MID-RANGE CASE

Cost Real 2005 dollars per ton CO<sub>2</sub>e



The analysis found that abatement options are highly fragmented and widely spread across the economy. Almost 40 percent of abatement could be achieved at “negative” marginal costs, i.e., the savings over the lifecycle of these options would more than pay for the incremental investment, operating, and maintenance costs. Realizing the potential of many negative-cost options would require overcoming persistent barriers to market efficiency.

-- McKinsey & Company



# What is the full array of transportation strategies to reduce GHG?

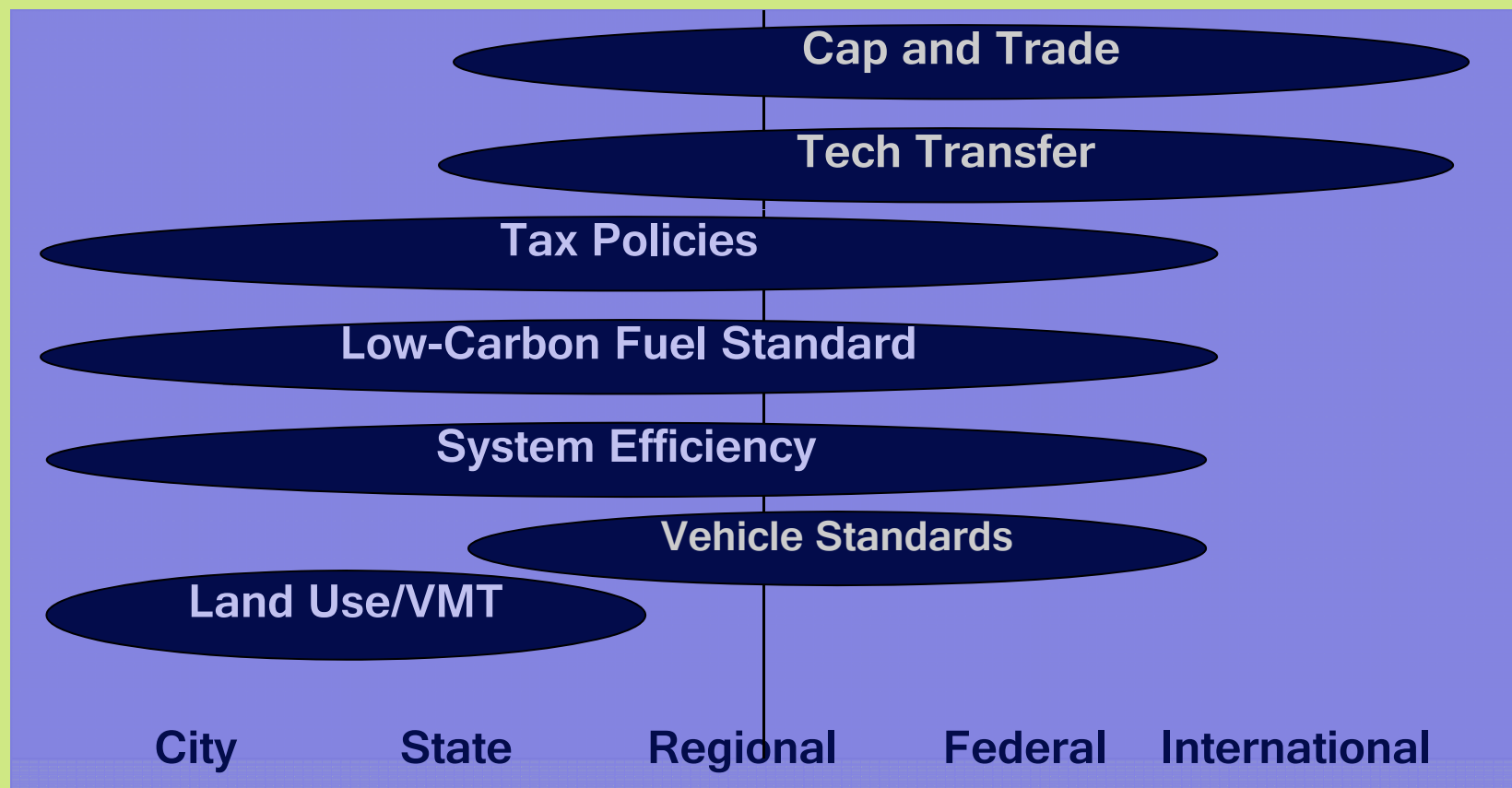
## Five GHG “legs”

1. Vehicle efficiency
2. Low-carbon fuels
3. VMT Reductions (including land use)
4. Vehicle/System Operations
5. Construction, Maintenance, and Agency Operations

## Examples

- Higher CAFE standards 380 gm/mile to 250 gm/mile 2016
- CA’s low carbon fuel standard
- Less travel, could be in part due to land use changes
- Signalization, ITS, Eco-driving
- Materials, maintenance practices

# What kinds of transportation strategies are needed? 2011 Pew Center Report



-- "Reducing GHG from U.S. Transportation," by David Greene and Steve Plotkin, for the Pew Center on Global Climate Change, January 2011

# How much can transportation strategies reduce GHG? 2011 Pew Center Report

- Presents base case + 3 scenarios for transportation GHG reductions
  - Base case: +28% in transportation GHG, 2010-2050
  - Low scenario: -17% in transportation GHG, 2010-2050
  - Mid scenario: -35% in transportation GHG, 2010-2050
  - High scenario: -65% in transportation GHG, 2010-2050
- High scenario: rapid tech progress, aggressive emission standards, 80 mpg for cars, transition to electric and hydrogen vehicles well underway by 2050, auto feebates, carbon pricing, eco-driving, land use policies, congestion pricing, PATP auto insurance, automated highways in 2050 on major routes, etc.
- GHG reductions are roughly equal from (a) vehicle efficiency; (b) low-carbon fuel; and (c) all other strategies combined.

-- "Reducing GHG from U.S. Transportation," by David Greene and Steve Plotkin, for the Pew Center on Global Climate Change, January 2011

# Washington State DOT Case Study

“WSDOT’s analysis suggests that implementing combinations of aggressive transportation emission reduction strategies can achieve roughly a ten percent reduction in total statewide GHG emissions compared to the 2050 baseline. Implementing many of these strategies would require changes in policy, funding, and authority, and also assumes ambitious improvements in vehicles and fuels. WSDOT did not assess the political or financial feasibility of implementing the strategies.” (highlighting added)

Source: 2011 WSDOT Sustainability report

Note: 10% reduction in 2050 is for GHG from all sectors, but it is not a 10% reduction below current levels. For the on-road sector, it corresponds to about 7-31% reduction in 2050 compared to 2010 on-road GHG, using “aggressive strategies.”

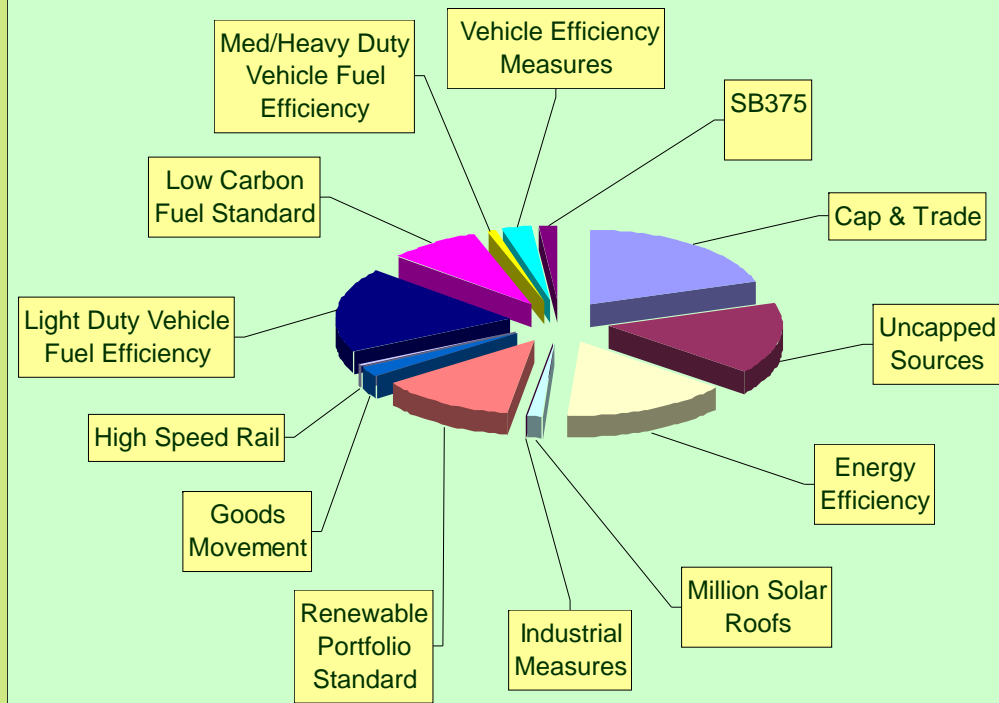
# Washington, D.C.- 2010 - 2030

- **Reduction Goal 33.5%**
  - CAFE 17.3%
  - Alt.Fuel 2.1%
  - TERMS\* .6%
  - Short term 3.9%
  - Long-term .85%
- **Shortfall 8.75%**
- \*TERMS : Access and service improvements to transit, bike/ped projects, rideshare assistance programs, telecommute programs, traffic improvements, engine technology programs
- Short term reductions (3.9%)
  - Increase transit .3%
  - Pricing 1.5%
  - Operational Efficiencies 1.8%
  - Reduced travel 3%
- Long-term reductions (.85%)
  - Increase transit .15%
  - Increase bike/ped .3%
  - Pricing .25%
  - Reduced travel .15%

