

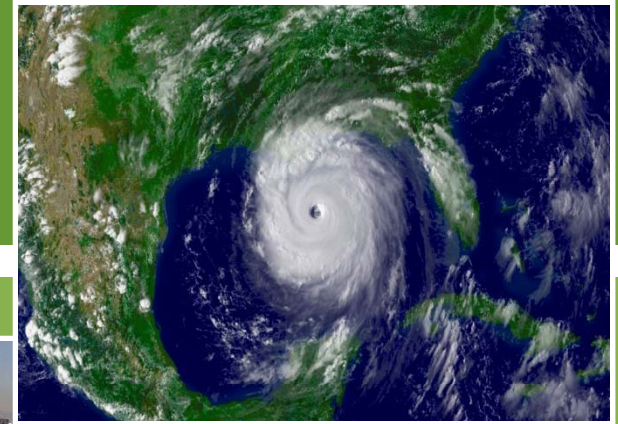
Climate Change

Information, Challenges, and Strategies for
West Virginia DOT

April 21, 2010

Workshop Purpose

- What is climate change?
- How will it affect state DOTs?
- How can state DOTs adapt to climate change?
- What is the current state of federal legislation?
- How can state DOTs influence national and state policy on climate change?
- How can state DOTs reduce transportation GHG?



Workshop Overview

- I. Climate Change Science, Sources, and Trends
- II. The Importance of Climate Change to State DOTs
- III. Climate Adaptation
- IV. Planning and NEPA Issues
- V. Strategies to Reduce GHG Emissions from Transportation Sources
- VI. Participant Workshop: Developing an Action Plan Framework

I. Climate Change – Science, Sources and Trends



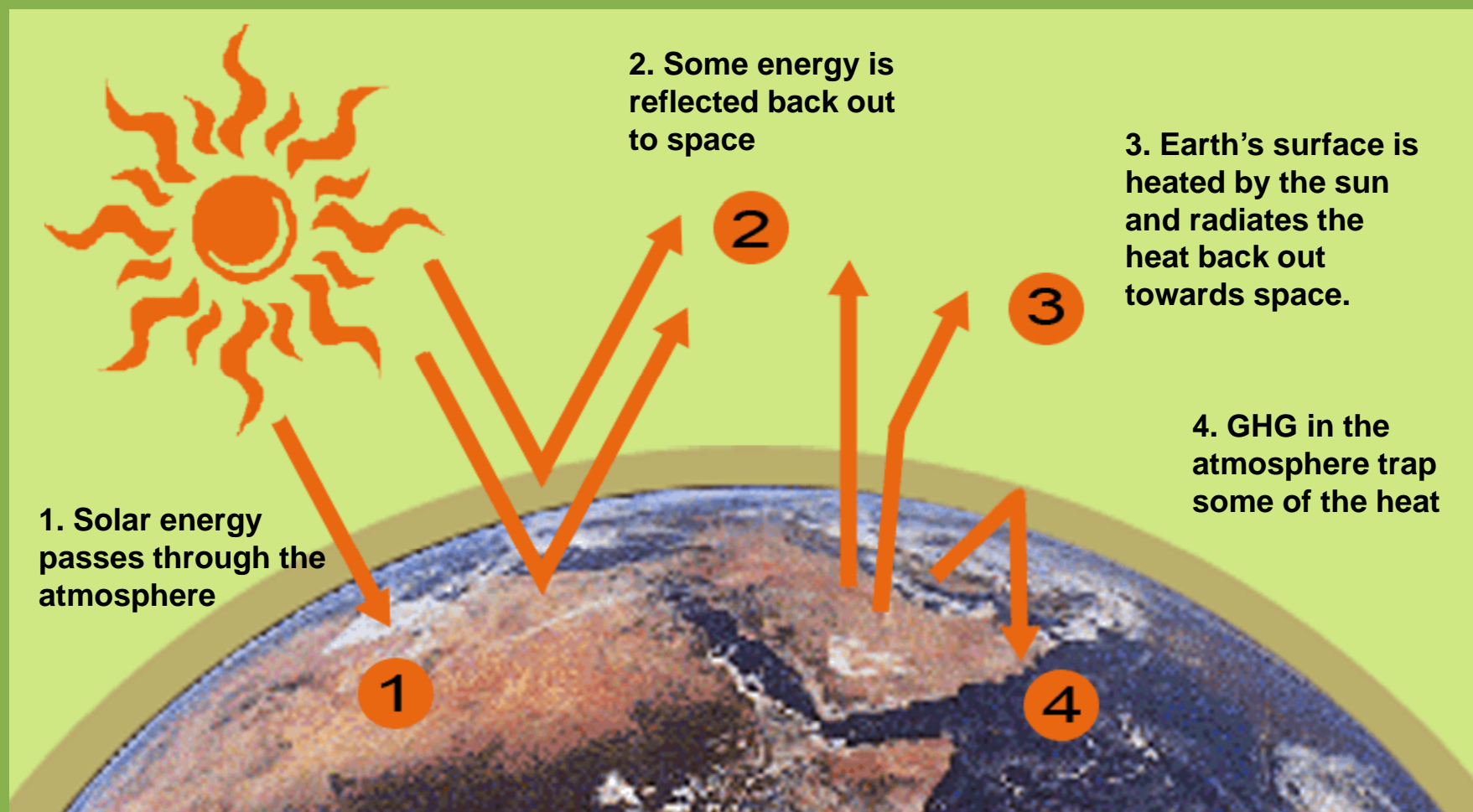
What is climate change?

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

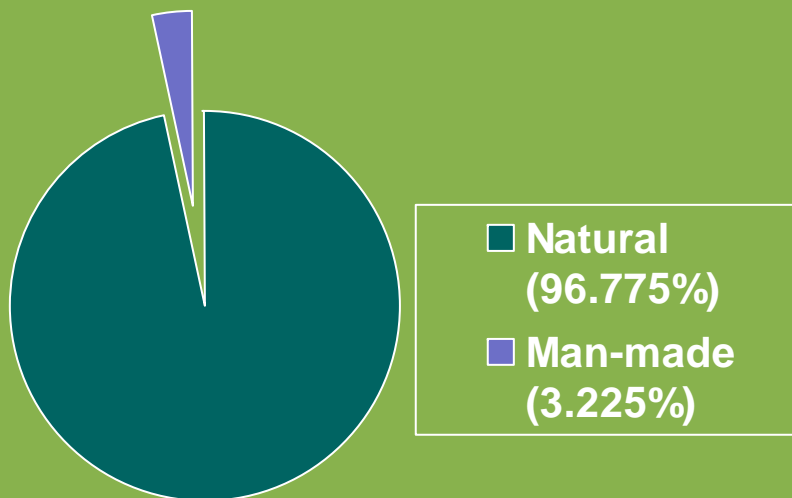
“A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.”



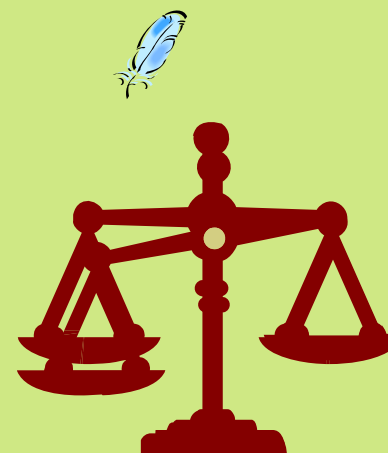
What is the “Greenhouse Effect”?



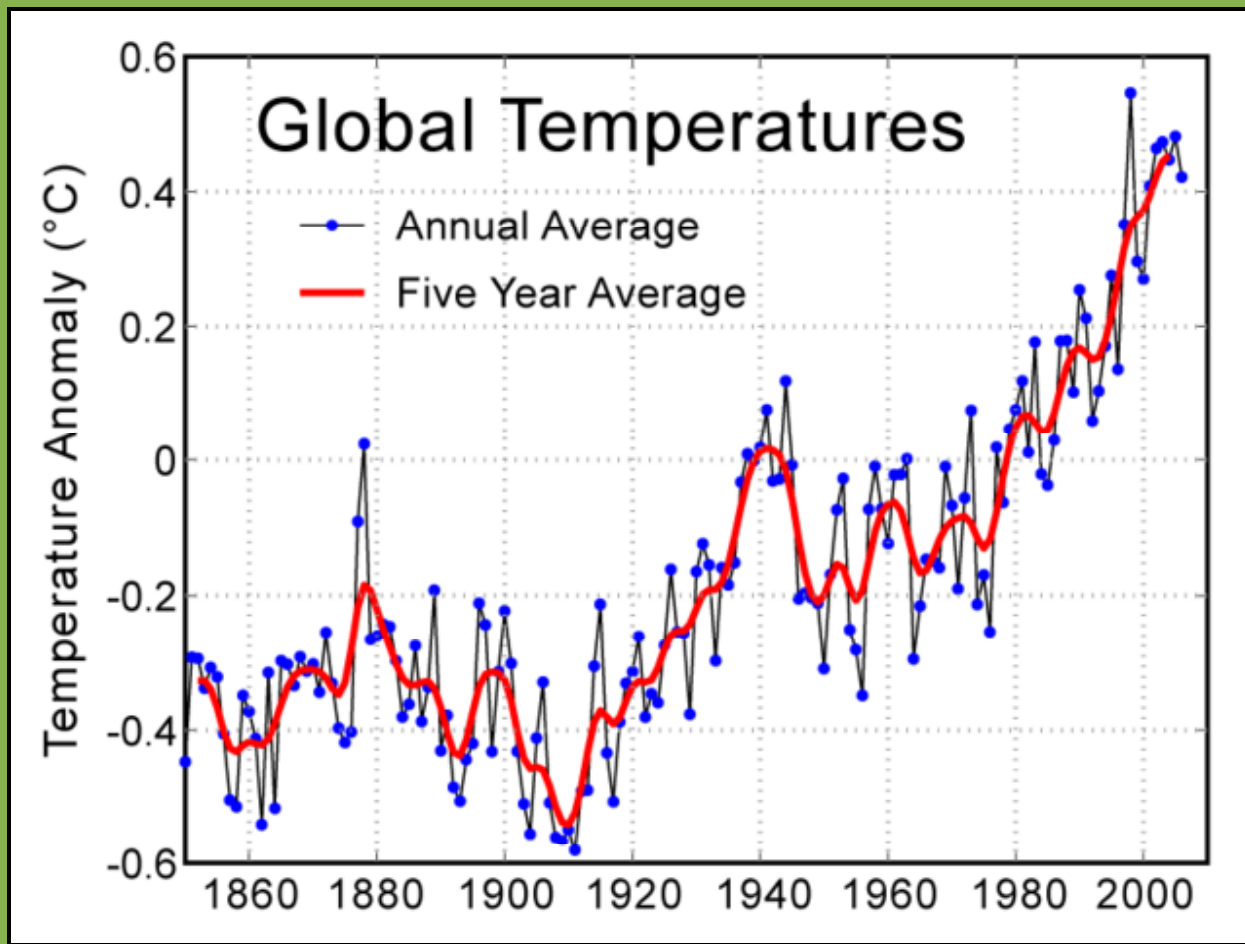
How significant is man-made CO₂?



- *...but it only takes small amounts to throw our ecosystem out of balance.*



What is the evidence on temperatures?

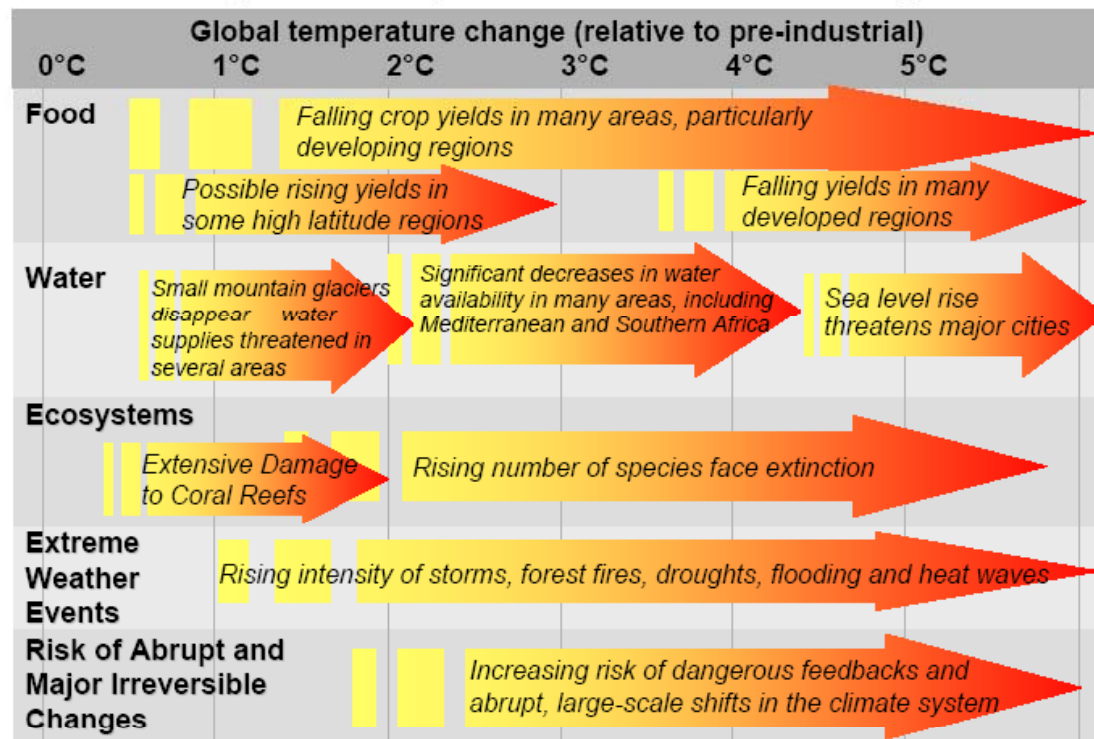


Source:

http://www.globalwarmingart.com/wiki/Image:Instrumental_Temperature_Record.png

What are the impacts at different temperature increases?

Projected impacts of climate change



Source:
Stern Review,
2008

What are the scientific findings?

Climate Change 2007: The Physical Science Basis

- Developed by the Intergovernmental Panel on Climate Change (IPCC)
- Contributions from 2,000 scientists assessing the Earth's environment and the effects of global warming

...a summary for policy makers...

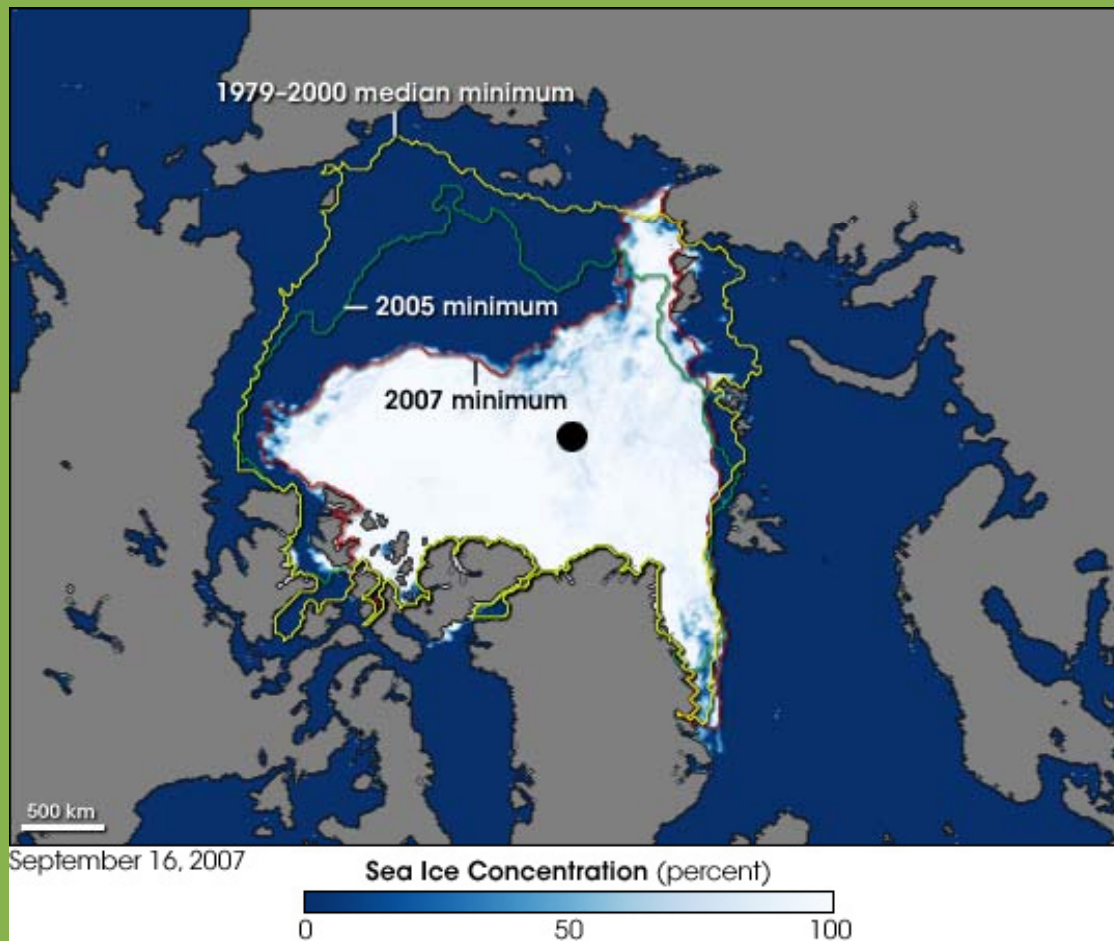
There is 90% certainty that humans are the cause of global warming.