Source: Washington, D.C. COG

# California Climate Change Act – AB32

California GHG Emissions Reduction Measures 2020



# Vehicle/Fuel Improvements Will be the Dominant Source of GHG Reductions for LDVs

- 50% cut in GHG/mile is feasible from conventional technologies and biofuels by 2020-2030
- Compare these GHG rates in U.S. and Europe:

380 grams/mile	2009 in the U.S.
250 grams/mile	2016 under new Obama standard
256 grams/mile	2007 actual in the E.U.
209 grams/mile	2012 under E.U. regulation
153 grams/mile	2020 under E.U. regulation
- LDV purchase cost will rise, but fuel savings will be greater than vehicle cost increase
- Win-win-win: reduces energy use, reduces GHG, saves money

# Vehicle “Decarbonization” is Critical

***“In the long term, carbon free road transport fuel is the only way to achieve an 80-90% reduction in emissions, essentially “decarbonization.”***

--The King Review for the U.K. Government, by Professor Julia King, Vice-Chancellor of Aston University and former Director of Advanced Engineering at Rolls-Royce plc, March 2008

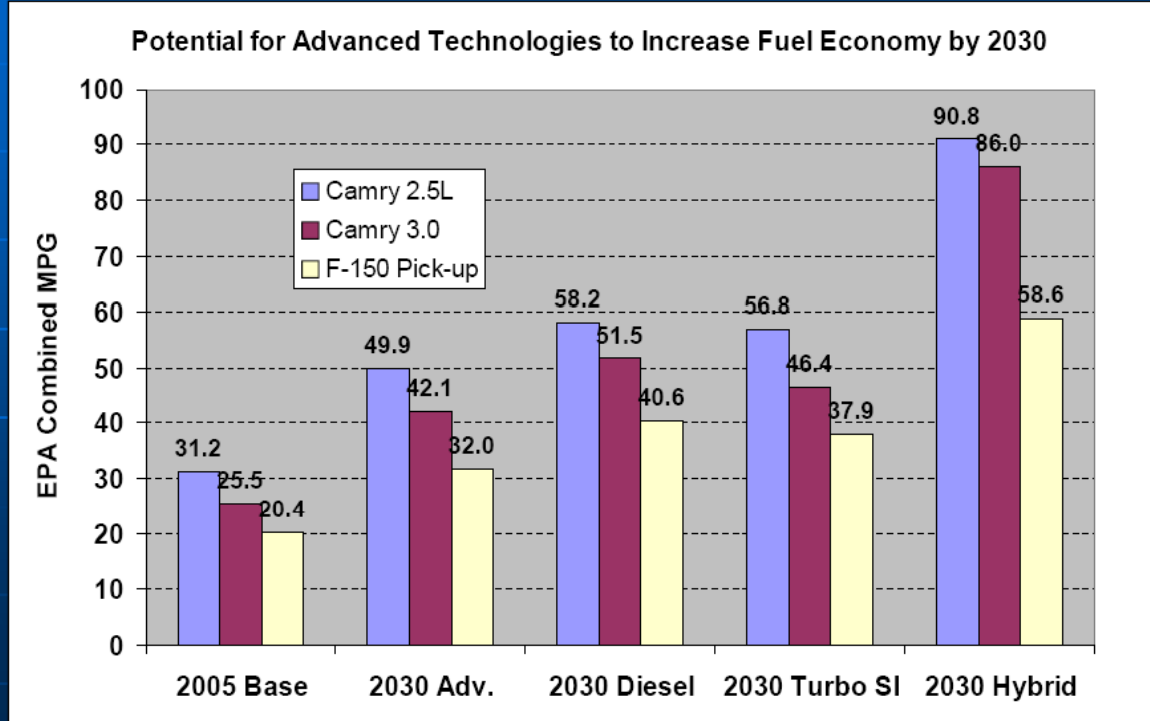
***“[I]n the period beyond 2100, total GHG emissions will have to be just 20% of current levels. It is impossible to imagine this without decarbonization of the transport sector.”***

-- Sir Nicholas Stern, Stern Review to the U.K. Government, 2007



# Vehicles: Potential Fuel Economy Increase by 2030

A 2007 MIT study predicts MPG gains of 80-85% for model year 2030 vehicles via continuous improvement of conventional technology at a rate of 2-2.5%/year.



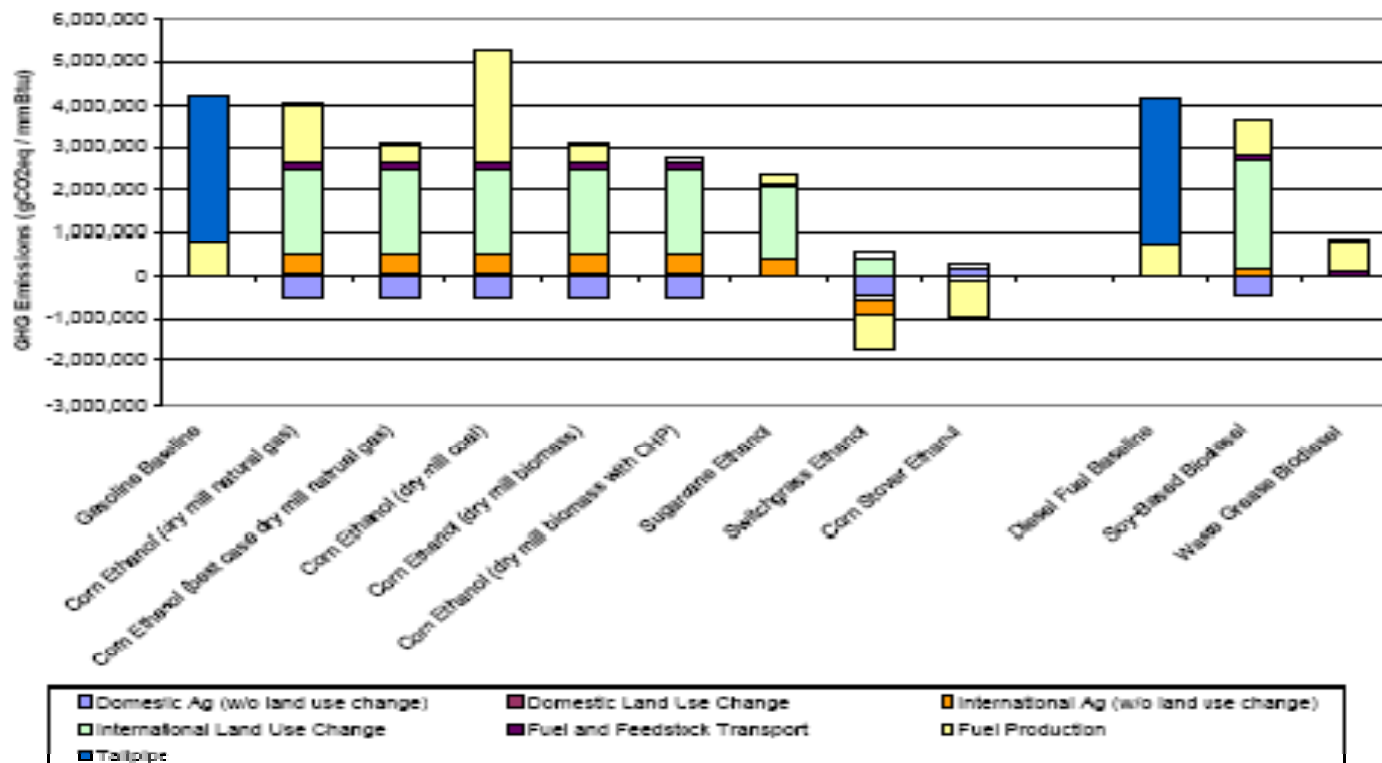
Source: Kasseris & Heywood, SAE Technical Paper 2007-01-1605, April, 2007.

# Fuels: Low-Carbon Fuels

- Many different low-carbon fuel possibilities:
  - Corn ethanol                      - Sugar cane ethanol                      - Biodiesel
  - Cellulosic biofuel                - Algae biofuels                                      - Hydrogen
  - Electricity from renewable energy or nuclear power
  - Electricity from utilities with carbon capture & storage
- Carbon intensity measured as GHG/unit of energy – must account for “life-cycle” emissions
- California LCFS:
  - Adopted in 2008
  - Aims to reduce carbon intensity of passenger vehicle fuels by 10% by 2020
  - Measures carbon-intensity on a life-cycle basis – “from field to wheel.”

# Many Different Fuels -- Lifecycle GHG Varies

**Figure 1. Net Lifecycle Greenhouse Gas Emissions By Lifecycle Component With 100 Year Time Horizon And 2% Discount Rate.**

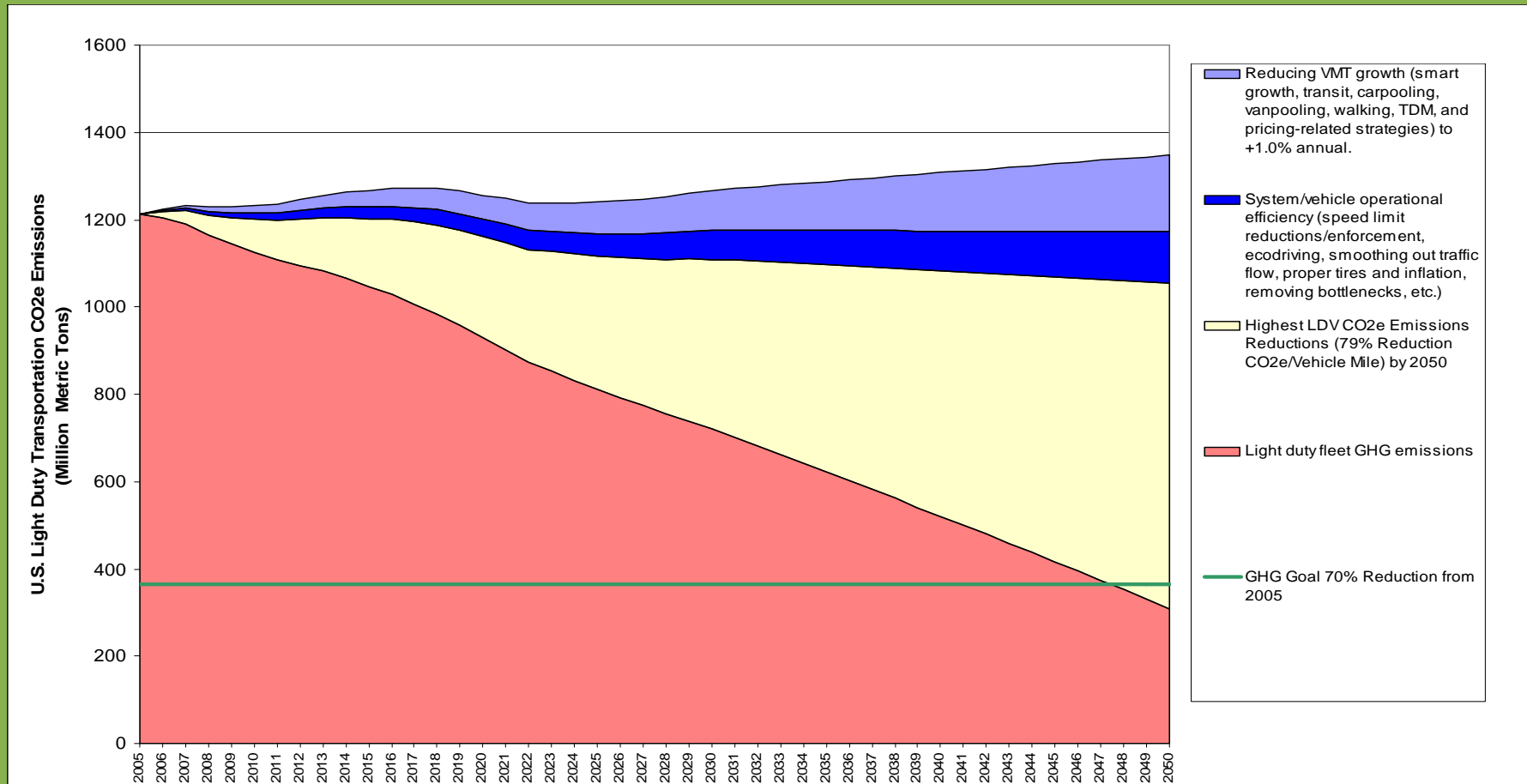


# Vehicles & Fuels: Possible State DOT Roles in Decarbonization

1. **Influence state policies** on low-carbon fuels/vehicles
2. **Use planning scenarios** to emphasize need for decarbonization
3. **Plan/provide plug-in infrastructure** for electric and PHEV vehicles (coordinate with utilities)
4. **Support federal transportation funding** for technology/fuel R&D
5. **Educate** the public and elected officials
6. **Provide incentives** for consumers to use lower carbon fuels/vehicles (lower fees for low-carbon vehicles/fuels)
7. **Support** low -carbon fleet conversion for state vehicle fleets
8. **Adjust** facilities and operations to accommodate decarbonized vehicles and fuels

# More than Vehicles and Fuels:

Achieving 74% LDV GHG Reduction by 2050 requires 100 mpgge LDV Fleet + 10% Operational Efficiency + Lower VMT Growth (1%/year)



# VMT: Cautionary Note

VMT is not a good metric for GHG reductions, as VMT does not take into account:

- Type of fuel
- Fuel efficiency of vehicle
- Passenger vs freight trip
- Number of passengers per vehicle
- As passenger fuel economy increases, effectiveness of VMT reductions diminishes
- Lessons from 1990s – marginal impacts from VMT strategies
- Effect on tourism?
- Effect on rural areas?

Reducing VMT is part of the strategy set – but just one element, not the end goal

# VMT: Many Strategies to Reduce VMT Growth

- Pricing - economy-wide (carbon tax or carbon cap and trade, which would raise fuel prices)
- Pricing – transportation (PAYD insurance, parking pricing, tolls, higher user fees, cordon pricing, congestion pricing, etc.)
- Carpooling and vanpooling
- Bike/ped and transit
- Trip chaining
- Tele-working, tele-shopping, tele-education, tele-medicine
- Compact land use

# VMT: Consumers respond to pricing

Gasoline Prices Surged in Summer '08,  
and Consumers Responded, revealing fuel price elasticity

National Vehicle Miles Traveled vs. Gasoline Prices



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# VMT: Carpooling and Vanpooling Potential

- Receives limited support and has been declining
- Yet is more important than is recognized (provides 300-400% of the PMT for work trips nationally as transit)
- Low cost for government, wide availability, saves users money
- Effective in all kinds of areas – rural, small urban areas, suburban, urban
- Nearer-term payoff than most transportation strategies
- Atlanta MPO and WASHCOG pay for commuters to carpool (\$3/day Atlanta, \$2/day WASHCOG)

# VMT: Carbon Intensity of Different Modes

	Occupancy	Lbs of GHG/PMT*
Auto, SOV	1.00	0.99
SUV, average	1.72	0.71
Transit Bus, average	8.80	0.71
Auto, Average	1.57	0.58
Carpools, average	2.10	0.47
Amtrak	20.50	0.39
Rail Transit, average	22.50	0.39
Motorcycles, average	1.20	0.37
Commuter Rail, average	31.30	0.36
Vanpools, average	6.10	0.21
Walking and Biking	1.00	0.00

\* PMT = Passenger Mile Travelled – national averages, DOE data

# VMT: Transit's Potential

- It is hard to generalize about transit
- Transit VMT/GHG benefits are realized with highly patronized, high-occupancy services -- a market limited to high volume, generally densely developed corridors
- Commuter rail is 38% less carbon intensive than average auto – but bus transit is more carbon intensive than average auto use and less carbon intensive than SOV (national averages; some corridors better, some worse)
- Two APTA studies: (a) Transit reduced GHG by 6.9 MMT\* in 2005; or (b) by 37 MMT in 2005 (this is 0.3% to 1.7% of U.S. transportation GHG – and the 1.7% includes effect of transit/land use combined)

\* MMT = million metric tons

# VMT: Land Use Effect on GHG is Helpful but Modest

<1 to 11% *	GHG reduction in 2050 on-road household GHG, for range of 3 scenarios (2009 TRB report, “Driving and the Built Environment”)
<1 to 4.4%	GHG reduction in 2050 on-road GHG, for up to 90% of new development compact with high quality transit (2009 “Moving Cooler” report)
3.5 to 5%	GHG reduction for 2007-2050, cumulative, as % of transportation GHG, for compact land use with very aggressive assumptions (2007 “Growing Cooler” report)

\* TRB Panel was not in agreement on 11%. Highest reduction supported by the full TRB panel was 1.3-1.7%, in 2050

# Compact Land Use + Transit + Bike + Ped + Intercity Passenger Rail + High Speed Rail + Car-Sharing + Urban Nonmotorized Zones + Urban Parking Restraints

Bundling these 9 strategies at the “Aggressive” level leads to these changes in on-road GHG:

~**2.7%** GHG reduction cumulatively, 2005-2050

And at the “Maximum” level:

~**4.4%** GHG reduction cumulatively, 2005-2050

What are the assumptions behind these reductions?

“Maximum” level = \$1.2 trillion transit expansion + \$220 billion in HSR and conventional intercity rail expansion + 50% cut in all transit fares + 90% of all new development is compact starting in 2005 + “complete streets” policies + bike lanes at ¼ mile intervals + 6% of CBD areas are nonmotorized by 2015 + urban parking freeze in 2015

Source: Estimates based on data in Moving Cooler, 2009

# Operations: Many Strategies, with 10-20% GHG Reduction Potential Overall

Potential for 10-20% LDV GHG reduction by improving traffic flow and individual driving behavior:

- Managing speed (35-55 MPH is optimal)
- Speed limits/enforcement (could reduce fuel use 2-4%)
- Eco-driving
- “Active” traffic management to smooth traffic flow
- Improving signal timing (could reduce 1.315 MMT CO<sub>2</sub>/yr)
- Roundabouts (multiple benefits)
- Reducing car and truck idling
- Work zone management to smooth flow
- Incident management
- Eliminating bottlenecks