Notable findings in the report:

- Atmospheric CO₂ levels are at their highest levels in 650,000 years.
- Avg global temperatures have risen ~1.3°F since the industrial age began.
- Sea level rose ~4.8 – 8.8“ worldwide during the 20th century, at a rate more than double that of the past decade

What is the physical evidence?



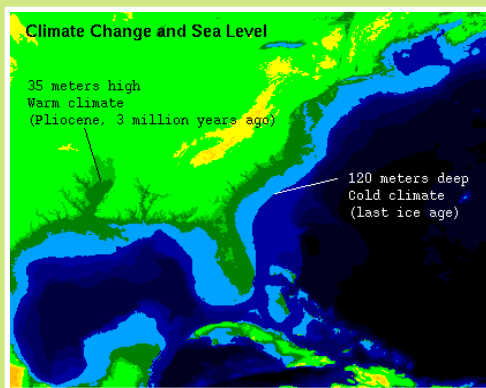
Arctic sea ice is retreating –

a measurable change in climate that can be seen

Source:
NASA

How will climate change affect the planet?

- Rising sea levels
- Extreme weather
- Higher temperatures
- Threats to human health
- Changes in crop yields
- Precarious ecosystems



How certain are the scientists?

- “Warming of the climate system is unequivocal...”

-- Intergovernmental Panel on Climate Change

- “An overwhelming body of scientific evidence paints a clear picture: climate change is happening, it is caused in large part by human activity, and it will have many serious and potentially damaging effects in the decades ahead.”

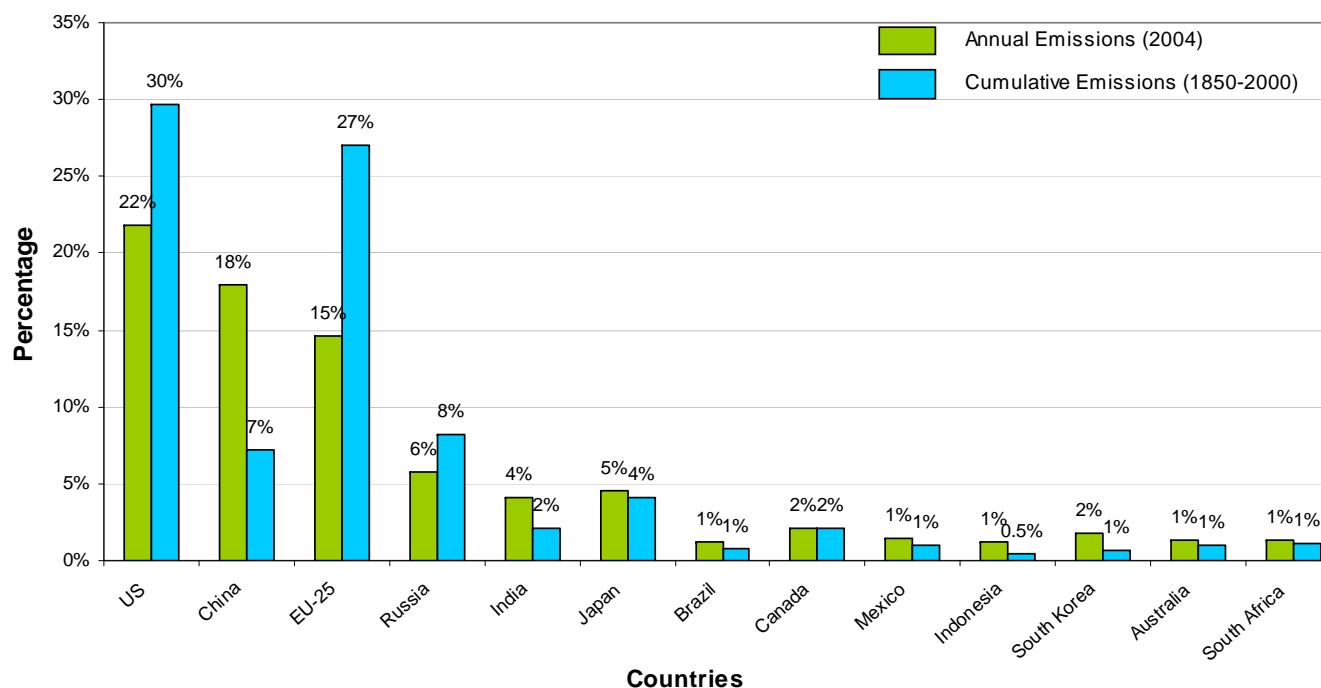
-- Pew Center on Climate Change

What are the latest news stories?

- “Climate Change Accelerating, Top Scientists Warn”
- “Globe Warming Faster than Forecast”
- “Urgent Action Needed”
- “ARCTIC: A feedback loop threatens the Earth’s air conditioner”
- “Climate Models Understate the Reality”
- “OCEANS: Pollock fishery, nation’s largest, faces a crisis”
- “SCIENCE: Prior Warnings of Sea Level Rise May be Understated”
- “Over 2 Trillion Tons of Ice Melted in Arctic Since ’03”
- “Climate Change Seen As Threat to U.S. Security”

Where do all those GHG come from?

Comparison: Annual* & Cumulative** CO₂ Emissions



Source: * Annual Emissions for the year 2004 from IEA (2006) CO₂ Emissions from Fossil Fuel Combustion

** Cumulative Emissions from 1850-2000, CAIT WRI

How much GHG reduction is needed?

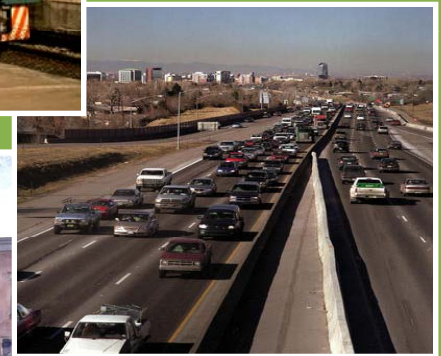
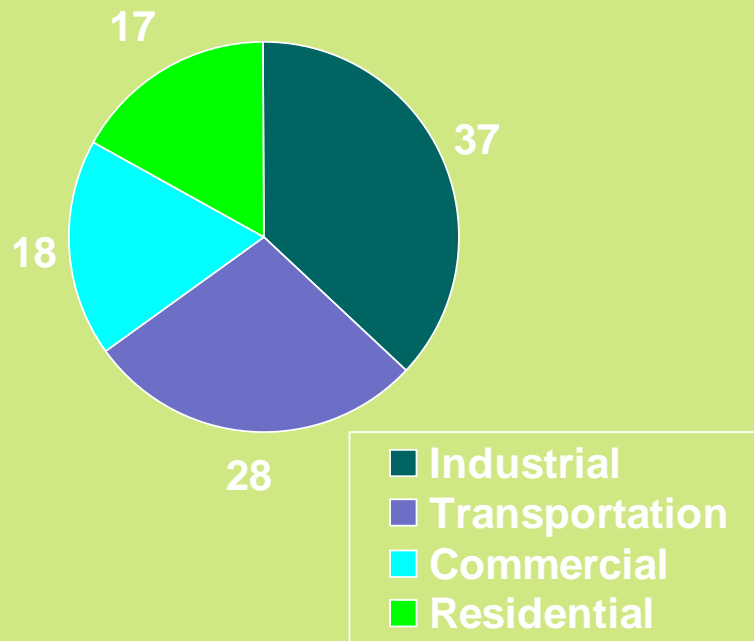
- We are past the point of halting climate change – the climate is already changing and temperatures will continue to rise, even if we make drastic GHG reductions.
- To avoid the most severe impacts of climate change, we need substantial reductions (60-80% below 1990 GHG by 2050).
- GHGs are cumulative, with a long half life (100 years).
- The longer we wait to make reductions, the deeper future cuts will have to be.

What targets have been set?

- Scientists recommend **60-80% GHG reduction below 1990 level by 2050**
- Many states and countries have adopted targets in this range
- President Obama's budget: **80%** GHG reduction below 2005 by 2050
- Waxman-Markey bill: **17%** below 2005 by 2020 and **83%** below 2005 by 2050

What are the sources of GHG emissions?

Transportation = 28%
of U.S. GHG



How much will transportation GHG increase?

- **United States**: GHG from all transportation modes are projected to remain almost constant through 2030 – but light duty vehicle GHGs will actually decline slightly.
- **World**: GHG emissions from transportation are expected to rise sharply; soon GHG emissions from transportation in the developing world will greatly exceed those of the U.S.

How fast will other countries motorize?

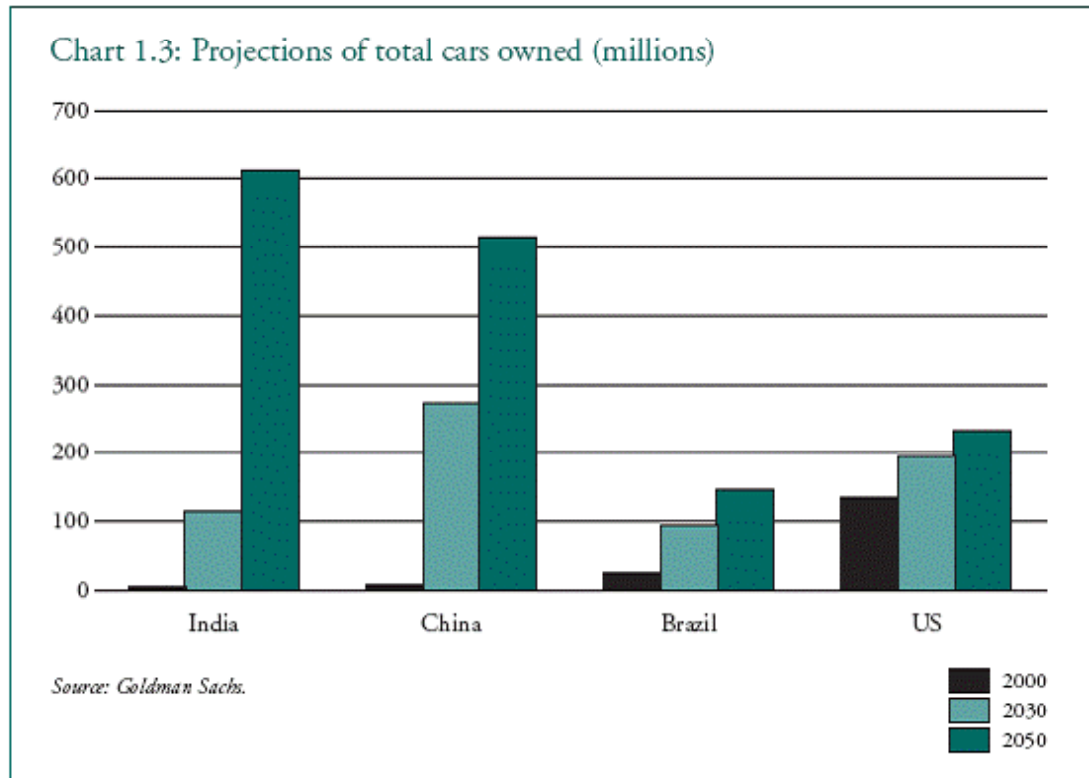
Hanoi, Vietnam



Beijing, China



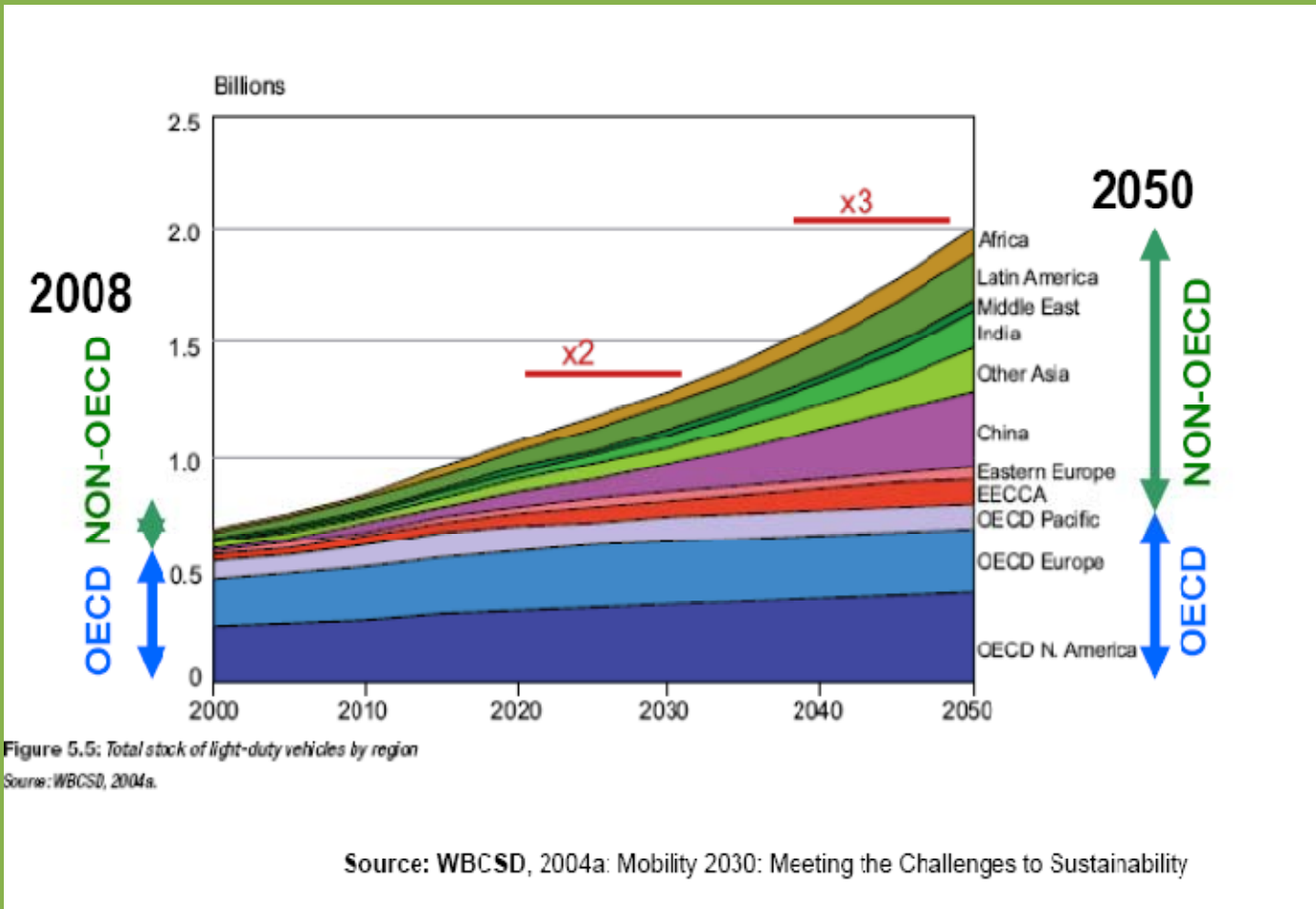
What are the global trends in vehicle ownership and use?



- 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.

What are the global trends in vehicle ownership and use?



Why is vehicle “decarbonization” necessary?

“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

Summary

- Climate change is real
- Substantial efforts are needed to stabilize and reduce GHG emissions
- It is a global and cumulative problem
- As underdeveloped countries develop, levels of GHG emissions increase
- Delay will magnify the challenges of GHG emission reduction

II. The Importance of Climate Change to State DOTs



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

- 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

A Five-Part Challenge to State DOTs

1. Reduce transportation GHG, especially highway GHG, 60-80% by 2050
2. Prepare for Federal climate change legislation
3. Help shape sound state climate policies
4. Find a new revenue stream suitable for low-carbon fuels
5. Adapt transportation infrastructure to rising sea levels, more severe storms, higher temperatures, and flooding

Wal-Mart Perspective

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

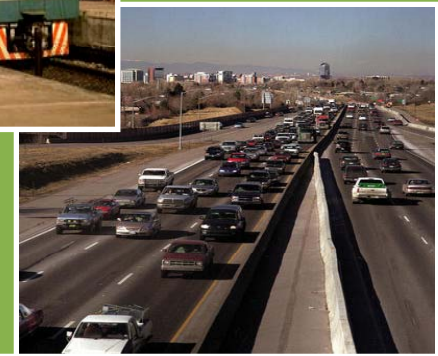
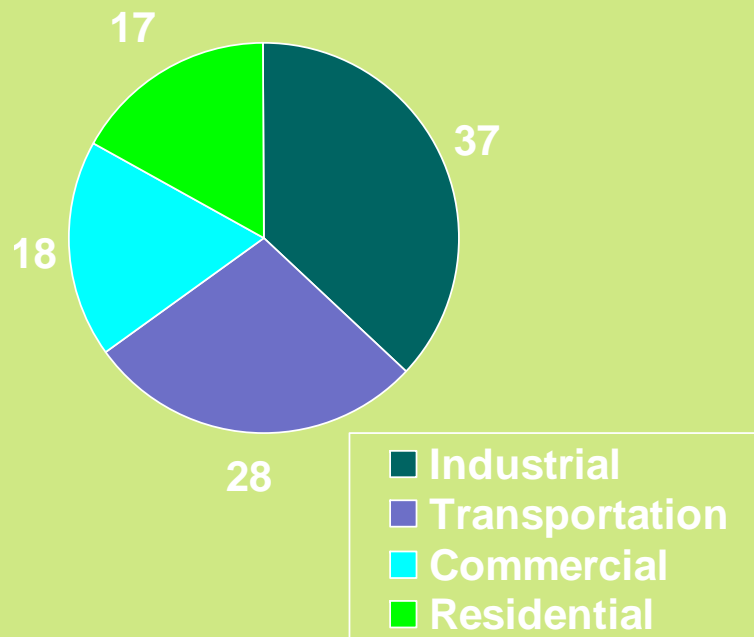
Wal-Mart will cut 20 MMT of GHG from its supply chain by the end of 2015 — equivalent to removing >3.8 million cars from the road for a year.

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

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

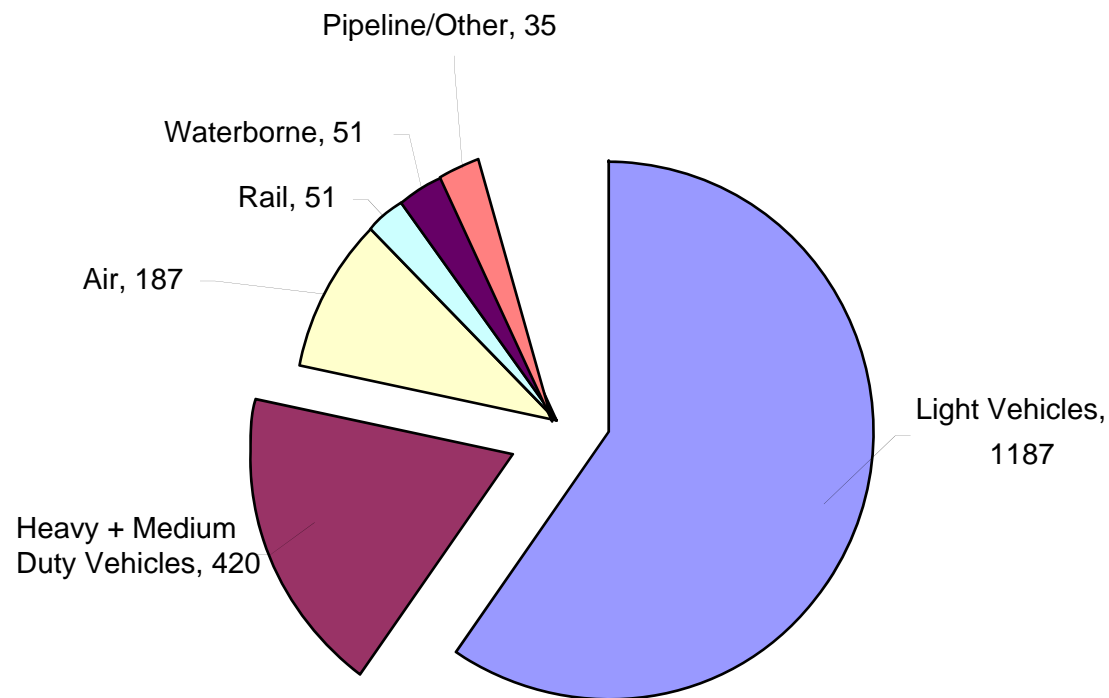
Transportation is a major source of GHG

Transportation = 28%
of U.S. GHG



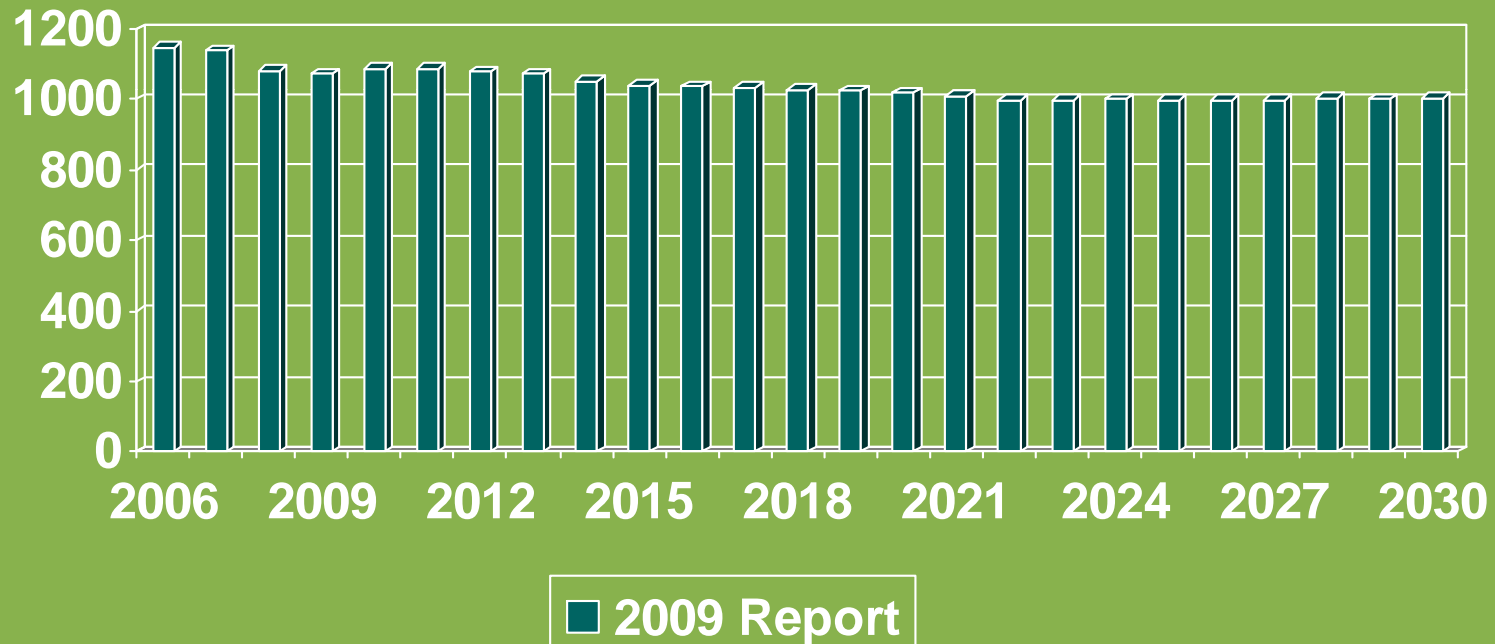
Highway Vehicles Account for 85% of Transportation CO2 Emissions – and 24% of all U.S. CO2 Emissions

**U. S. Transportation CO2 Emissions by Mode, 2007
(Million metric tons CO2)**



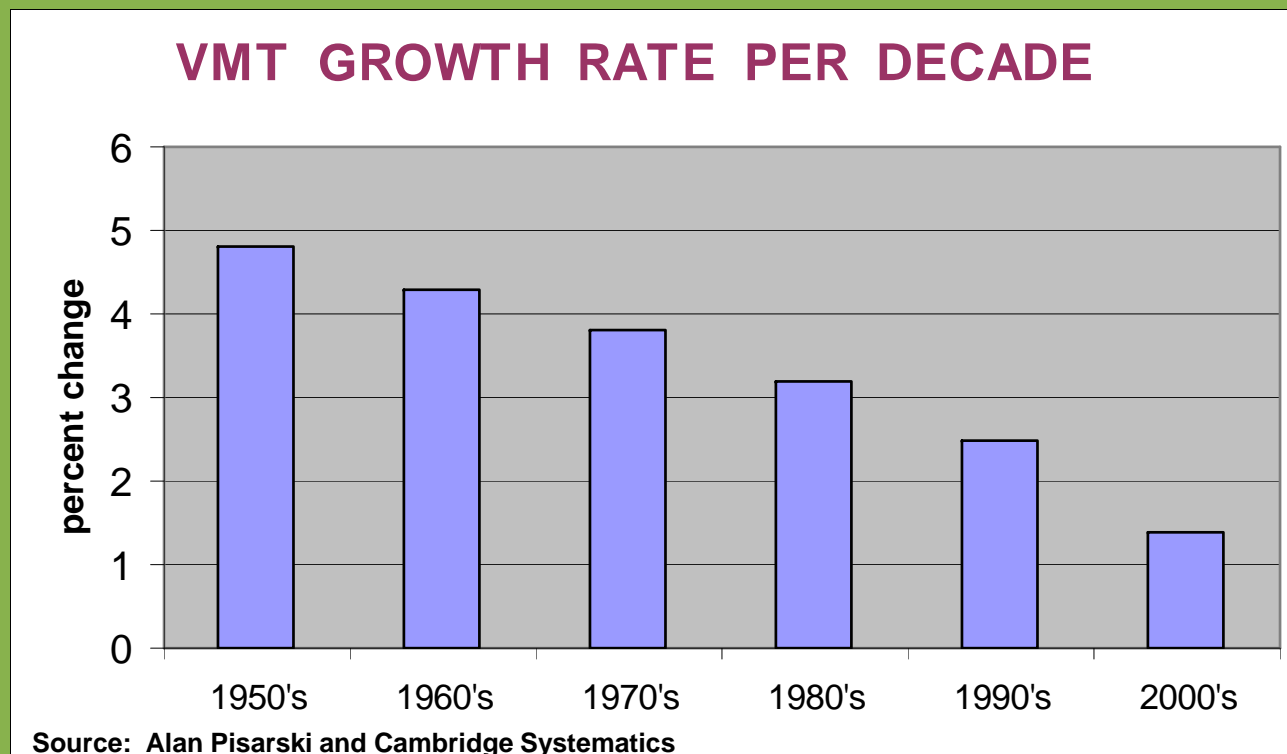
DOE Projects Slight Decline in LDV GHG Emissions

GHG Emissions from Light-Duty Vehicles
(USDOE, Annual Energy Outlook 2009)



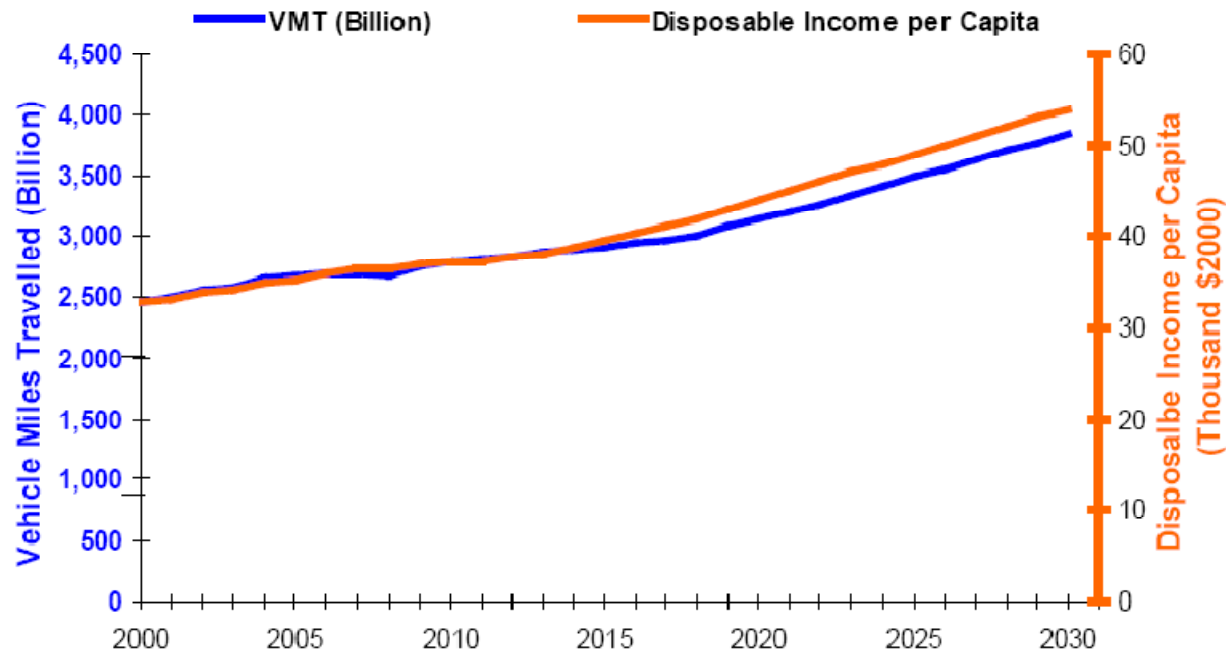
U.S. VMT growth rates are declining– but will zero or negative VMT growth be expected?

- 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
- VMT is affected by population, economy, transportation prices, demographics, land use
- AASHTO supports reducing VMT growth rate to 1% per year



VMT closely linked to disposable income

Light Duty Vehicle Miles Travelled (1 of 3)

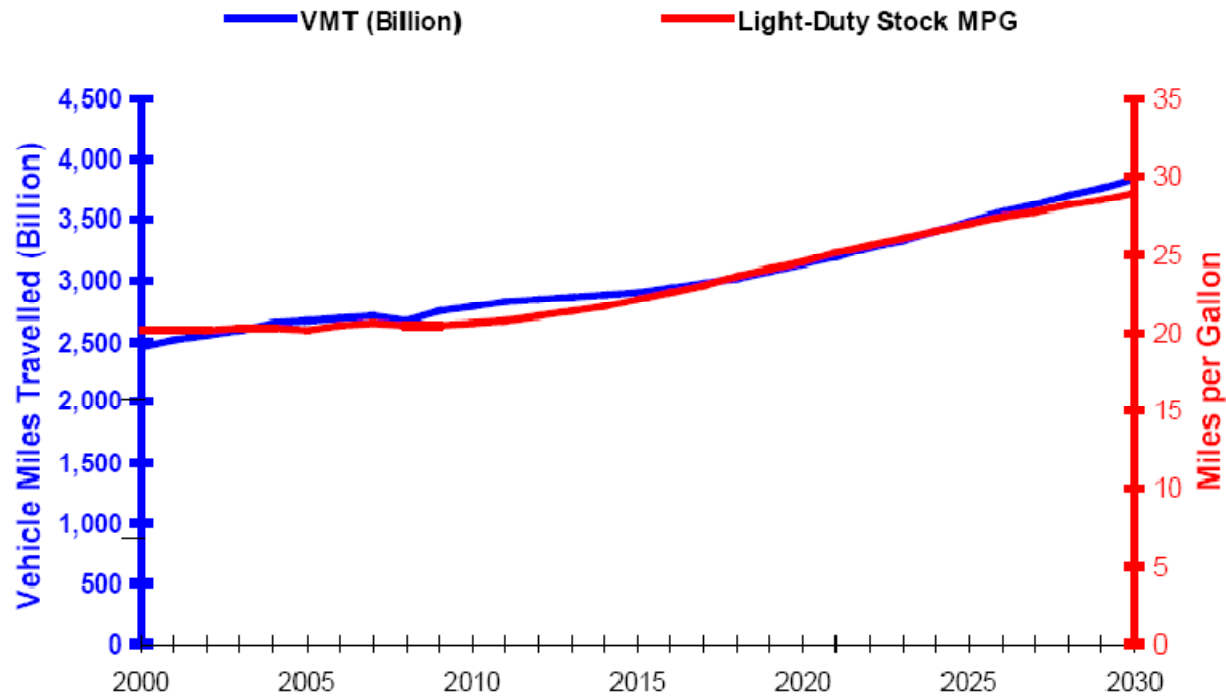


Source: Annual Energy Outlook 2009 Reference Case d041409a

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DOE expects VMT and MPG both to rise

Light Duty Vehicle Miles Travelled (2 of 3)