# Operations: EcoDriving

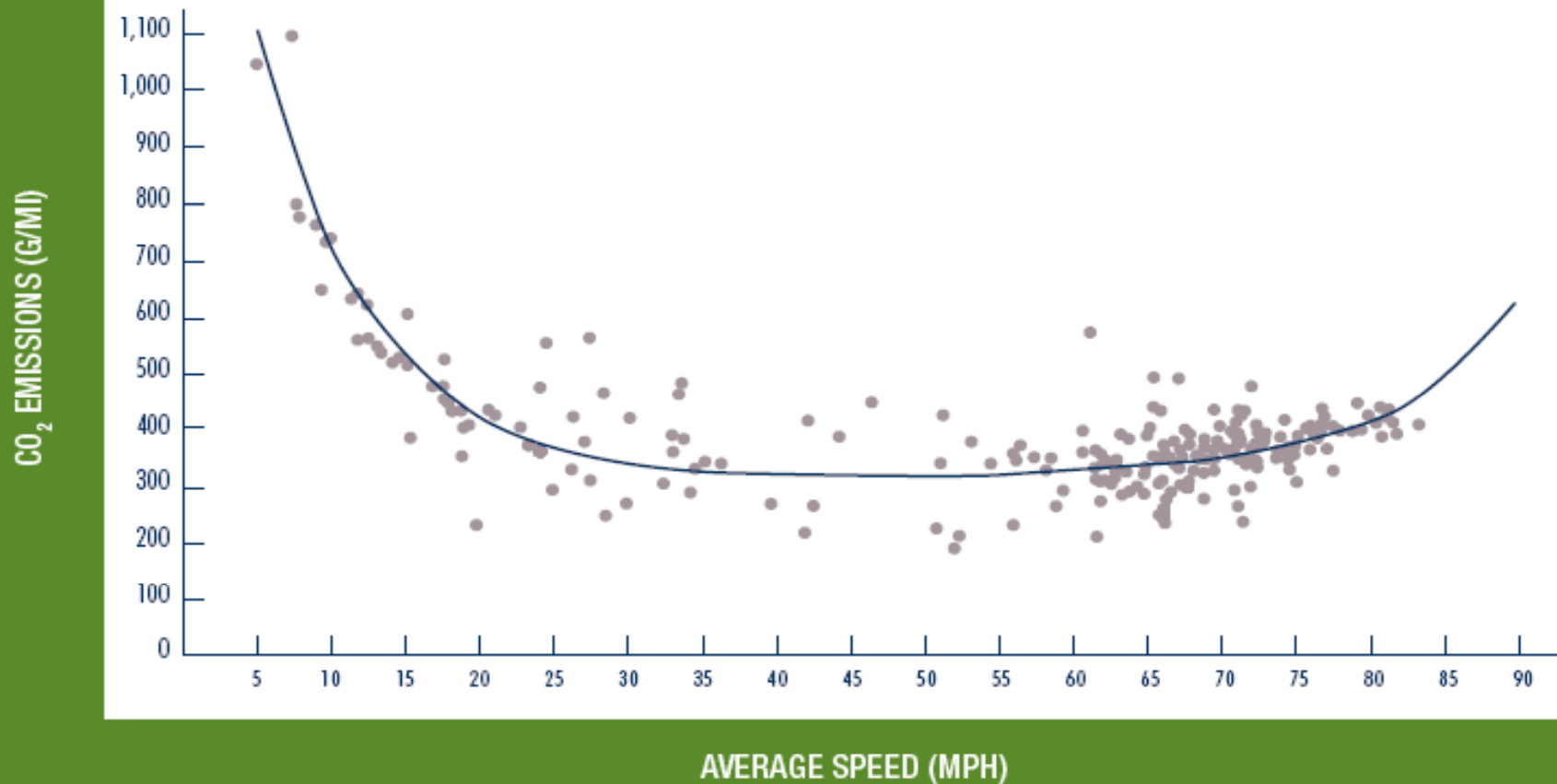
- EcoDrivers can reduce fuel and CO2 by 10-15% through smart driving and vehicle maintenance.
- 10 years of Dutch experience found 10% GHG reduction and extremely cost effective (\$6-9.50/ton reduced)
- Pilot in Denver with 300 drivers achieved 10% fuel reduction and similar GHG reduction
- Useful for HDV, MDV, and LDV drivers
- Major push in Europe as GHG strategy
- Aided by dashboard displays of real-time MPG

# Operations: EcoDriving

- EcoDrivingUSA™ -- nationwide effort to increase overall vehicle fuel economy and preserve the environment
- Partnership of Governors, auto industry, environmental groups
- Website:
  - [Be an EcoDriver](#)
  - [EcoCalculator](#)
  - [EcoDriving Quiz](#)
  - [Virtual Road Test](#)
  - [Is Your Community EcoDriving?](#)
  - [Educational Tools](#)
  - [News and Events](#)
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  - [Link this website on your blog or site](#)

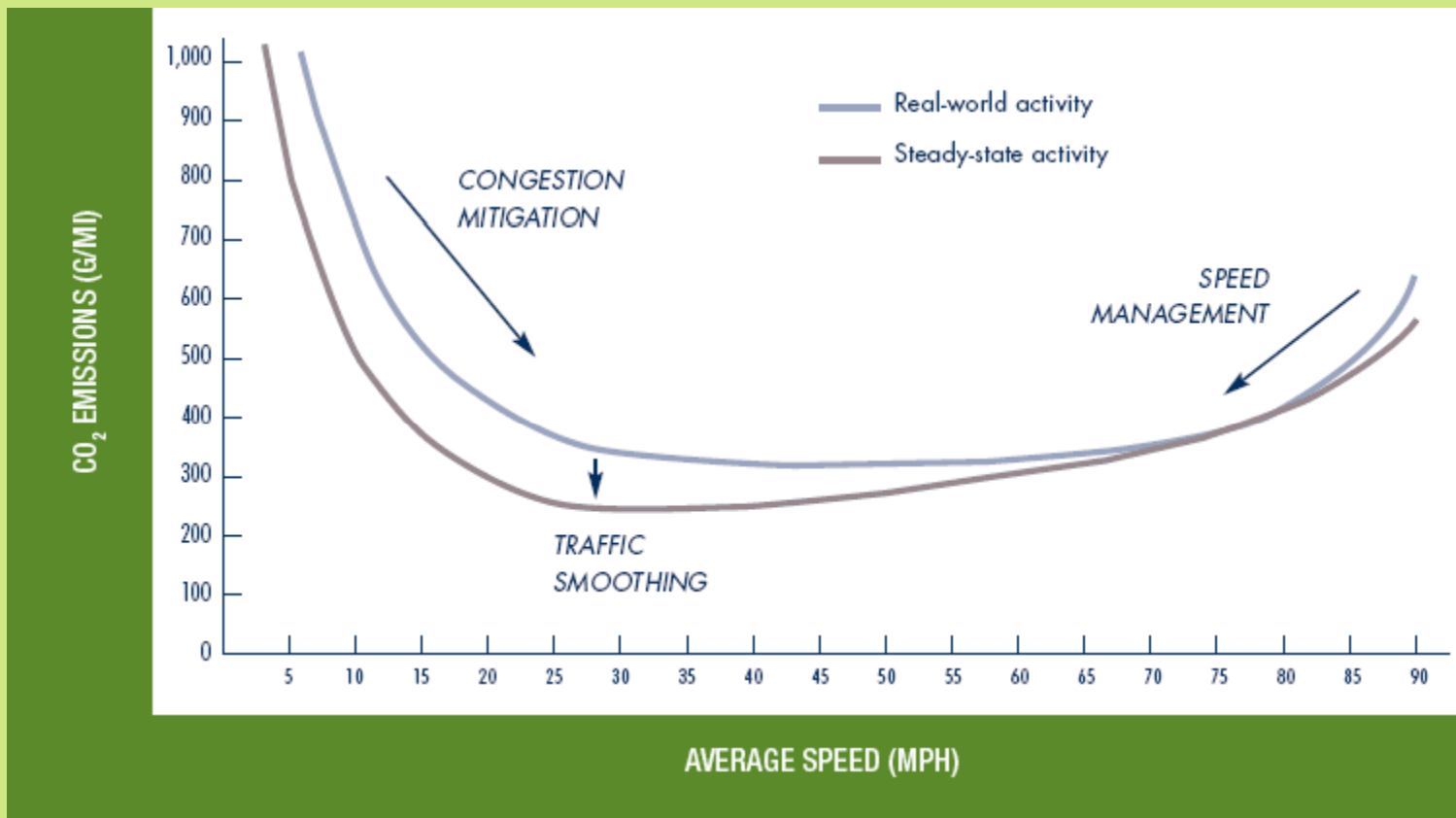


# Operations: Effect of Speed on GHG



Source: Matthew Barth and Kanok Boriboonsomsin, "Traffic Congestion and Greenhouse Gases," *Access* magazine, Fall 2009.

# Operations: Traffic Operation Strategies To Reduce CO<sub>2</sub>



Source: Matthew Barth and Kanok Boriboonsomsin, "Traffic Congestion and Greenhouse Gases," *Access* magazine, Fall 2009.

# Construction/Maintenance/Agency Operations: Strategies to Reduce GHG, Energy Use, and Costs

- LED traffic lights
- LED roadside lighting
- Low carbon pavement
- More durable pavements
- LEED buildings
- Reduced roadside mowing
- Vegetation management on ROW
- Solar panels/wind on ROW
- Alt fuels and hybrid vehicles in DOT fleets
- Alt fuel buses

# Solar Panels for Highway Lighting – Oregon DOT

- 594 solar panels produce 122,000 KWH/year to light interchange
- Avoids nearly 43 metric tons of GHG/year from normal electricity
- \$1.28 M project in operation for over a year
- PPP of OR DOT, PGE, and US Bank, using state and federal tax credits
- Could be a model for other DOTs
- ORDOT planning 2 additional projects
- [www.oregonsolarhighway.com](http://www.oregonsolarhighway.com)

## Washington State: West Coast Green (Electric) Highway

- WA DOT is using a PPP to provide “Quick Charge” stations for electric vehicles along I-5 corridor
- \$1.32 million seed funding from US DOT grant
- Target completion of EV stations: 10/31/11
- 9 stations along I-5 and SR-2, from OR border to Canadian border
- Coordination with Oregon DOT and, eventually, California
- Pooled fund study opportunity: Strategies and Best Practices to Support Commercialization of EV and Infrastructure

[www.westcoastgreenhighway.com](http://www.westcoastgreenhighway.com)

# FHWA- Carbon Sequestration Pilot Program

- Two pilots: MN and NM
- Assess how much carbon can be sequestered by native vegetation in the NHS right-of-way
- Determine feasibility of carbon credit sales by state DOTs and estimates of amount of revenue potential for state DOTs
- Final report available
  - Estimate of NHS ROW in each state
  - Highway carbon sequestration estimator
- [http://www.fhwa.dot.gov/hep/climate/carbon\\_sequestration/index.htm](http://www.fhwa.dot.gov/hep/climate/carbon_sequestration/index.htm)

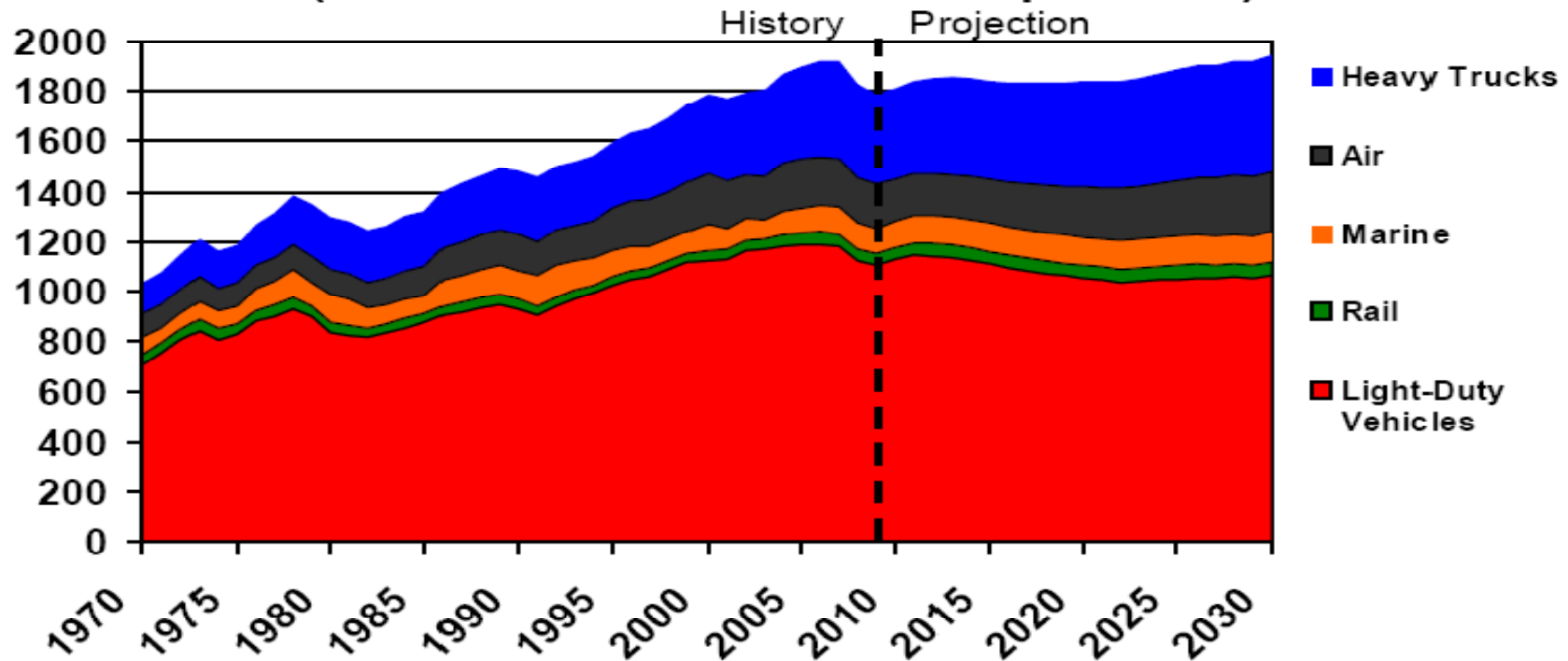
# Alternative Energy Resources for State DOTs

- Missouri DOT report, January 2011
- Surveyed other state DOTs
- Evaluated cost-effectiveness of various strategies
- MoDOT recommended pursuing alt energy sources:
  - Wastewater treatment (“baffled bio-reactors”)
  - LED roadway lighting (in addition to LED traffic signals)
  - Renewable solar/wind installations
  - HVAC efficiency measures
  - Interior building lighting (including fluorescents, reflectors, and LED lamps)
  - High performance window systems
  - Energy management system
  - Re-commissioning and continuous commissioning of buildings

Source: Alternative Energy Resources for the Missouri Department of Transportation, 2011

# Freight: Truck GHG is Growing Faster than Other Transportation GHG

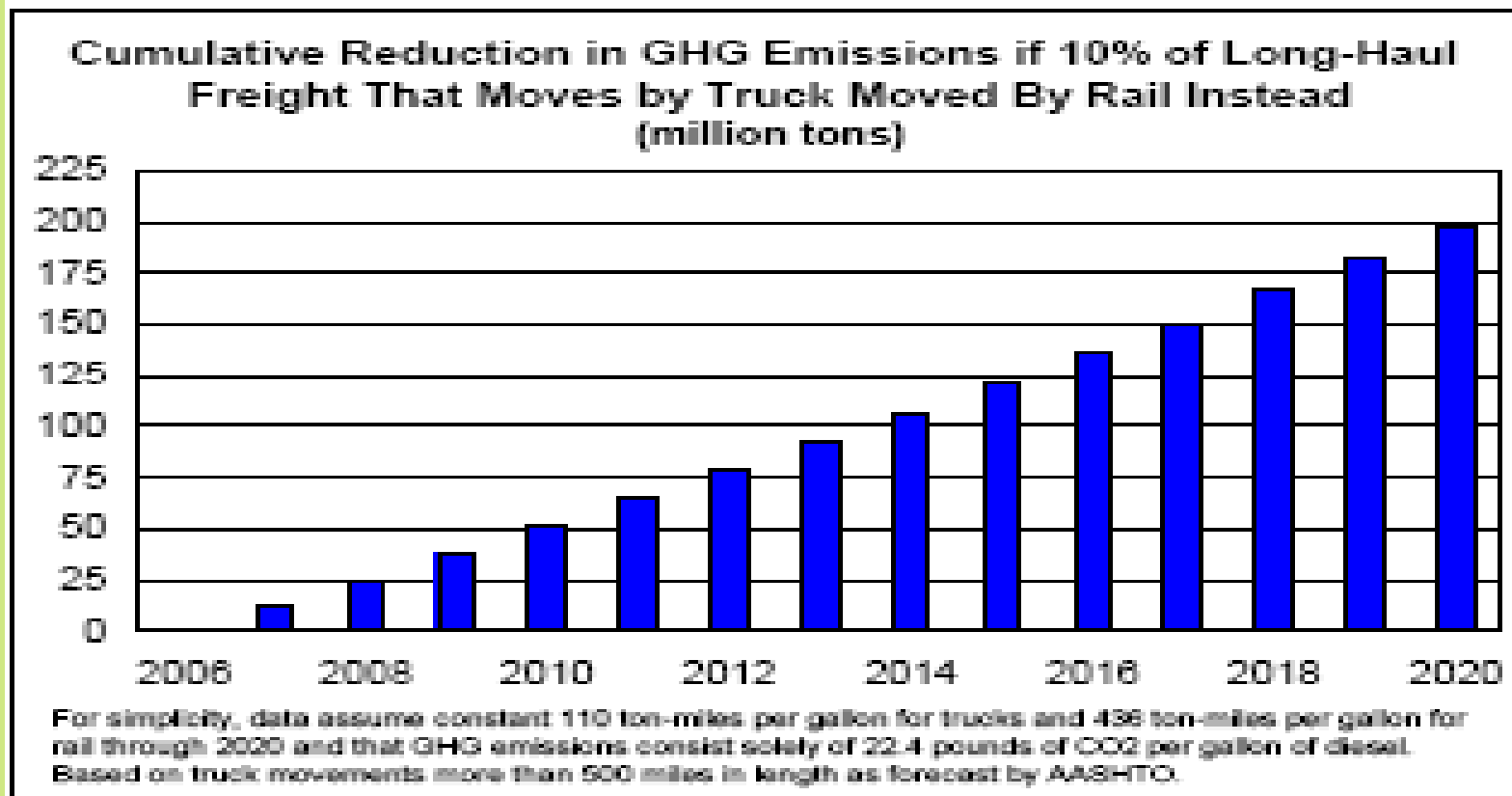
## GHG Emissions by Transportation Mode (Million Metric Tons CO2 Equivalent)



Source: History: *Transportation Energy Databook 28th Edition*  
Projection: *Annual Energy Outlook 2009 Updated Reference Case d041409a*