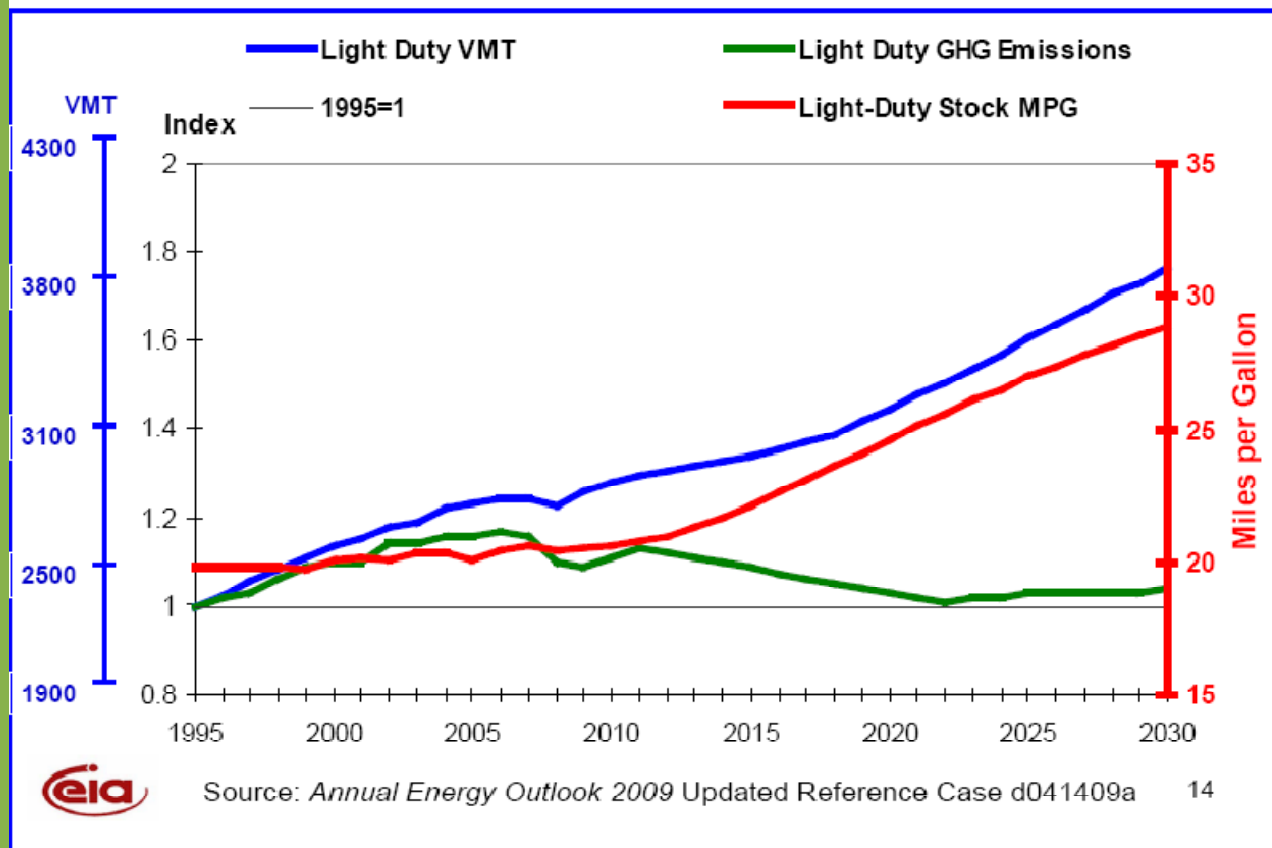


Source: Annual Energy Outlook 2009 Reference Case d041409a

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As VMT and MPG rise, GHG is nearly flat

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



What should the GHG reduction target be for the transportation sector?

- **Economists:**

- Reduce GHG emissions as cost-effectively as possible, even if that means much larger reductions in some sectors than others
- Evidence is accumulating that reducing transportation GHG 80% would be more costly than same % reduction in other sectors
- Ergo: Transportation GHG reduction targets probably should be lower

- **Political reality:**

- Transportation will be expected to contribute its "fair share"
- Room for debate about what "fair share" means.
- Often-cited goal is **60 to 80%** from current levels.

Policy debate can be intense

- Climate skeptics: Climate change isn't happening, or isn't human-induced
- Environmental view: Transform land use, increase transit, and reduce VMT
- Techno-optimist view: Transform vehicle/fuel technology and improve highway/driver operations
- Pragmatic view: Combination -- mostly vehicles/fuels, some operational efficiency, plus modest role for land use, transit, and VMT moderation

Federal Climate Legislation and Policy are Taking Shape

1. AASHTO position
2. EPA proposed “endangerment” finding (section 202(a) of CAA)
3. Federal legislation – cap and trade
4. Federal legislation – transportation

AASHTO Position on Climate Change

- Major R&D to decarbonize vehicles/fuels (comparable to “man on the moon”)
- Reduce VMT growth to 1%/year
- Double transit ridership
- Increase intercity passenger rail
- \$100 M/year Federal funding for coordinated land use/transportation planning
- Oppose GHG conformity requirement
- See AASHTO “Real Transportation Solutions” at <http://www.transportation1.org/RealSolutions/summary.html>.

Clean Air Act – EPA Finding of “Endangerment”

- EPA is acting to 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)
- GHG conformity possible, but not likely

Federal Climate Legislation - Status

- **House: Passed Waxman-Markey bill on the floor in 2009**
- **Senate: Boxer-Kerry bill reached floor in 2009, then stalled**
- **Senate: Now working on new bipartisan compromise bill**
 - Led by Kerry, Graham, Lieberman
 - Potentially a much different approach:
 - "Sector-specific"
 - Transportation fuels may be outside the cap, but subject to a "carbon tax" that is linked to cost of allowances
 - Increased role for nuclear power, oil & gas production.
 - Concepts being floated now
 - Bill could be introduced soon

Source: Bill Malley, Perkins Coie

Federal Legislation – Major Elements of Climate Bills

- **Cap-and-Trade**
 - Mandate reductions in total GHG emissions
- **Energy Production**
 - Provides incentives and other support for production of renewable energy (and maybe nuclear, oil & gas)
- **Energy Efficiency**
 - Provides incentives and tighter regulations to promote greater efficiency.
- **Transition Assistance**
 - Provides assistance to ease impact of higher energy prices on consumers and U.S. industries

Source: Bill Malley, Perkins Coie

Federal Climate Legislation – Basics of Cap and Trade

How a cap-and-trade program works:

- Set a cap on total GHG emissions, and reduce it over time
 - 17 to 20% reduction by 2020
 - 83% reduction by 2050
- Issue "allowances" to emit GHGs within the cap
 - Some allowances are auctioned; others distributed free
 - Allowances are an economic asset that can be traded
 - Receiving a free allowance is like receiving dollars.
- Offsets can be purchased in lieu of allowances
 - An offset is obtained by paying for a reduction made by sources outside the cap, including sources in other countries.
 - Example: pay to avoid deforestation in a developing country.

Source: Bill Malley, Perkins Coie

Federal Climate Legislation – Transportation Provisions

- **How would the House and Senate bills reduce GHG emissions from transportation?**
 - Include transportation fuels in the cap
 - Provides a "price signal" to promote technological innovation and changes in vehicle choices, land use, and behavior
 - Promote cleaner vehicles and fuels with funding, regulation:
 - Vehicle and fuels R&D
 - Vehicle recharging infrastructure
 - GHG emission regulations
 - Create new transportation planning requirements
 - Development of models and methods
 - State and MPOs set targets for GHG emission reductions
 - States and MPOs develop strategies for achieving targets

Source: Bill Malley, Perkins Coie

Federal Climate Legislation – Impact on Transportation Fuel Prices

- **How would the House and Senate bills affect the price of transportation fuels?**
 - EPA analysis of House Bill (6/23/09) estimated House bill would raise gas prices by 14 cents/gallon by 2015.
 - EPA makes two key assumptions:
 - Relatively low cost to adopt new technologies that reduce GHG emissions, such as carbon capture and sequestration (CCS).
 - Relatively widespread use of "offsets"
 - Without these assumptions, prices could be much higher.
 - EPA has not yet released an estimate of the gasoline price impacts of the Senate bill.

Source: Bill Malley, Perkins-Coie

Federal Climate Legislation – Impact on Transportation Fuel Prices

| | 2015 | 2030 | 2050 |
|---------------------------------|--------|--------|--------|
| EPA Projection | \$0.14 | \$0.24 | \$0.69 |
| CRA: Base Case | \$0.19 | \$0.38 | \$0.95 |
| CRA: "Low-Cost" | \$0.17 | \$0.34 | \$0.84 |
| CRA: "High-Cost" | \$0.36 | \$0.71 | \$1.82 |
| CRA: "No International Offsets" | \$0.52 | \$1.08 | \$2.79 |

Source for CRA Estimates: CRA International, "Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R.2454), pp. 4 and 64-66.

Federal Climate Legislation - Impact on Transportation GHG

- **Would the House and Senate bills be effective in reducing transportation GHG emissions?**

EPA projects that the price signal from cap-and-trade would have little effect on transportation emissions

"The increase in gasoline prices that results from the increase in the carbon price ... is not sufficient to substantially change consumer behavior in their vehicle miles traveled or vehicle purchases"

"The relatively modest indirect price signal on vehicle manufacturers from this particular cap-and-trade policy creates little incentive for the introduction of low-GHG automotive technology."

Source: <http://www.epa.gov/climatechange/economics/economicanalyses.html>

Federal Climate Legislation – Transportation Planning Provisions

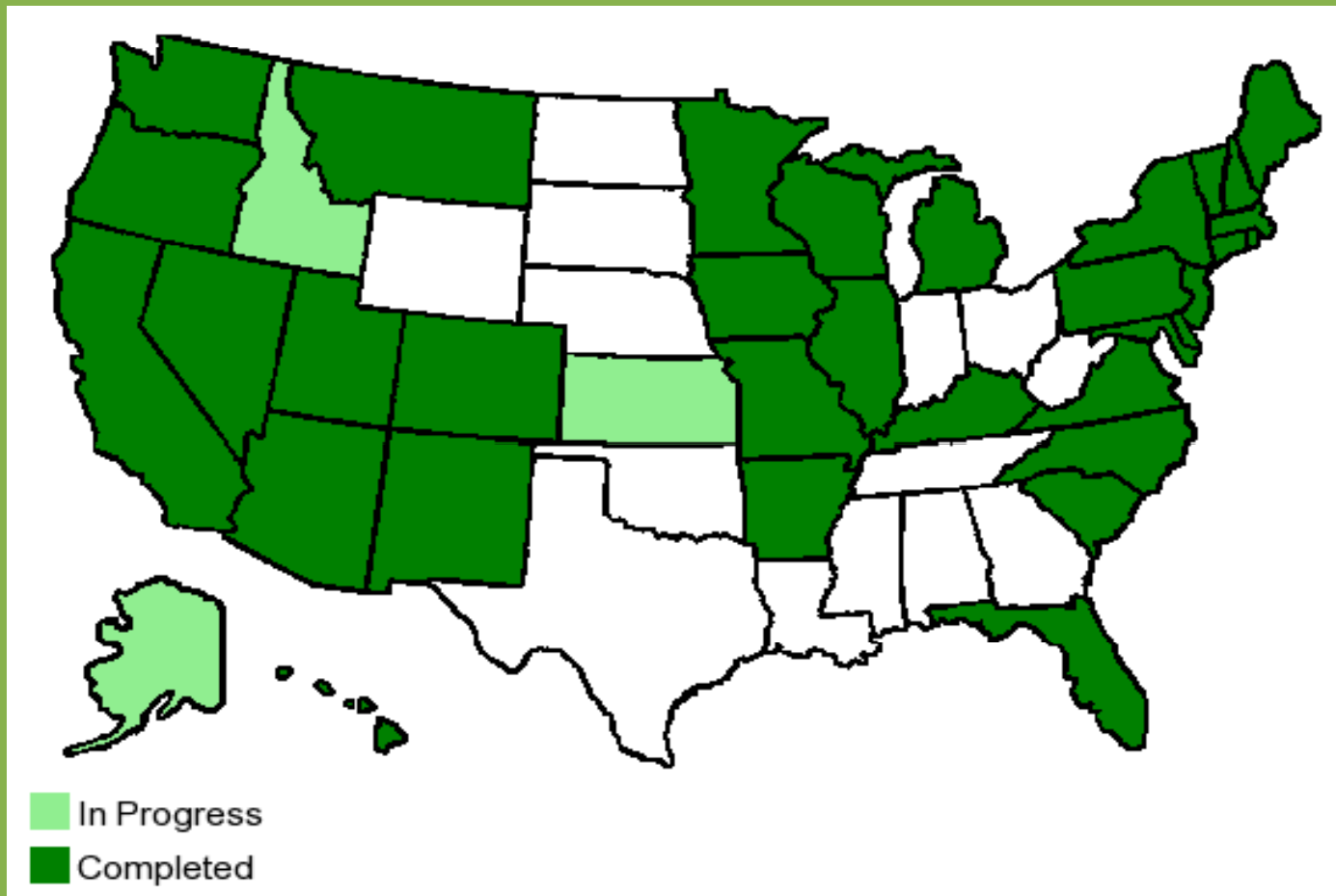
- States and TMA MPOs must develop GHG reduction targets and strategies, as part of transportation plans
- States and TMA MPOs must “demonstrate progress in stabilizing and reducing” GHG emissions
- EPA must issue regulations on transportation GHG goals, standardized models, methodologies, and data collection
- US DOT shall not certify state or MPO plans that fail to “develop, submit or publish emission reduction targets and strategies”
- 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.”

Federal Transportation Legislation – Potential Climate Provisions

- Key climate change issues in transportation legislation include:
 - Modal funding and policy emphases to support GHG goals
 - Explicit or implicit VMT reduction goals?
 - Compact land use planning incentives?
 - GHG reduction targets?
 - GHG conformity requirements?
 - GHG performance measures?
 - GHG planning requirements?
 - GHG environmental review requirements?
 - Adaptation planning requirements?
 - Adaptation funding?

State Climate Action Plans

Source: Pew Center on Climate Change



State Climate Action Plans

- Highly “aspirational”
- Managed by state environmental agencies
- Steering Committees included multiple environmental advocates and rarely had transportation agency reps
- State DOT involvement was at a technical advisory level, whose input was often rebuffed
- Example: VT strategies would reduce 2030 VMT from 10.5 billion (base case) to 3.9 billion VMT

State Climate Plans – Transportation Share Of GHG Reductions Varies Widely

| State | Year | % Reduction in Transportation GHG | % of all GHG Reductions from Transportation |
|----------------|------|-----------------------------------|---|
| Rhode Island | 2020 | N/A | 20% |
| New York | 2020 | 18% | 7% |
| Connecticut | 2020 | N/A | 7% |
| Pennsylvania | 2025 | 30% | 8% |
| Maine | 2020 | 23% | 27% |
| Minnesota | 2025 | 27% | 5% |
| Oregon | 2025 | 25% | 8% |
| New Mexico | 2020 | 30% | 8% |
| Colorado | 2020 | 22% | 6% |
| North Carolina | 2020 | 31% | 11% |

State Climate Plans – Transportation Elements Vary All Across the Map

| State | Year | Vehicle | Low Carbon Fuels | Smart Growth and Transit | Other |
|-------|------|---------|------------------|--------------------------|-------|
| RI | 2020 | 46% | 10% | 31% | 14% |
| NC | 2020 | 35% | 12% | 38% | 15% |
| SC | 2020 | 14% | 55% | 29% | 1% |
| CT | 2020 | 51% | 38% | 8% | 2% |
| ME | 2020 | 53% | 25% | 21% | 1% |
| MD | 2025 | 24% | 12% | 45% | 20% |
| NY | 2020 | 59% | 11% | 27% | 4% |
| PA | 2025 | 45% | 36% | 18% | 0% |
| MN | 2025 | 15% | 35% | 25% | 25% |
| VT | 2028 | 21% | 14% | 49% | 17% |

What are other state DOTs doing on climate change – in Planning?

- Preparing GHG inventories/footprints
- Developing GHG estimation tools, models (OR)
- Documenting their ongoing GHG reducing activities
- Planning to expand on these activities
- Planning for transportation elements of state climate plans
- Estimating GHG for new projects (NY)
- Developing climate adaptation plans – esp. for coastal areas (MA, AK)
- Developing adaptation plans – also inland areas (MA, AK)
- Developing state DOT climate action plans (VT)
- Evaluating heat-adaptive pavements (KS)

What are other state DOTs doing on climate change – implementation?

- Reducing roadside mowing (GA)
- Using low-carbon pavements (CA)
- Reducing energy consumption in state buildings/facilities (NY)
- Installing solar panels in highway ROW (OR)
- Converting to LED traffic lights (RI)
- DOT fleet conversions (many)
- Installing alt fueling facilities for public (TN)

What are other state DOTs doing on climate change – web links?

- 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
- 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%20_AASHTO_0.ppt

GHG reduction debates overshadow 2 more challenges bearing down on state DOTs

- New revenue sources: New revenue sources are needed that are appropriate in a climate change-dominated world, with electric vehicles and new fuels
- Climate adaptation: Huge funding increases, risk-based planning and programming, and tough policy decisions will be needed to adapt to a changing climate

Summary

- Reduce transportation GHG, especially highway GHG, 60-80% by 2050
- Prepare for Federal climate legislation
- Help shape state climate action policies
- Find a new revenue stream suitable for a world of new low-carbon fuels
- Adapt transportation infrastructure to rising sea levels, more severe storms, heat, and flooding

IV. Climate Adaptation for Transportation



Why Transportation Agencies Should Plan for Adaptation

- **Sea level rise & storm surges**
 - Destruction of bridges
 - Erosion & permanent inundation of roads
 - Disruption of evacuation routes & road network
 - Bridge clearance limitations
- **Other types of impacts**
 - Increased flooding
 - Pavement rutting
 - Rail buckling
 - Increased flooding
 - More severe inland storms
 - Increased maintenance



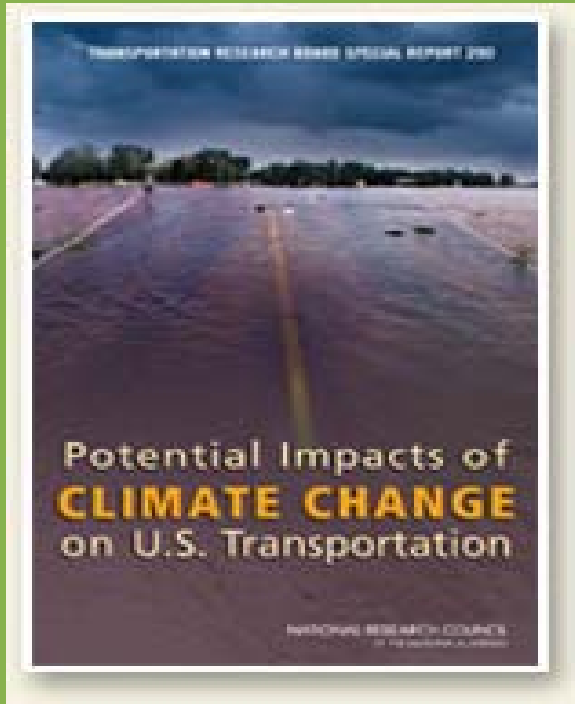
Source: <http://mceer.buffalo.edu/research/Reconnaissance/Katrina8-28-05/05BiloxiBay1/09lg.jpg>

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

Transportation Research Board 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.

States Focusing on Climate Adaptation

- Coastal states are most concerned
- Multi-sector reviews of vulnerability
- Often led by resource agencies
- State DOT role -- significant to minor
- Still early on the learning curve

- California
- Pennsylvania
- Maryland
- Washington
- Hawaii
- Alaska
- Florida
- Massachusetts
- North Carolina

Implications for Design

- Changes in bridge height
- Changes in bridge foundation and superstructure
- Changes in materials specifications
- Changes in suspended and cable-stay bridges to withstand more severe wind and turbulence
- Changes in culvert design, capacity, and location
- Changes in slope design
- Changes in pavement drainage systems

Implications for Maintenance/Operations

- Pavement rutting and rail buckling
- Longer construction season
- Closures and detours due to rock slides, soil erosion, flooding
- Speed reductions
- Flooding of culverts
- Change in weight restrictions
- More grass cutting/less snow plowing
- Work crew limitations during severe heat periods

Implications for Environmental Reviews

- In NEPA process, sponsor must 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

MASSDOT: Mid-Term Recommendations Being Considered for Inland Areas

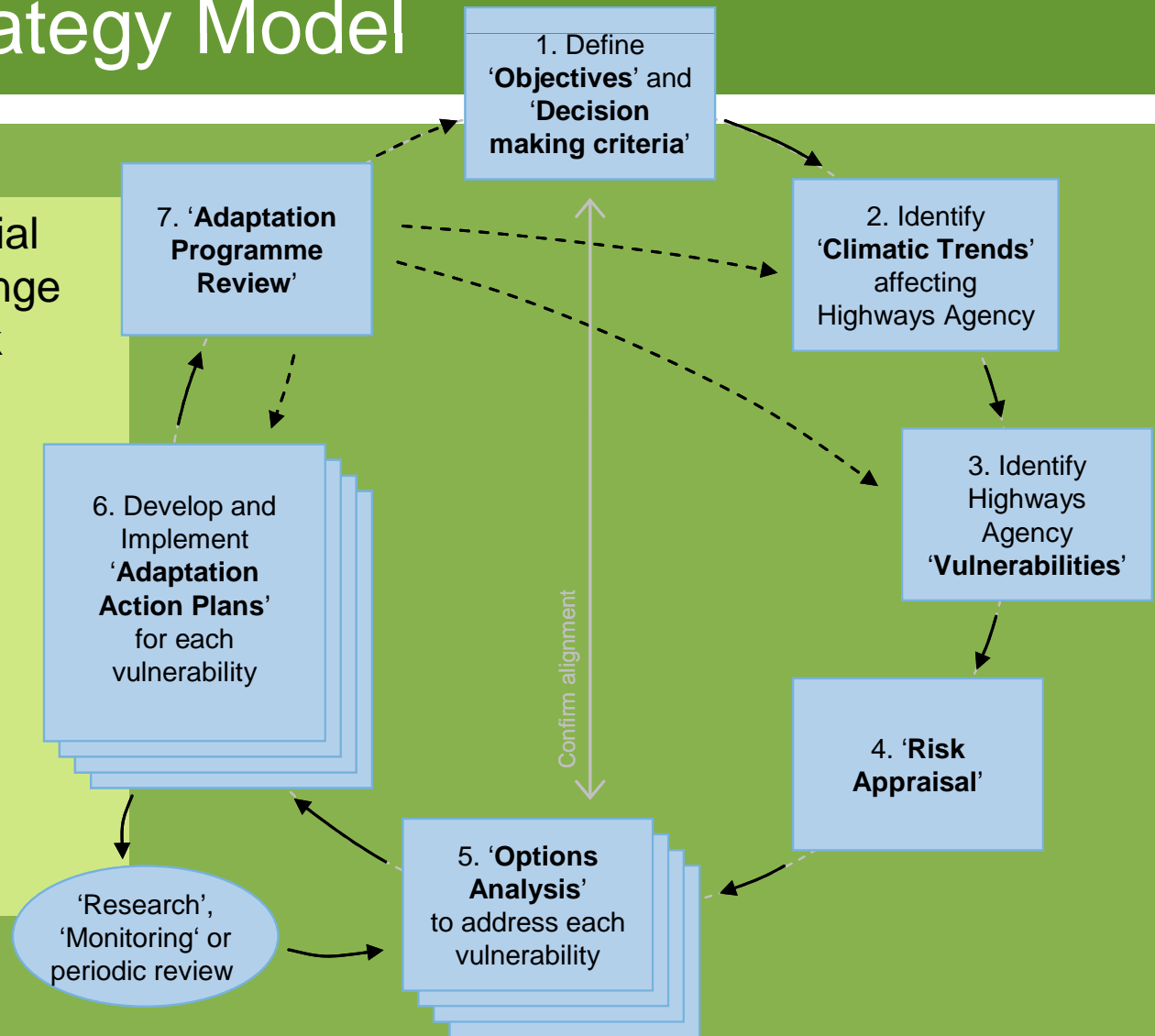
- Update Peak Flood Flow Frequency Regional Regression Equations to produce more accurate flood level predictions (40-year old data)
- Identify and prioritize inland vulnerable assets
- Develop design requirements on a project by project basis
 - Increased clearances
 - Rip-rap, scour protection
 - Relocation – most extreme

MASSDOT: Long-Term Recommendations

- Continue development of engineering standards with FHWA and AASHTO
- Progressively adapt standards as:
 - More data becomes available
 - Climate change impacts are realized
 - Climate change events are predicted with greater accuracy
 - Universal models are developed

U.K. Highways Agency Adaptation Strategy Model

- Model identified potential impacts of climate change of the UK road network
- Resulted in a climate change adaptation strategy
- Strategy addresses design, construction, and maintenance
- Includes a risk appraisal for all operations



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. Planning and NEPA Issues



New Federal Planning Requirements are Very Likely

- House-passed Cap-and-Trade bill includes new planning requirements for climate change
- Oberstar's draft bill for transportation authorization includes new planning requirements for climate change
- Various Senate bills include new planning requirements for climate change
- Most of the provisions in the different bills are virtually identical

Federal Legislation – Cap and Trade - Transportation Planning Provisions

- **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.”

Transportation Planning Ground Rules will be Critical – Methods, Tools, etc..

1. Who will set the rules for transportation GHG planning?
2. What models will be allowed or required?
3. What data will be required?
4. What assumptions will be permitted?
5. How will baseline GHG be calculated?
6. What form will GHG targets take? (total GHG? per capita? for freight and passenger? passenger only?)
7. How will through-traffic GHG be counted?
8. How will state GHG planning and MPO GHG planning mesh?

GHG Calculators On Line

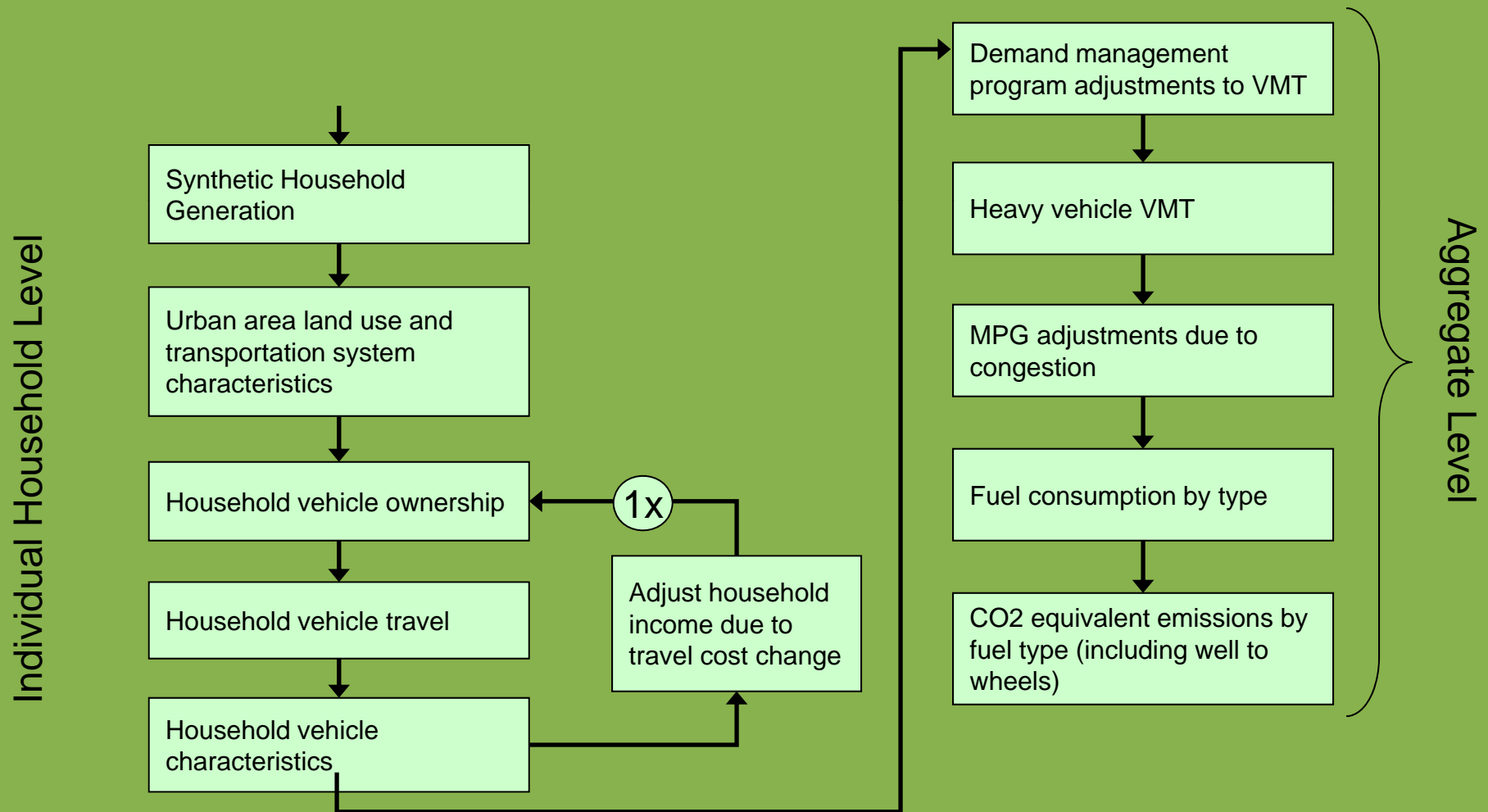
- EPA GHG calculator (converts GHG tons to equivalencies in terms of annual operation of cars, power plants, etc.)
<http://www.epa.gov/cleanenergy/energy-resources/refs.html#vehicles>
- EPA GHG calculator for households (enter HH activity data to get GHG)
http://www.epa.gov/climatechange/emissions/ind_calculator.html
- University of Vermont Transportation Research Center (GIS-based travel demand model/carbon calculator)
[VMT calculation spreadsheet](#)
- GreenSTEP statewide transportation GHG estimator
<http://www.oregon.gov/ODOT/TD/TP/docs/HB2186page/GreenhouseGasEmissions.pdf>
- Summary and assessment of GHG methodologies
<http://www.commerce.wa.gov/site/1277/default.aspx>

One Emerging Tool: GreenSTEP

GreenSTEP = Greenhouse gas State Transportation Emissions Planning model

- A statewide planning model to help Oregon develop a statewide transportation strategy on greenhouse gas (GHG) emissions
- Complements metropolitan travel demand models and ODOT's integrated statewide model
- Peer Review by Oregon travel modelers and experts in other disciplines
- Many elements have been estimated using 2001 NHTS data
- Open source model developed and implemented in open source software (R programming language)
- Partially developed with FHWA SPR program funds

GreenSTEP Overview



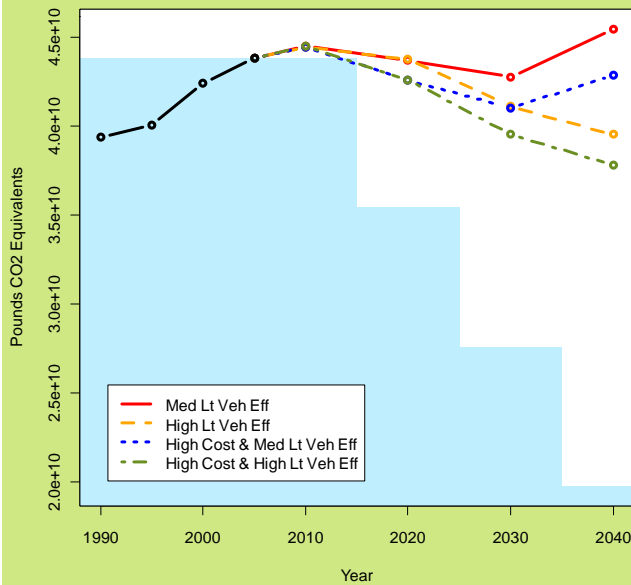
GreenSTEP Inputs

- Demographic changes
- Relative amounts of development occurring in urban and rural areas
- Metropolitan and other urban area densities
- Urban form
- Amounts of metropolitan area public transit service
- Highway capacity
- Vehicle fuel efficiency
- Vehicle ages

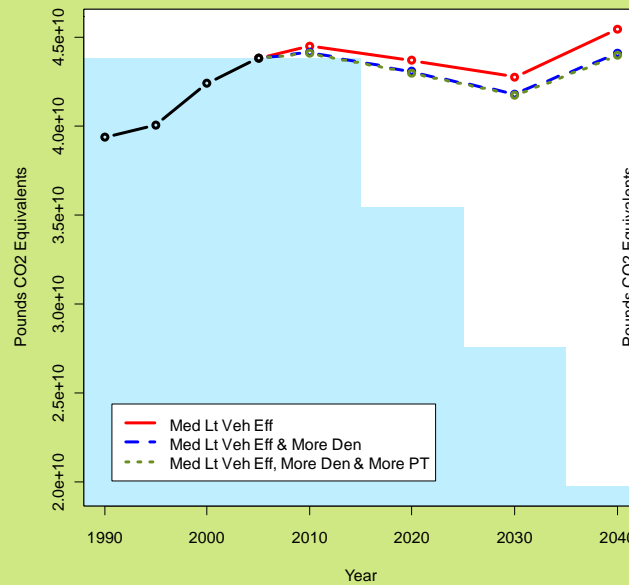
- Electric vehicles
- Fuel & carbon pricing
- VMT pricing
- Demand management
- Effects of congestion on fuel economy
- Carbon content of fuels – including well to wheels impacts
- CO2 production from electrical power use for transportation