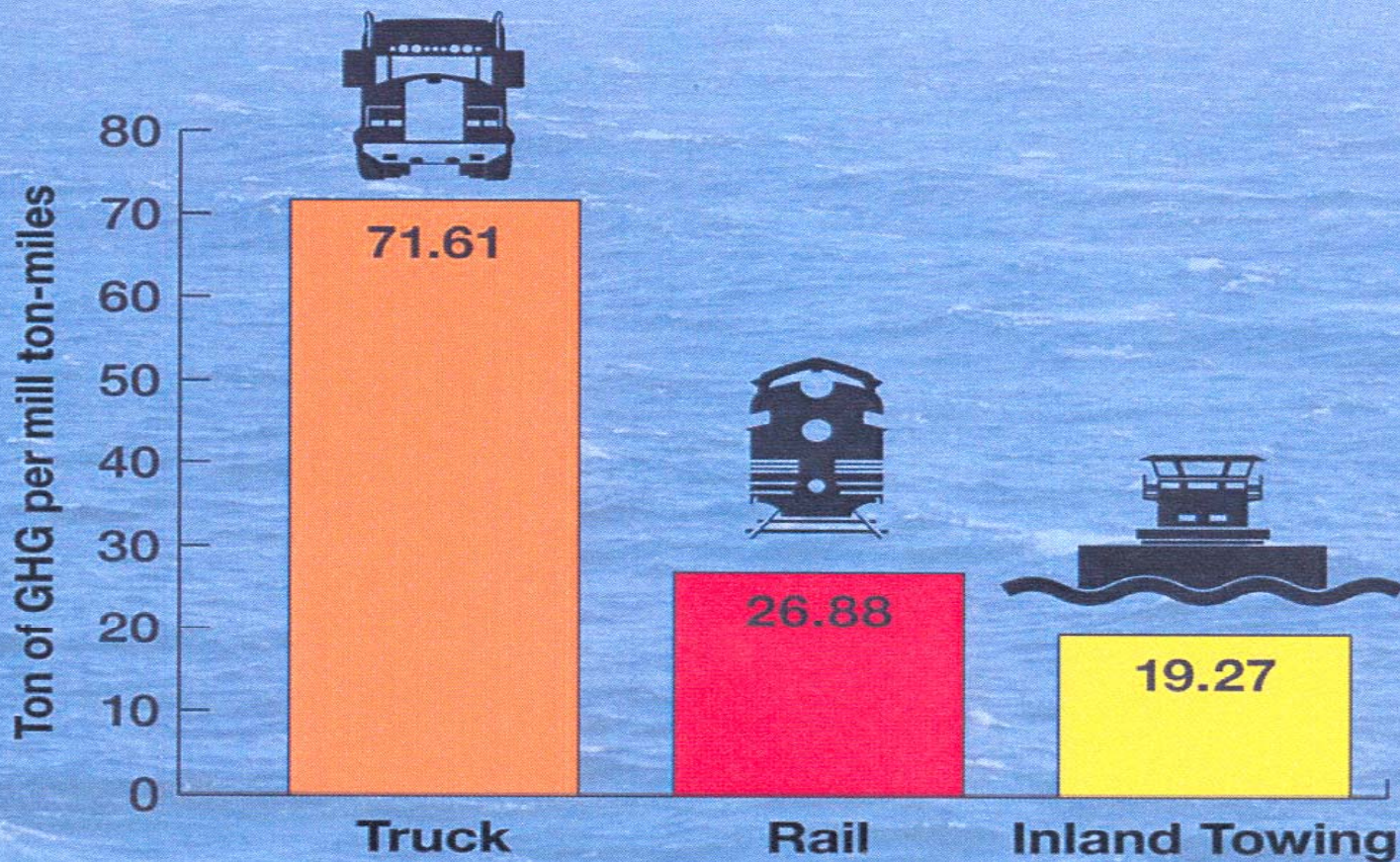


# Freight Rail Can Reduce GHG



# Freight: Modal GHG Comparisons

Source: Texas Transportation Institute and Center for Ports and Waterways



# Freight GHG Strategies in State Climate Action Plans

- Anti-idling programs
- Truck stop electrification
- Speed limit enforcement
- Freight villages/consolidation centers
- Feeder barge container service
- Bottleneck reduction
- Traffic flow improvements
- Pre-clearances at scale houses
- Truck driver training
- EPA SmartWay up-grade kits & loans & diesel retrofits
- Improvements to highway grade crossings
- Efficient Intermodal Facilities
- ECOdriving
- Incentives to retire older trucks
- Freight logistics improvements
- Shifting freight from truck to rail
- Hybrid power trucks
- Low-viscosity lubricants
- Single wide-base tires
- Automatic tire inflation systems
- Retrofits - PM and “Black carbon” reduction technologies  
85% reduction in PM

Detailed info available in NCHRP 20-24(59), Appendix C



# “Best Practices Guidebook for GHG Reductions in Freight Transportation”

- NC State University report to US DOT, 2007
- Covers trucks, freight rail, marine, air freight, pipeline
- Identifies 33 “best practices” for reducing truck GHG (plus 26 for other freight modes)
- All 33 could reduce truck GHG in 2025 by 12% below 2003 (compared to 67% increase in truck GHG if best practices are not implemented)

# Freight: GHG, Diesel and Black Carbon

- Black carbon is a major contributor to climate change, diesel engines a primary source of BC
- Black carbon particles absorb sunlight, generate heat in the atmosphere, warms the air
- Every gallon of diesel emits 22 pounds of CO<sub>2</sub>
- CO<sub>2</sub> has long atmospheric lifetime; black carbon remains in atmosphere only a few weeks
  - Reducing black carbon provides immediate reduction in the rate of warming along with public health benefits

# Freight: Diesel Retrofits Reduce PM and Black Carbon

- Diesel truck retrofits reduce PM 99% (= 2007 EPA standards) and also reduce black carbon
- Locomotive retrofits reduce PM and black carbon; achieve over 76% PM and 25% fuel efficiency
- Cost-effective way to reduce emissions and save energy immediately
- Retrofits of construction equipment, state fleets and locomotives could be promising as state DOTs work to reduce emissions to meet air quality requirements

# Strategy Comparisons

## Potential GHG reductions, cumulatively 2010-2050, compared to on-road baseline GHG

- 15,186 mmt – carbon pricing equiv to \$2.71/gallon
- 3,361 mmt – VMT fees equiv to \$2.53/gallon
- 2,428 mmt – speed limit reductions
- 2,233 mmt – PAYD auto insurance (100% coverage)
- 1,815 mmt – eco-driving by 20% of drivers
- 1,445 mmt – at least 90% of new urban development is compact, with high quality transit
- 1,241 mmt – congestion pricing fully implemented in 120 metro areas at 65 cents/mile
- 575 mmt – \$1.2 trillion transit expansion

MMT = million metric tons

Source: "Moving Cooler," 2009

# Strategy Bundling

**“Maximum” strategy bundle can reduce cumulative on-road GHG by 16% over 40 years, compared to on-road baseline:**

- Tolls imposed in 2010 at 5 cents/mile on national Interstate system
- Congestion pricing at 65 cents/mile in 120 metro areas
- \$400 permit fee to park on neighborhood streets
- \$1.2 trillion transit expansion
- Bike lanes every 1/4 mile
- New and increased parking fees
- 90% of new urban development is compact, in dense Census tracts, with high quality transit
- Heavier and longer trucks allowed (up to 139,000 lbs)
- Eight more freight strategies
- Eco-driving by 20% of drivers
- Speed limit reductions
- Top 200 bottlenecks improved to LOS

Source: “Moving Cooler,” 2009



# Federal Climate/Energy Legislation

- Federal cap-and-trade legislation: unlikely for foreseeable future (but state/regional cap-and-trade programs are proceeding – Northeast and California)
- EPA authority on GHG: Congress may limit it or roll back it back
- Federal energy legislation: could take many different forms (incentives for efficient vehicles, R&D, “clean energy” support, etc.)
- Political climate: volatile – uncertain outcomes
- GHG planning requirements: could be put in transportation authorization legislation – or energy bills

# Existing Law: Clean Air Act – EPA GHG Endangerment Finding

- EPA can regulate GHG under existing Clean Air Act (CAA)
- December 2009 EPA finding:
  - Atmospheric concentrations of GHG “**endanger**” public health and welfare (per CAA section 202(a))
  - Emissions of GHG from new motor vehicles “**contribute to**” air pollution which is endangering public health and welfare
- Based on this finding EPA is obligated to regulate GHG (e.g., GHG standards for autos)
- Based on this, GHG conformity is possible, but very unlikely
- Endangerment finding challenged in court by several states
- Congress may limit/roll back EPA authority over GHG

# Federal Legislation: Proposed Transportation Planning Provisions

**Several bills contain these provisions – which could be added to authorization legislation or energy bills:**

- **TARGETS AND STRATEGIES:** States and TMA MPOs must develop GHG reduction targets and strategies, as part of transportation plans
- **PROGRESS:** States and TMA MPOs must “demonstrate progress in stabilizing and reducing” GHG emissions
- **METHODOLOGIES:** EPA must issue regulations on transportation GHG goals, standardized models, methodologies, and data collection
- **CERTIFICATION:** US DOT shall not certify state or MPO plans that fail to “develop, submit or publish emission reduction targets and strategies”
- **PERFORMANCE REQUIREMENTS:** US DOT must establish requirements, including performance measures, “to ensure that transportation plans... sufficiently meet the requirements.., including achieving progress towards national transportation-related GHG emissions reduction goals.”

# How should climate change be considered in NEPA ?

- Under NEPA's broad scope, some EISs/EAs are already considering climate change
- Litigation history is building
- CEQ issued draft guidance on February 18, 2010
- Comments were due: May 24, 2010
- Proposal:
  1. Evaluate proposed actions that are reasonably expected to cause direct emissions of 25,000 metric tons or more of CO<sub>2</sub>-equivalent on an annual basis, and,
  2. Consider impact of climate change on the project (e.g., effect of rising sea level on coastal bridges)
- FHWA and AASHTO each provided extensive comments

# CEQ Proposal: Consider GHG on a Project Level

1. Cumulative emissions over life of project\*
2. Construction-related emissions
3. Emissions from vehicles using the highway
4. Up-stream emissions from fueling cycle (drilling, refining, shipping, etc.) and vehicle cycle?
5. Emissions effects of land use changes?
6. Emissions from roadway maintenance, lighting, etc.?
7. Others?