GreenSTEP can Analyze Many Different Strategies

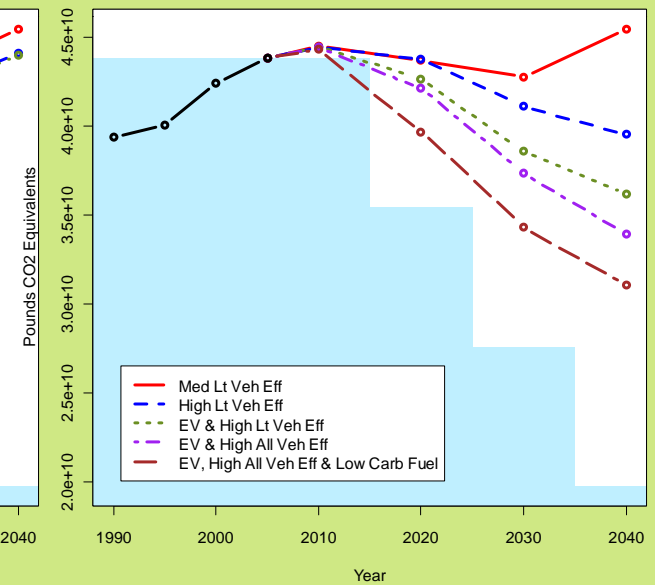
Fuel Economy & Costs



Urban Planning



Vehicle Tech & Fuel



NEPA: Draft CEQ Guidance

- Draft issued by CEQ on February 18, 2010
- Comments due: May 24, 2010
- Proposal:
 - Evaluate proposed actions that are reasonably expected to cause direct emissions of 25,000 metric tons or more of CO₂-equivalent on an annual basis
 - Quantify cumulative emissions over the life of the project
 - Consider impact of climate change on the project

NEPA: Potential GHG Considerations

- Emissions from vehicles using the highway
 - In no-action and build alternatives
 - Usually treated as direct emissions in NEPA air quality analysis
- Construction-related emissions
- Up-stream emissions from fueling cycle (drilling, refining, shipping, etc.) and vehicle cycle
- Others?
 - Emissions effects of land use changes, roadway maintenance and lighting, etc.

NEPA: Roadway GHG Emissions

- 25,000 metric tons = 43,000,000 VMT/year or about 120,000 VMT/day
 - Examples:
 - One mile highway with 120,000 ADT
 - Two mile highway with 60,000 ADT
 - Action that would increase VMT by 120,000/day (NEW VMT) would trigger analysis, with all else being equal (e.g. speeds, congestion, fleet mix, etc.)

NEPA: Future Roadway GHG Emissions

- 25,000 ton is based on annual emissions over life of the project
- Future fuel economy projected by US DOE
 - 2020 fleet - ~14% more fuel efficient than 2010 fleet; raises VMT threshold to 137,000 VMT/day
- Upstream and downstream emissions?
 - Fuel supply (well to pump) and vehicle manufacture and disposal included in EPA national inventories
 - Proposed approach would add 40% to emissions generated to account for upstream and downstream emissions
 - 120,000 VMT becomes 86,000 VMT **IF** 40% and upstream/downstream emissions included

NEPA: Construction GHG Emissions

- Methodologies to quantify construction emissions dated
- But, based upon NY procedures
 - 25,000 metric tons could result from 30-50 lane-miles of new road work
 - Emissions vary widely
- Construction emissions would be annualized over life of project

NEPA: Construction GHG Emissions

Source: NYSDOT

| Construction Energy Factors -- Lane-Mile Approach | | |
|--|---|--------------------------|
| Type of Improvement | Construction Energy Consumed per Rural ^a -Lane-Mile (10 ⁹ Btu/mi) | CO ₂ , tonnes |
| New construction | 12.70 | 637 |
| Relocation | 10.50 | 526 |
| Reconstruction | 5.20 | 261 |
| Restoration and rehabilitation | 2.30 | 115 |
| Resurfacing | 0.75 | 38 |
| Major widening | 5.00 | 251 |
| Minor widening | 1.90 | 95 |
| New Bridges | 192 | 9624 |
| Bridge Replacement | 222 | 11128 |
| Major rehabilitation | 134.4 | 6737 |
| Minor rehabilitation | 11.91 | 597 |
| ^a Increase rural energy consumption by 20% for urban construction | | |

NEPA: Projects Potentially Triggering GHG Analysis

- New 6-lane bridge,
 - 1.2 miles long, 100,000 ADT, 70 mph (in 2020, 114,400 ADT)
- New 4-lane highway,
 - 3.5 miles long, 40,000 ADT, 70 mph (2020, 45,800 ADT)
- New 2-lane highway,
 - 6 miles long, 25,000 ADT, 60 mph (2020 ADT 28,600)
- Widening existing highway –
 - 6 to 10 lanes, 13 miles, speeds increase from 60 to 70 mph (2020 volumes could increase by 14%)
- Transit Projects
 - Light-Rail, Heavy-rail, Inter-city Rail?

NEPA: Bottom Line

It all depends...

- What emissions sources are included in total?
- How are direct and indirect emissions defined?
- What analysis year (or years) are used?
- Speed assumptions?
- Fleet assumptions?
- New VMT vs. VMT shifted from elsewhere?
- Many questions...

NEPA: Also Consider Climate Impacts on Project

- **Climate Adaptation Planning**
 - 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
- Guidance provides references to useful materials and links.

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

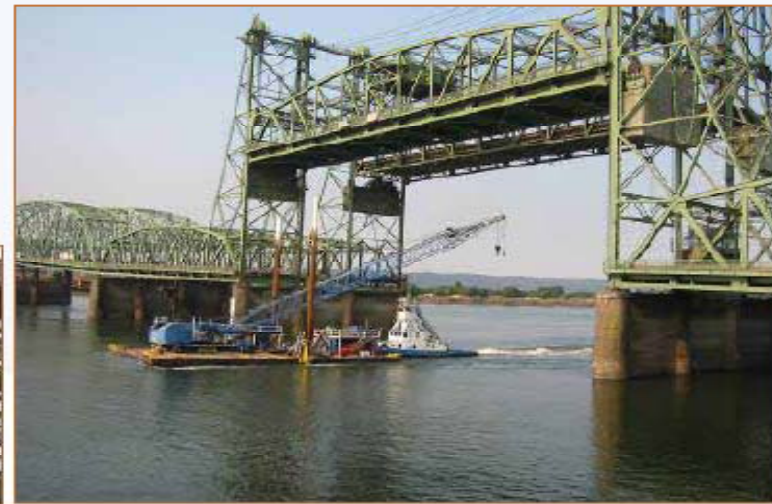
4 cases upheld lack of climate analysis or sufficiency of analysis:

- 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

DEIS for Columbia River Crossing

The Interstate Bridge I-5 over the Columbia River

- 2 side-by-side bridges
- Northbound built in 1917, southbound built in 1958
- 3 lanes each direction
- The only red light on I-5 from Canada to Mexico



DEIS For Columbia River Crossing

- Won national award for GHG analysis from National Association of Environmental Professionals
- DEIS issued May 2008
- Project is for congested river crossing between Portland OR and Vancouver WA
- Estimated cost of \$3.1 - \$4.2 billion
- 4 build alternatives – all are a combination of transit (BRT or LRT) and improved highway capacity

DEIS For Columbia River Crossing – GHG Results

- Build alternatives have lower GHG than no-build
- Relatively small differences among build alternatives
- Transit GHG emissions varied substantially
- Highest GHG: The alternative with more transit, higher toll, and less highway improvement

Source: Colin McConnaha, Parametrix, Inc.

Summary

- CEQ Draft Guidance will impact required NEPA Analysis
- Consider both
 - * impact of project on GHG; and
 - * impact of climate change on project
- Tools will be needed to evaluate GHG emissions
- Documentation will be important
- Mitigation actions can be helpful

V. Strategies to Reduce GHG from Transportation



Five GHG Reduction “Legs”

Transportation GHG reduction has 5 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

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

By 2020-2030:

- 50% cut in GHG/mile is feasible from conventional technologies and biofuels

- 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

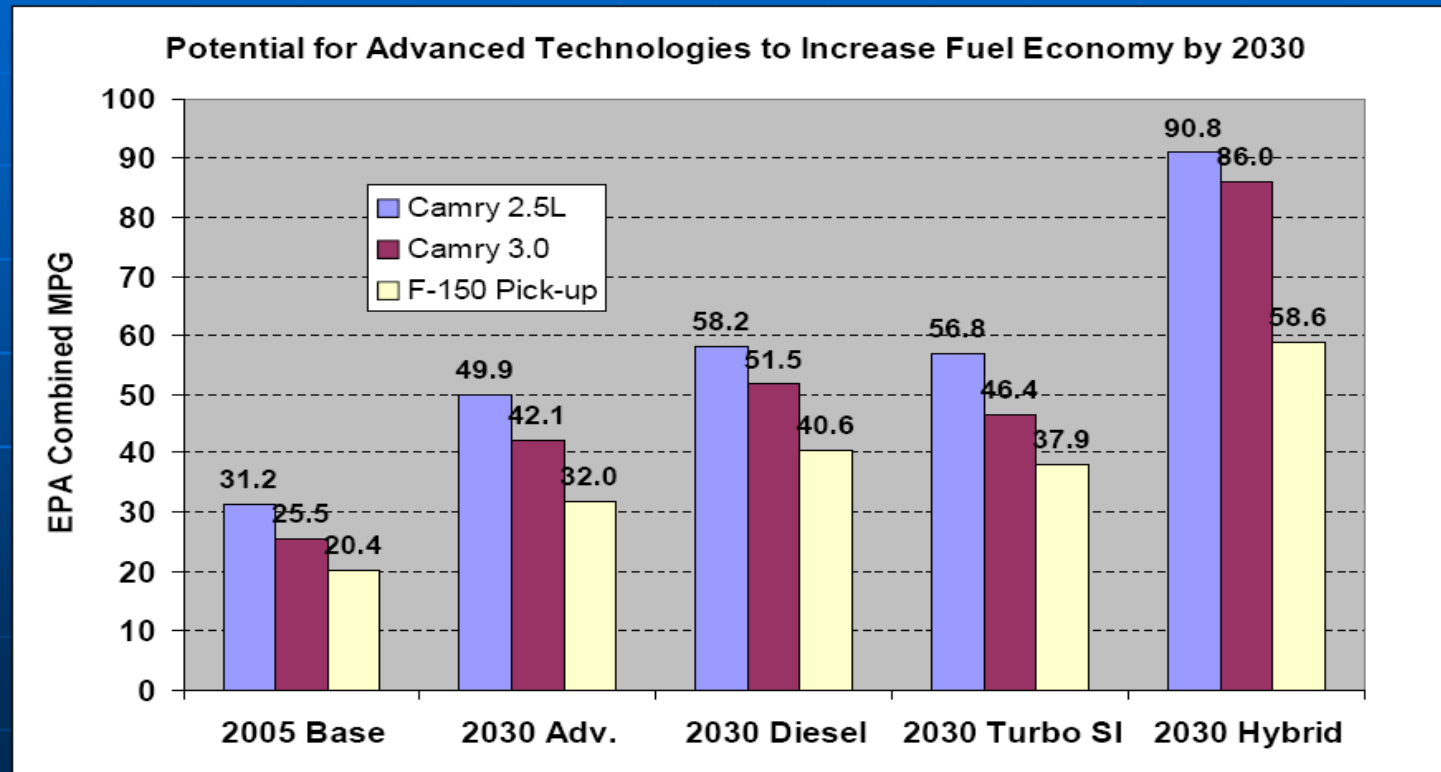
Recently Announced NHTSA/EPA Rule Significantly Reduce Highway GHG Below Baseline

EPA MY2012-2016 GHG Standards Projections Based on Public Target

| | Fuel Economy | Greenhouse Gas Emissions |
|--------------------------|---------------|--------------------------|
| 2011 CAFE standard | 27.3 mpg | 325 gpm |
| 2016 target GHG standard | (34-35.5 mpg) | 250 gpm |
| % GHG reduction | -- | 23% |

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.

Even Greater Vehicle “Decarbonization” is Necessary

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

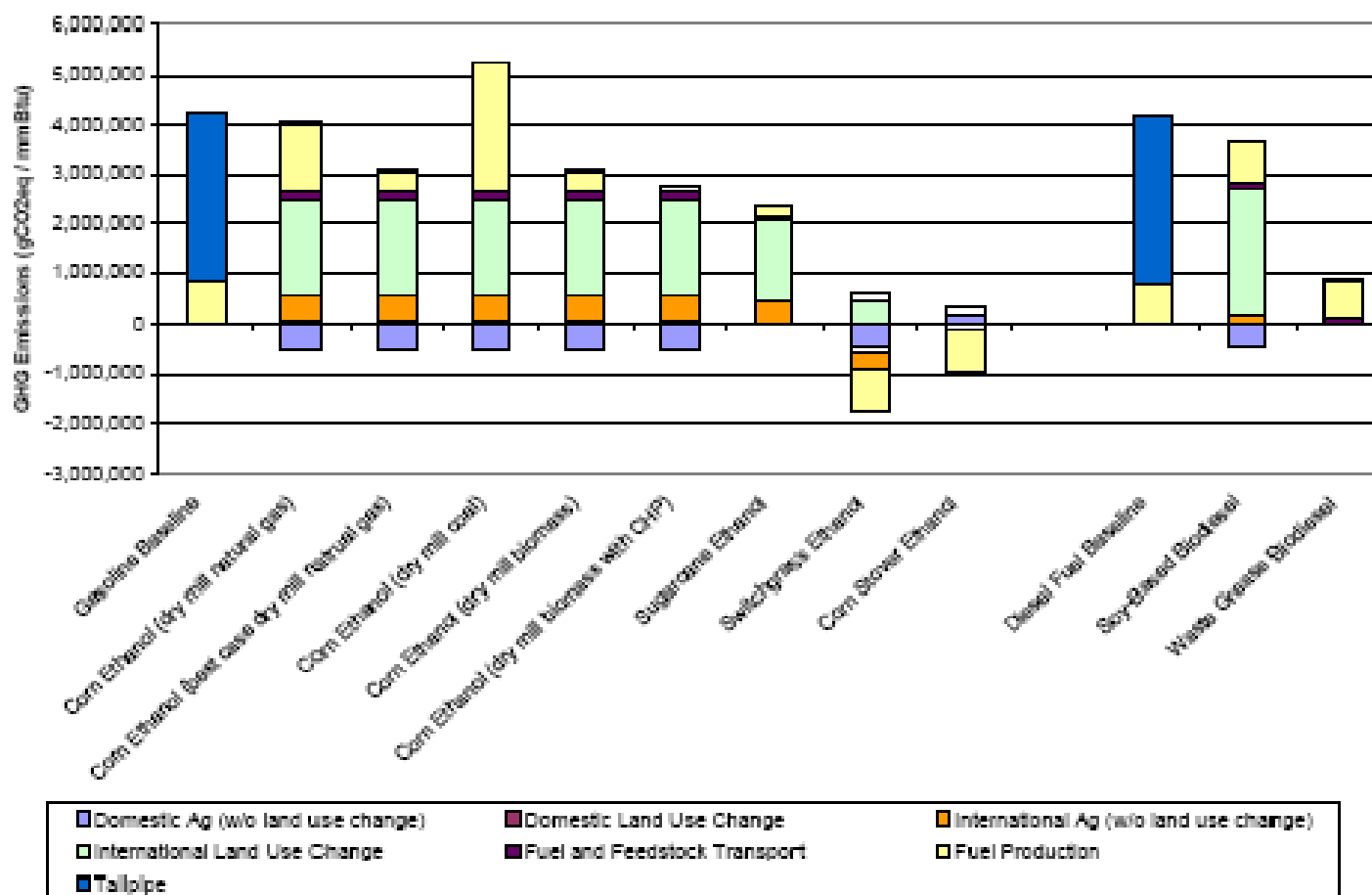
-The King Review for the U.K. Government, by Professor Julia King, Vice-Chancellor of Aston University and former Director of Advanced Engineering at Rolls-Royce plc, March 2008

“[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

GHG Intensity of Different Fuels

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



Low-Carbon Fuels

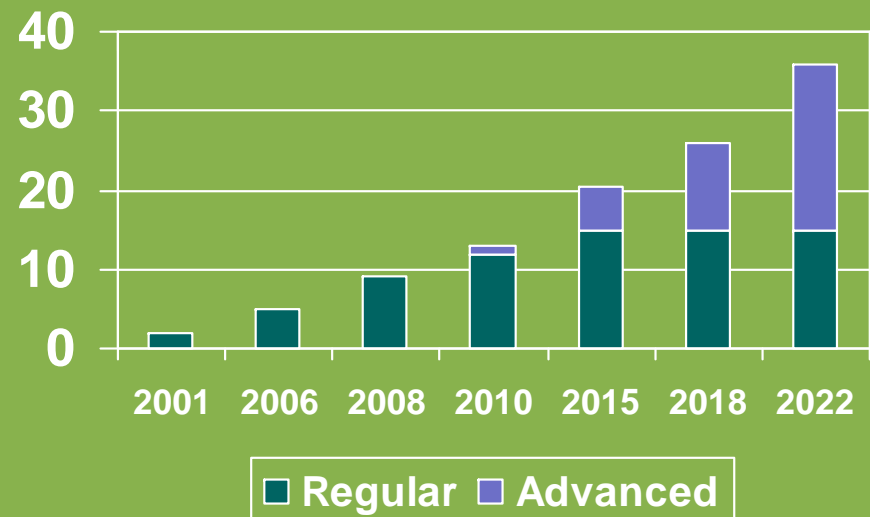
- Many different low-carbon fuel possibilities:
 - Corn ethanol
 - Sugar cane ethanol
 - Diesel
 - Cellulosic biofuel
 - Algae biofuels
 - Electricity from renewable energy or nuclear power
 - Electricity from utilities with carbon capture & storage
 - Hydrogen
- Carbon intensity measured as GHG/unit 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.”

Renewable Fuel Standard

- EISA of 2007 requires use of 36 billion gallons of biofuels by 2022.
 - Includes 21 billion gallons of advanced biofuels
 - Up from 5 billion in 2006.
- To achieve that goal, EPA mandates % of biofuels to be blended into all gasoline.

Biofuel Usage Mandates under EISA (billions of gallons)

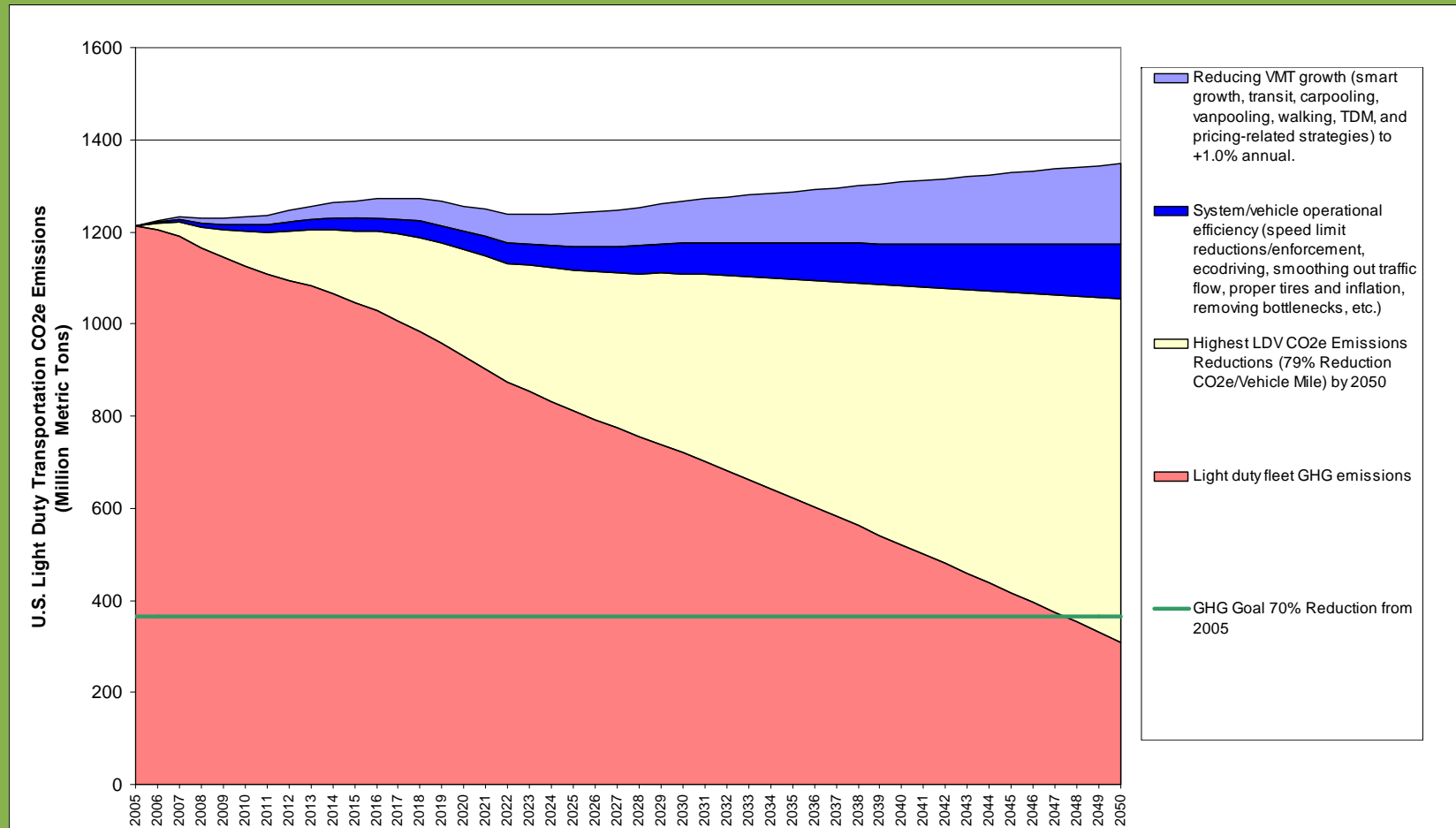
Source: Bill Malley, Perkins-Cole



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

What Would it Take to Achieve 74% LDV GHG Reduction by 2050? 1% Annual VMT Growth + 100 mpgge LDV Fleet + 10% Operational Efficiency



Many Strategies to Reduce LDV VMT

- Economy-wide **carbon cap and trade** (raises fuel prices)
- **Transportation pricing** (PAYD insurance, parking pricing, tolls, higher user fees, cordon pricing, congestion pricing, etc.)
- **Carpooling and vanpooling** (currently carry 7 times as much work trip PMT as transit)
- **Bike/ped and transit** (but some transit is higher GHG than LDV)
- **Trip chaining**
- **Tele-working, tele-shopping, tele-education, tele-medicine**
- **Compact land use**

In 2008, when fuel prices spiked and VMT dropped, where did it go? We know <2% of the lost VMT went to transit, but don't know where the rest of the drop went.

Pricing – A Necessary and Powerful Tool

- Without price signals, trying to reduce GHG is swimming upstream
- Pricing incentivizes 3 legs of the GHG stool
 - Purchase of lower-carbon vehicles and fuels; and
 - Lower VMT
 - Eco-driving behavior
- Many different pricing tools available: auto “feebates,” carbon/fuel prices, PAYD insurance, mileage fees, parking pricing, congestion pricing, etc.
- Pricing produces revenue to invest in alternatives

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

Consumers Respond to Prices

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

National Vehicle Miles Traveled vs. Gasoline Prices



Monthly total VMT for June of each year.

Carpooling and Vanpooling

- **Important but underappreciated** (7 times as many PMT for work trips nationally are in carpools and vanpools as on 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)

Transit Helps Reduce GHG – but has Small Impact Nationally

- Transit serves many goals and has broad support.
- But transit serves just 1% of PMT and 0% of freight
- DOE: *Bus transit has higher GHG/passenger mile traveled than average auto use in the U.S.*
- *APTA studies: (a) Transit reduced GHG by 6.9 MMT in 2005; or (b) by 35 MMT in 2005. This is 0.3% to 1.7% of U.S. transportation GHG*
- Transit GHG benefits are realized with highly patronized services in high volume corridors -- a market limited to high volume, generally densely developed corridors.

CO₂e Emissions Per Passenger Mile for Various Modes

| NATIONAL AVERAGE | Energy Intensities | | Load Factor | CO ₂ e |
|---|--------------------------------|----------------------------------|---------------------|---|
| | (Btu or kWhr per vehicle mile) | (Btu or kWhr per passenger mile) | Persons Per Vehicle | (Estimated Pounds CO ₂ e Per Passenger Mile) |
| Single Occupancy Vehicle (SOV) LDVs | 5,987 | 5,987 | 1.00 | 0.99 |
| Personal Trucks at Average Occupancy | 6,785 | 4,329 | 1.72 | 0.71 |
| Transit Bus | 37,310 | 4,318 | 8.80 | 0.71 |
| Cars at Average Occupancy | 5,514 | 3,496 | 1.57 | 0.58 |
| Electric Trolley Bus | 5.2 | 0.39 | 13.36 | 0.52 |
| High Occupancy Vehicle (HOV) LDVs at 2+ Occupancy | 5,987 | 2,851 | 2.10 | 0.47 |
| Intercity Rail (Amtrak) | 54,167 | 2,760 | 20.50 | 0.39 |
| Light and Heavy Rail Transit | 62,797 | 2,750 | 22.50 | 0.39 |
| Motorcycles | 2,226 | 2,272 | 1.20 | 0.37 |
| Commuter Rail | 92,739 | 2,569 | 31.30 | 0.36 |
| Vanpool | 8,048 | 1,294 | 6.10 | 0.21 |
| Walking or Biking | - | - | 1.00 | 0.00 |
| REGIONAL EXAMPLE (SEATTLE/PUGET SOUND REGION) | Energy Intensities | | Load Factor | CO ₂ e |
| | (Btu or kWhr per vehicle mile) | (Btu or kWhr per passenger mile) | Persons Per Vehicle | (Estimated Pounds CO ₂ e Per Passenger Mile) |
| Cars (64%) and Personal Trucks (36%) at Average Occupancy | 5,987 | 4,468 | 1.34 | 0.74 |
| King County Metro Diesel and Hybrid Buses | 33,024 | 2,854 | 11.57 | 0.47 |
| Sound Transit Buses | 33,024 | 2,517 | 13.12 | 0.42 |
| King County Electrically-Powered Trolley Buses | 5.33 | 0.44 | 12.12 | 0.11 |

Land Use Effect on GHG is Modest – and Depends on Assumptions

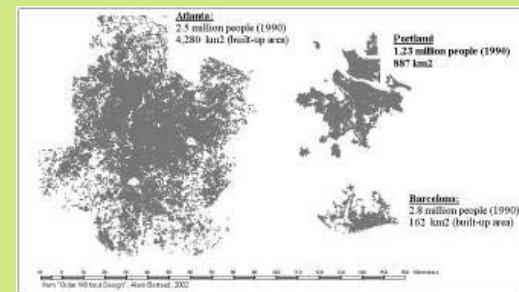
- “Growing Cooler” finds compact development can achieve **3.5-5% reduction in transportation GHG, 2007-2050**
- GC’s assumptions of land use change are **very aggressive**:
 - 67% of all development in place in 2050 will be constructed or rehabbed after 2005
 - 60-90% of that development is compact (comparable to 13.3 housing-units per acre)
 - Compact development **has 30% less VMT than very sprawling development**
- “Moving Cooler” finds **smaller GHG effect**, even with 90% compact land use for future urban development

TRB Study: “Driving and the Built Environment”

- 2009 TRB Study finds <1% to 11% GHG reduction by 2050, depending on aggressiveness of assumptions
 - Study looks at effects of compact development on travel, energy use, and CO2 emissions
 - Disagreement among committee members about feasibility of changes in development patterns and public policies necessary to achieve high-end of estimated reductions
- Recommendations
 - Policies that support compact, mixed use development should be encouraged
 - More carefully designed studies of the effects of land use patterns on VMT, energy use, CO2 emissions are needed to implement compact development more effectively
- Source: National Academies, Transportation Research Board, *Driving and the Built Environment*, August 2009

Less VMT via Land Use: The 8 “D”s

1. **Diversity** (mix) of land uses
2. **Density** of urban form – e.g. UGB
3. **Design** - quality of the (ped/bike) environment
4. **Destination accessibility** – O/D links
5. **Distance** to transit
6. **Development scale** (site, sector, municipality, region)
7. **Demographics**
8. **Demand Management**



Less VMT via Land Use: Planning Process

- Create a trends/base case
- Create a set of land use alternatives with greater 8-D features and matching transportation features (more transit, less highways usually)
- Include parking/pricing policies
- Test outcomes (sketch tools or models)
- Compare outcomes via expanded indicators
- Adopt regional plans (or State plans) that set targets and incorporate mix of sticks and carrots

Tysons Corner – Sector Plan

Unprecedented transformation

- Suburban to urban
- Doubling jobs
- Adding 10X housing
- New land use plan
- Adding street connectivity with redevelopment
- New implementing authority



Tysons Today



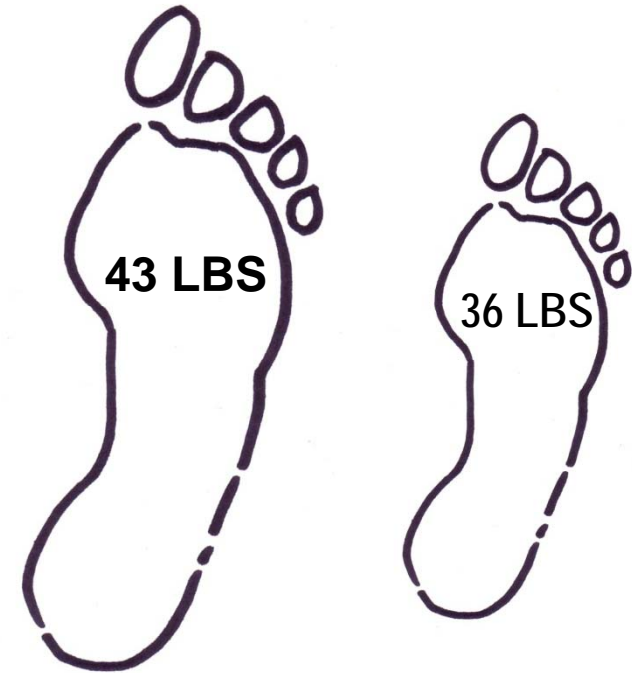
Tysons Transformed

Tyson's Corner - Lower Carbon Footprint

Preliminary assessment:

- Greenhouse Gas emissions 16% less per capita
- 2.5 billion lb. annual reduction
- Results from
 - Compact development
 - Fewer auto trips
 - Greater transit use

Daily CO2 Per Capita



Base Case

Prototype B

“Moving Cooler” (MC)

- Evaluated non-technology transportation strategies for (a) GHG reductions and (b) cost-effectiveness in reducing GHG
- Analyzed 46 individual transportation strategies and 6 “bundles” of strategies
- The 46 individual strategies: pricing strategies, transit strategies, land use strategy, operational strategies, freight strategies, nonmotorized strategies, regulatory strategies, bottleneck/capacity strategies, etc.

MC Findings – Individual Strategies

Individual strategies achieve GHG reductions ranging from <0.5% to 4.0% 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%)
- 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
- 352 mmt – combination of 10 freight strategies

MC Findings – Maximum Bundle

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

- Intercity tolls imposed in 2010 at 5 cents/mile
- Congestion pricing fully implemented 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 D
- And more...