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\* 25,000 tons GHG/year is a reference point, above which to do project GHG analysis – but this is not a “bright line test”

# CEQ Proposal: Roadway GHG Emissions

25,000 metric tons/year = 43,000,000 VMT/year or about 120,000 VMT/day\*

- Therefore, action that would increase VMT by 120,000/day (NEW VMT) could trigger analysis, with all else being equal (e.g. speeds, congestion, fleet mix, etc.)
- This conversion is based on current average MPG; in future, higher MPG vehicles would allow a higher VMT before reaching 25,000 metric tons/year

# CEQ: Also Consider Climate Impacts on Project

- Will the project be impacted by climate change? (rising sea level, more severe precipitation, etc.)
- CEQ said:
  - Discuss **climate change effects that should be considered in project development** such as flooding in low lying areas, development of coastal infrastructure
  - Also discuss **reasonably foreseeable future conditions** with no action



# AASHTO Comments on CEQ Draft

- Planning process is the appropriate venue for developing and implementing GHG reduction strategies -- not project level
- Project-level analysis not meaningful
  - Inadequate tools
  - Disconnect between global emissions vs project-level analysis
  - Basis for 25,000 metric ton threshold?
- Major emphasis on adaptation needed in transportation policy



# Recent History –Court Rulings on NEPA/GHG

3 cases overturned FONSI/EA/EIS for lack of climate analysis:

- Center for Biological Diversity et al. v. NHTSA
- Mid States Coalition for Progress v. Surface Transportation Board
- Border Power Plan Working Group v. DOE

4 cases upheld lack of climate analysis or sufficiency of analysis:

- Audubon v. DOT, 2007
- Friends of the Earth v. Mosbacher, 2007
- Association of Public Agency Customers, Inc. v. Bonneville Power Admin, 1997
- Mayo Foundation v. Surface Transportation Board, 2006

# AASHTO Position on Climate Change/Energy

- Accelerate energy technology innovation to increase energy efficiency and decrease the carbon intensity of the energy supply
- Increase vehicle fuel economy and advance biofuels by:
  - Support federal R&D to de-carbonize vehicles/fuels
  - Continue to strengthen fuel economy standards
  - Promoting and providing funding for clean vehicle and fuel programs
- Reduce VMT growth to 1% per year
- Double transit ridership by 2030
- Increase intercity passenger rail

See AASHTO “Real Transportation Solutions” at <http://www.climatechange.transportation.org/>

# FHWA Climate Change Activities

## Current activities:

- Research (Gulf Coast study, VMT, GHG mitigation strategies, GHG estimation tools, adaptation pilots)
- Education (webinars, workshops, Clearinghouse, Q&As, peer-to-peer exchanges)
- Outreach/collaboration (NOAA, USGS, CEQ, EPA, DOE, FTA, HUD, Pew Center on Climate Change, AASHTO, AMPO, etc.)
- Technical assistance (GHG modeling, adaptation, NEPA documentation)
- Input for CEQ guidance on NEPA/climate change
- Linkages with sustainability, CSS, planning, including FHWA's new sustainable highways self-evaluation tool

## Future activities:

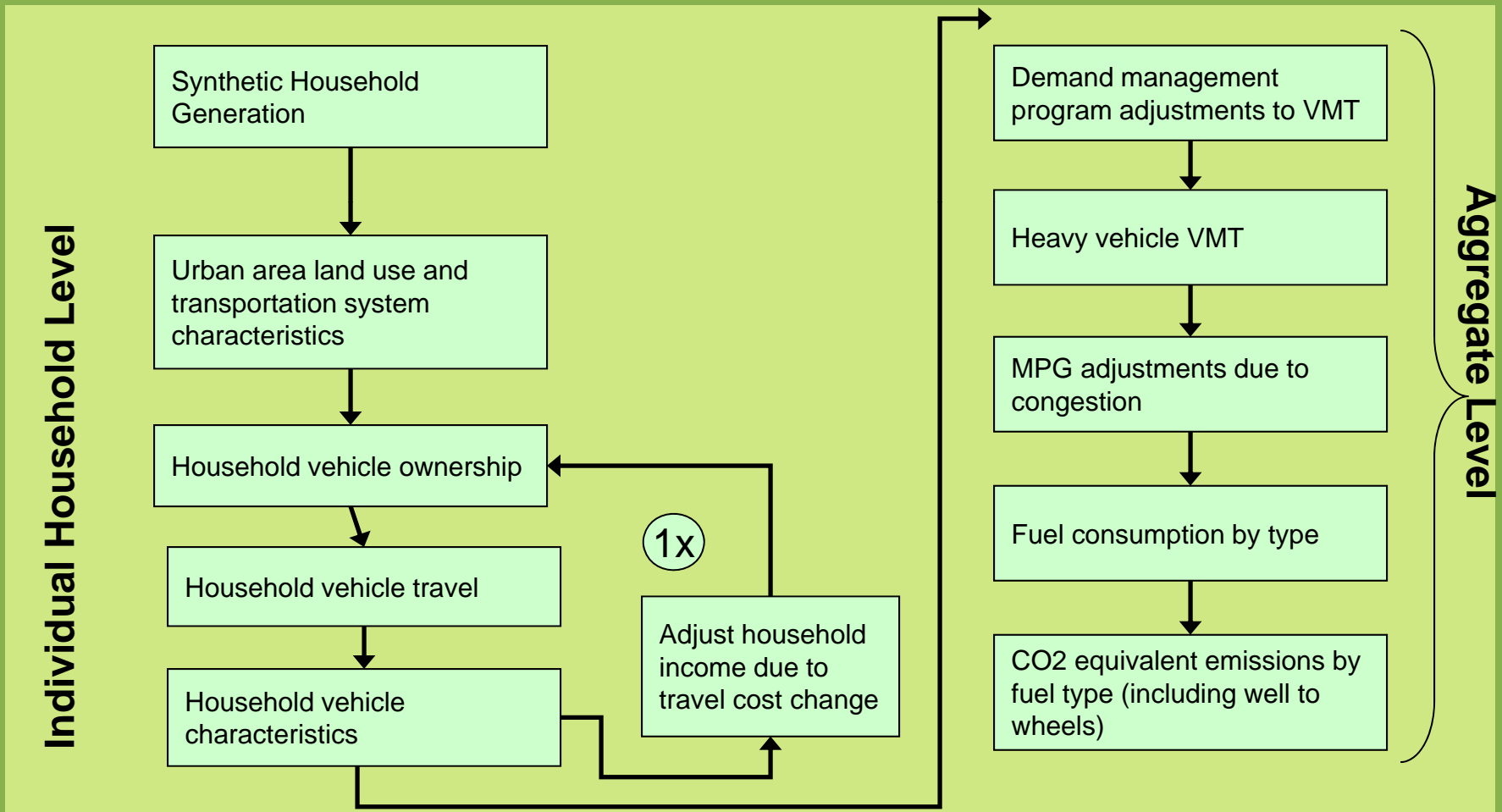
- Reauthorization proposal re climate change
- Guidance for considering adaptation in NEPA documents
- Working with EPA and others on data/modeling issues

# FHWA Is Developing Tools for GHG Estimation

- Forecasting tools needed to estimate GHG impacts of strategies
- Most statewide and regional travel models not sensitive to GHG/TSM/TDM strategies
- Travel models need to link with GHG emission models
- FHWA is sponsoring carbon calculator and mitigation strategies guidebook
  - Enhancing GreenSTEP model for this project
  - Developing users manual

# GreenSTEP Model

(developed by Oregon DOT, enhanced by FHWA)



# GreenSTEP

## Inputs

- Demographic changes
- Urban/rural development share
- Metropolitan/other densities
- Urban form
- Transit service
- Highway capacity
- Vehicle fuel efficiency and ages
- Electric vehicles
- Pricing (fuel, carbon, VMT)
- Demand management
- Congestion effects on MPG
- Carbon content of fuels
- CO2 production from electrical power use for transportation



## Outputs

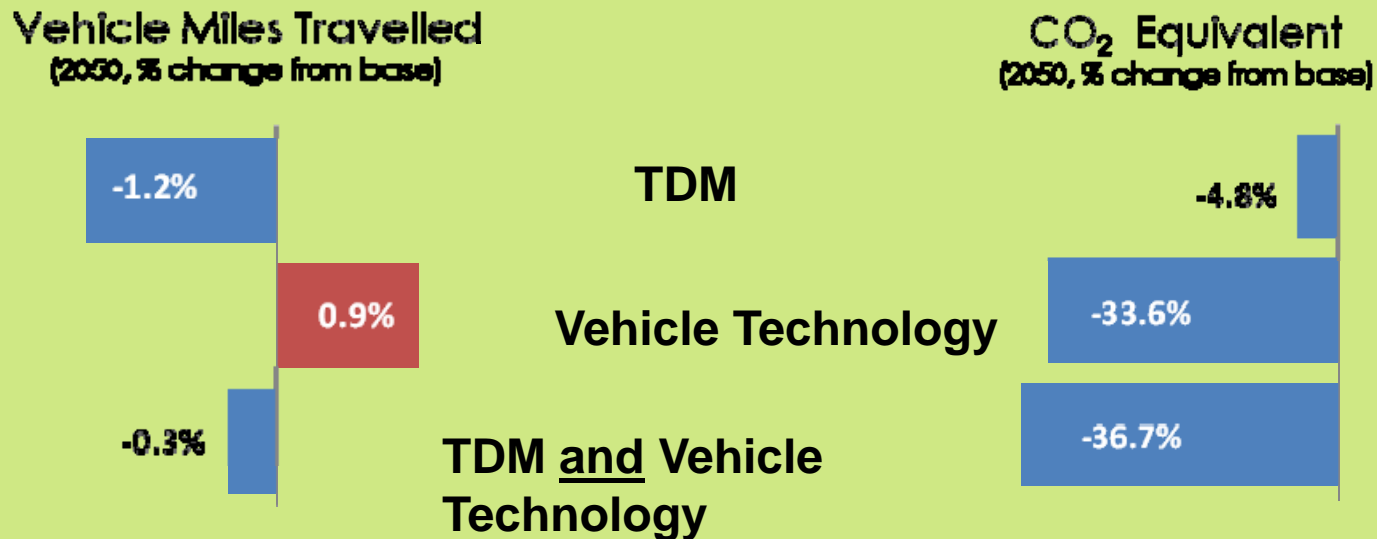
- VMT
- Fuel use
- Electricity use
- CO2 equivalent emissions

# Example: Using GreenSTEP to Analyze GHG Policy Options

Used GreenSTEP to analyze:

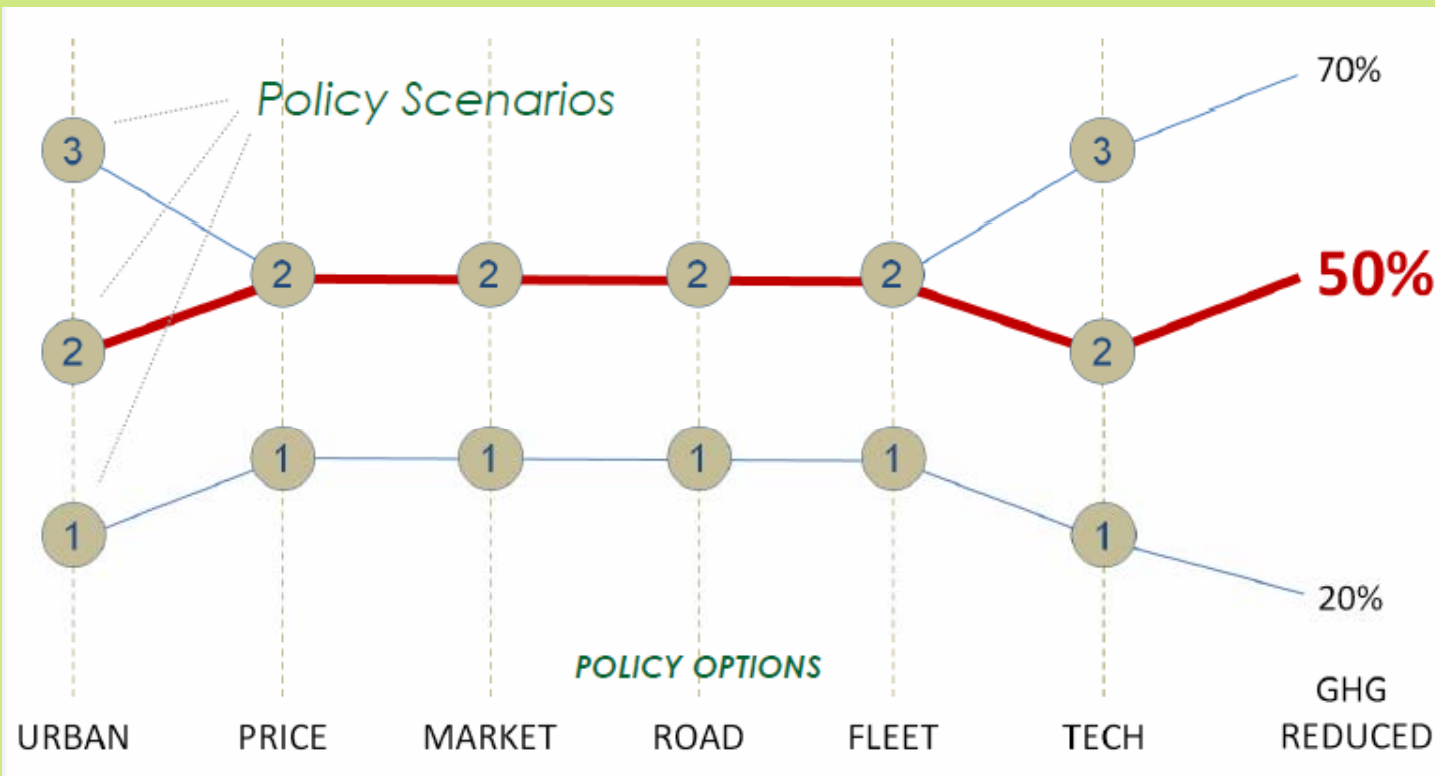
- Travel Demand Management
- Vehicle Technology: increased vehicle MPG and more EVs
- TDM and Vehicle Technology

Results:



# Vermont Climate Action Plan

38 strategies that achieve the goal



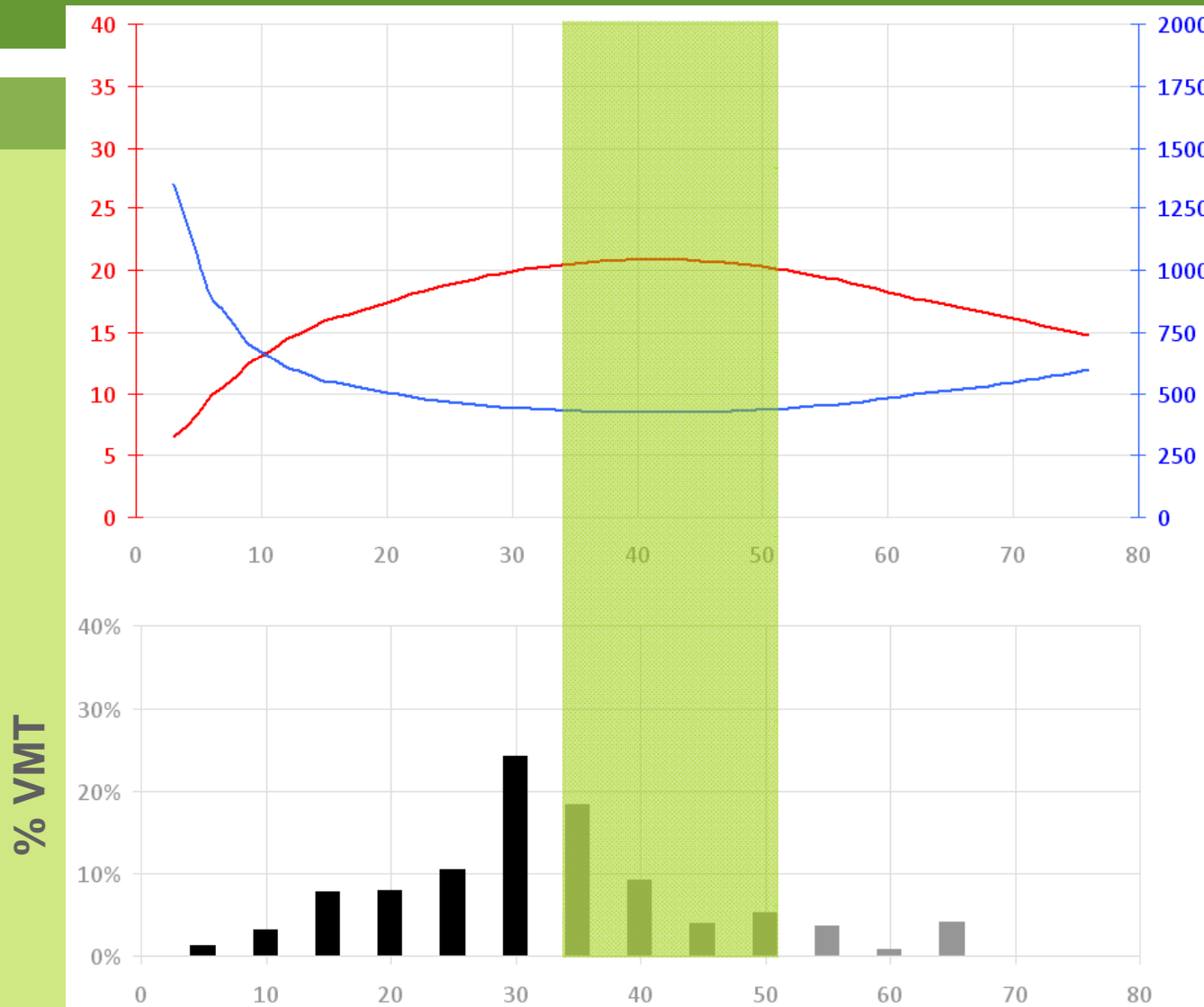
*The tool allows the user to package several policies together for complex scenario comparisons.*



# Chittenden County GHG Analysis

MPG

GHG



## V. Next Steps for VTRANS and VTRANS Partner Agencies



# RESOURCES



Parsons Brinckerhoff / Sarah J. Siwek & Associates, Inc. | Climate Change

# Resources

- AASHTO: <http://climatechange.transportation.org/>
- Intergovernmental Panel on Climate Change (IPCC):  
<http://www.ipcc.ch/>
- US DOT Transportation and Climate Change Clearinghouse:  
<http://climate.dot.gov/index.html>
- FHWA Climate Change Program  
<http://www.fhwa.dot.gov/hep/climate/index.htm>
- The Pew Center on Global Climate Change:  
<http://www.pewclimate.org/>
- EPA Climate Change Program  
<http://www.epa.gov/climatechange/>
- TRB Climate Change Activities  
<http://www.trb.org/main/SpecialtyPageClimateChange.aspx>

## Resources – Key Documents

- AASHTO, “Primer on Transportation and Climate Change,” 2008
- NCHRP 20-24 (59), “Strategies for Reducing the Impacts of Surface Transportation on Global Climate Change,” 2009
- European Council of Ministers of Transport, “Review of CO2 Abatement Policies for the Transport Sector,” 2006
- U.S. DOE, “Annual Energy Outlook,” 2009 (primary source of official U.S. data on energy and GHG)
- TRB Special Report 290: “Potential Impacts of Climate Change on U.S. Transportation,” 2008
- Pew Center on Climate Change, “Climate Change 101” and “Reducing GHG Emissions from U.S. Transportation

## Resources – AASHTO

- **AASHTO Climate Change Steering Committee:** CCSC acts as a focal point and coordinating body for AASHTO's activities related to climate change. CCSC members act as the focal point for AASHTO on climate change policy issues and provide oversight and guidance to AASHTO's Climate Change Technical Assistance Program.
- **AASHTO Technical Assistance Program on Climate Change:** This is a new, voluntary program that provides timely information, tools and technical assistance to assist AASHTO members in meeting the difficult challenges that arise related to climate change.

For more information on AASHTO's Climate Change Steering Committee and Climate Change Technical Assistance Program, please contact:

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