Vehicle/System Operations to Reduce GHG

Potential for 10-20% LDV GHG reduction by:

- Managing speed (35-55 MPH is optimal)
- Speed limits/enforcement (could reduce fuel use 2-4%)
- Eliminating bottlenecks
- “Active” traffic management to smooth traffic flow
- Improving signal timing (could reduce 1.315 MMT CO₂/yr)
- Roundabouts (multiple benefits)
- Reducing car and truck idling
- Work zone management to smooth flow
- Encouraging eco-driving

Eco-Driving – 15% GHG Reduction Potential

- EcoDrivers can reduce fuel and CO₂ by an average of 15% through smart driving and vehicle maintenance.
- If 50% of drivers practiced EcoDriving, CO₂ would drop by 100 million tons annually (the equivalent of heating and powering 8.5 million households)
- 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

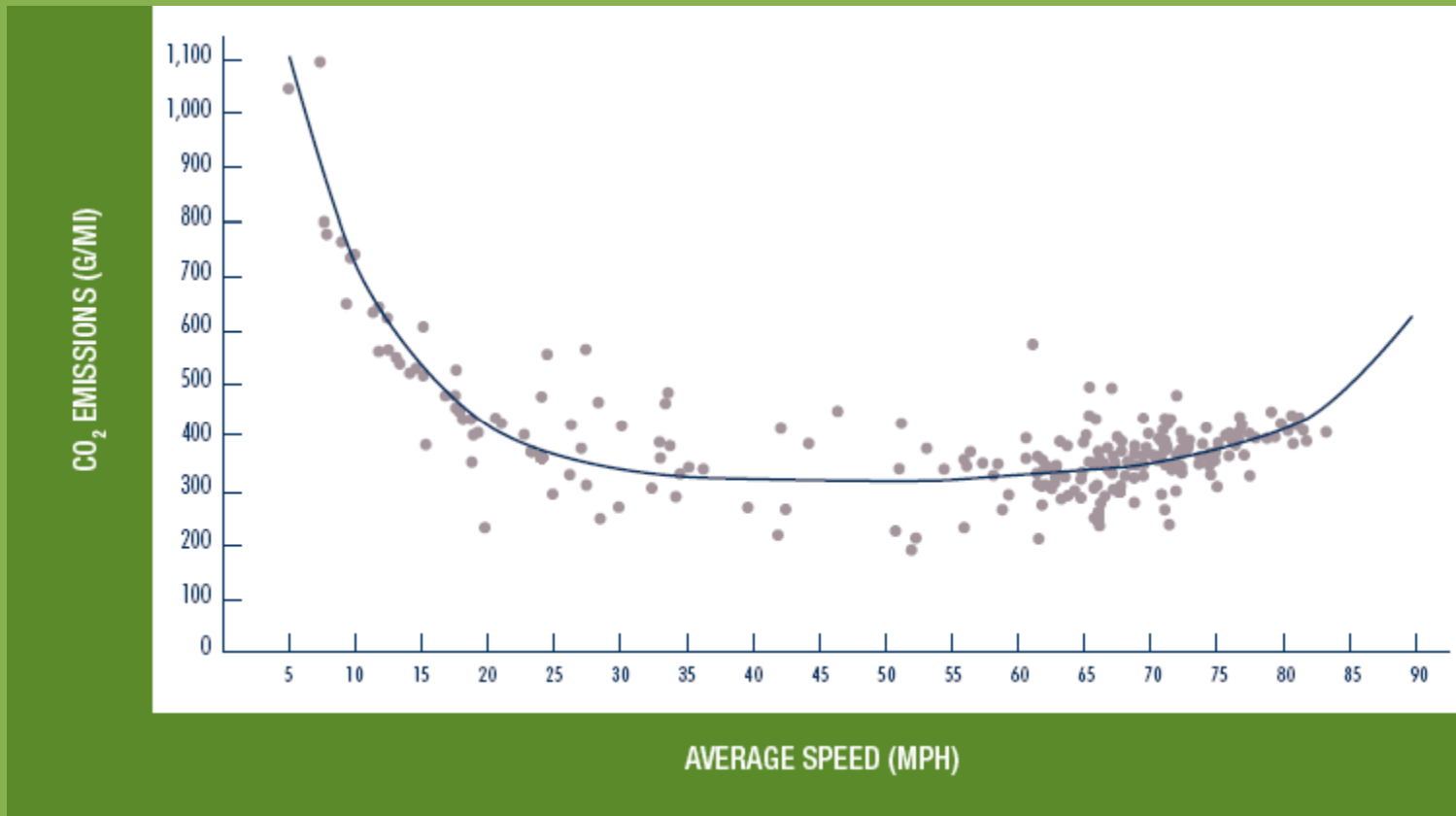
www.EcoDrivingUSA.com

- 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](#)
 - [Join the EcoDriving Movement](#)
 - [Link this website on your blog or site](#)
- For more information and to join the EcoDriving movement contact: Seena Faqiri at 202.326.5518 or sfaqiri@autoalliance.org.

U.C. Riverside - Traffic Congestion and Its Impact of GHG Emissions: Can ITS Help?

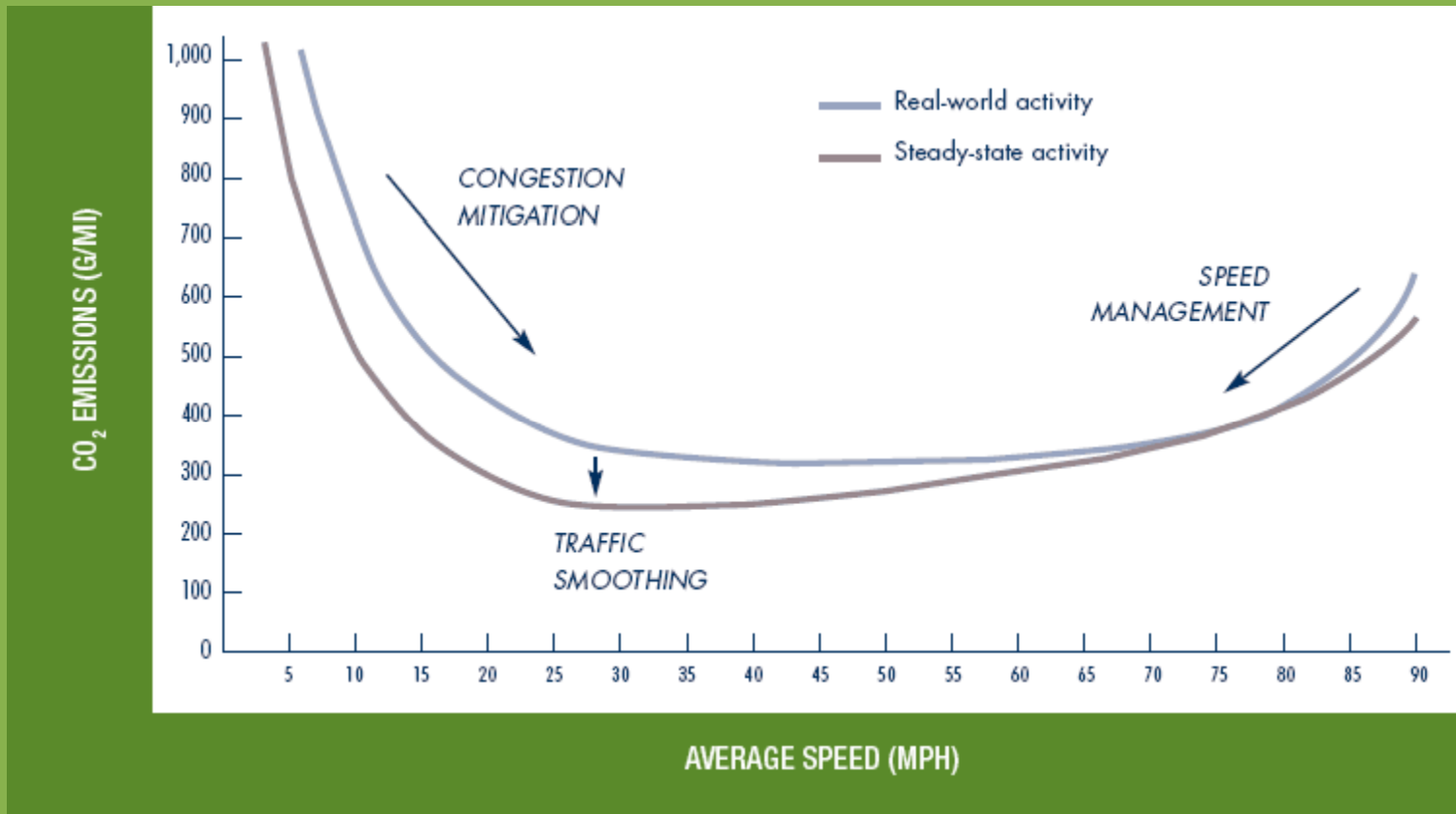
- Studied congestion and impact on CO₂, used detailed energy and emissions models linked to real-world conditions
- CO₂ emissions can be reduced with three strategies
 - Reduce severe congestion, allow traffic to flow at higher speeds
 - Reduce excessively high free-flow speeds to more moderate conditions
 - Eliminate accel/decel events associated with stop and go traffic in highly congested conditions
- Author: Dr. Matthew Barth, et al., May 2008
- <http://www.its.uci.edu/its/whatsnew/barth2.pdf>.

Effect of Speed on GHG



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

Traffic Operation Strategies To Reduce CO₂



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

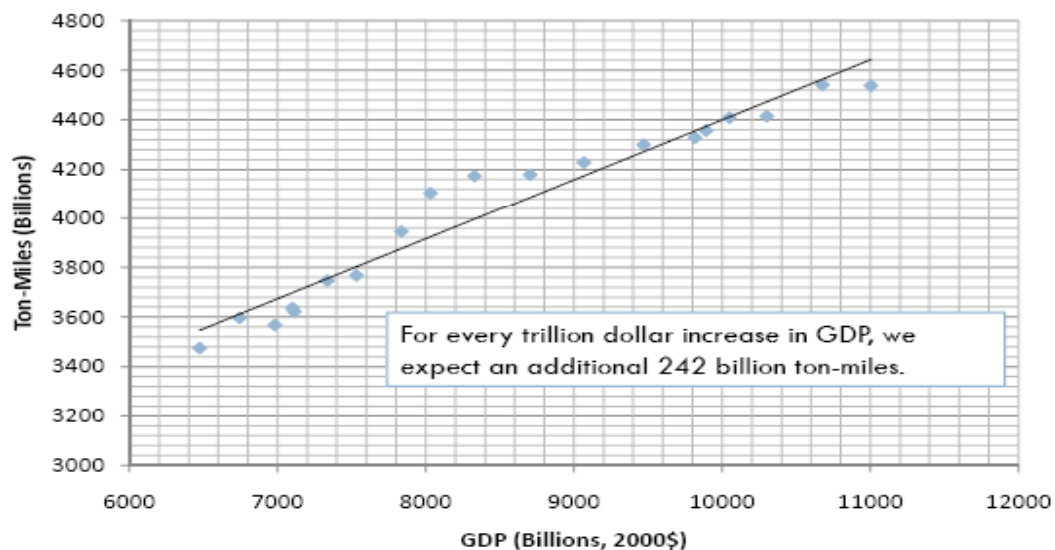
Portland, OR Traffic Signal Timing Project

- Improve signal timing on 17 major arterials
 - Optimize traffic flow
 - Reduce idling, acceleration, CO2 emissions and emissions from criteria pollutants
- Began in 2002 as 10-year effort
- Climate Trust will pay Portland for CO2 offsets from project
- Model for traffic signal offset projects
- http://www.climatetrust.org/traffic_signals.html

Freight – Ton-Mile/GDP Trends

Goods Movement and GDP

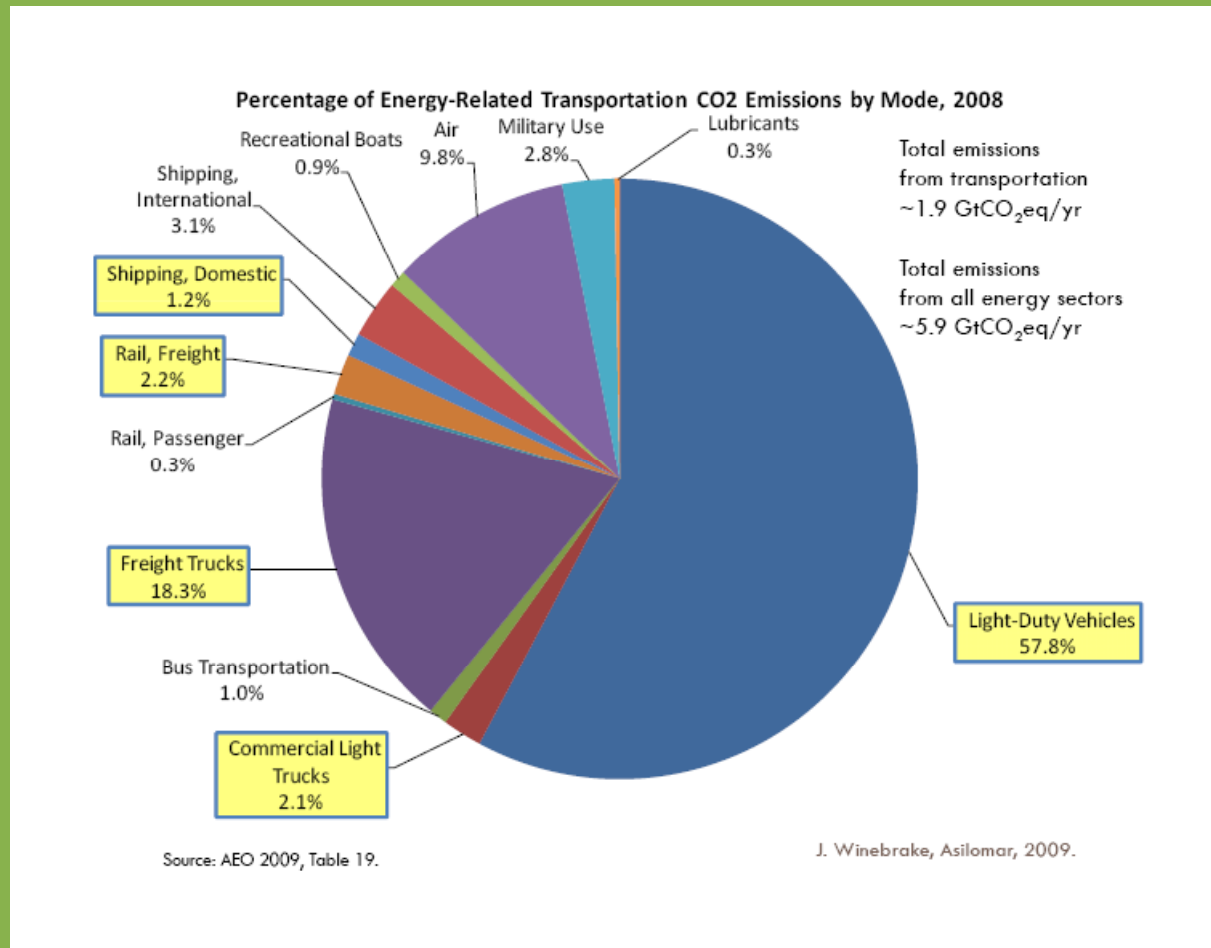
Ton-Miles v. GDP for the U.S. (1987-2005)



Source: Corbett and Winebrake, 2009.

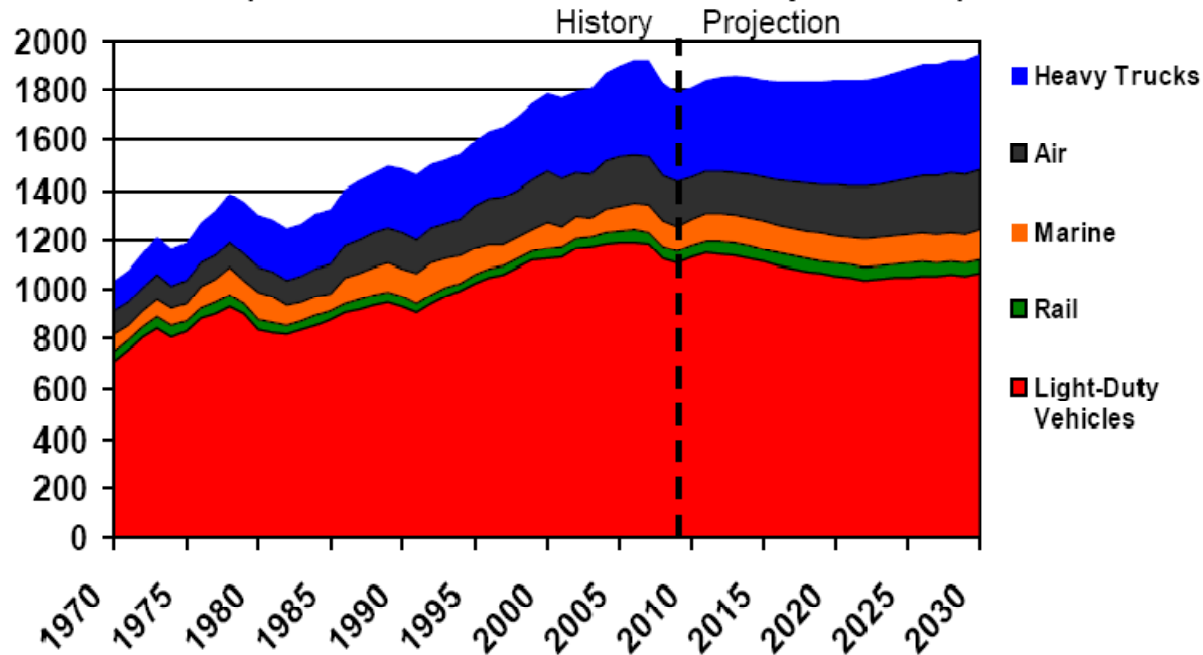
J. Winebrake, Asilomar, 2009.

Truck GHG is 20% of U.S. Transportation GHG – and Rising



Truck GHG is Growing Faster than Other Transportation GHG

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

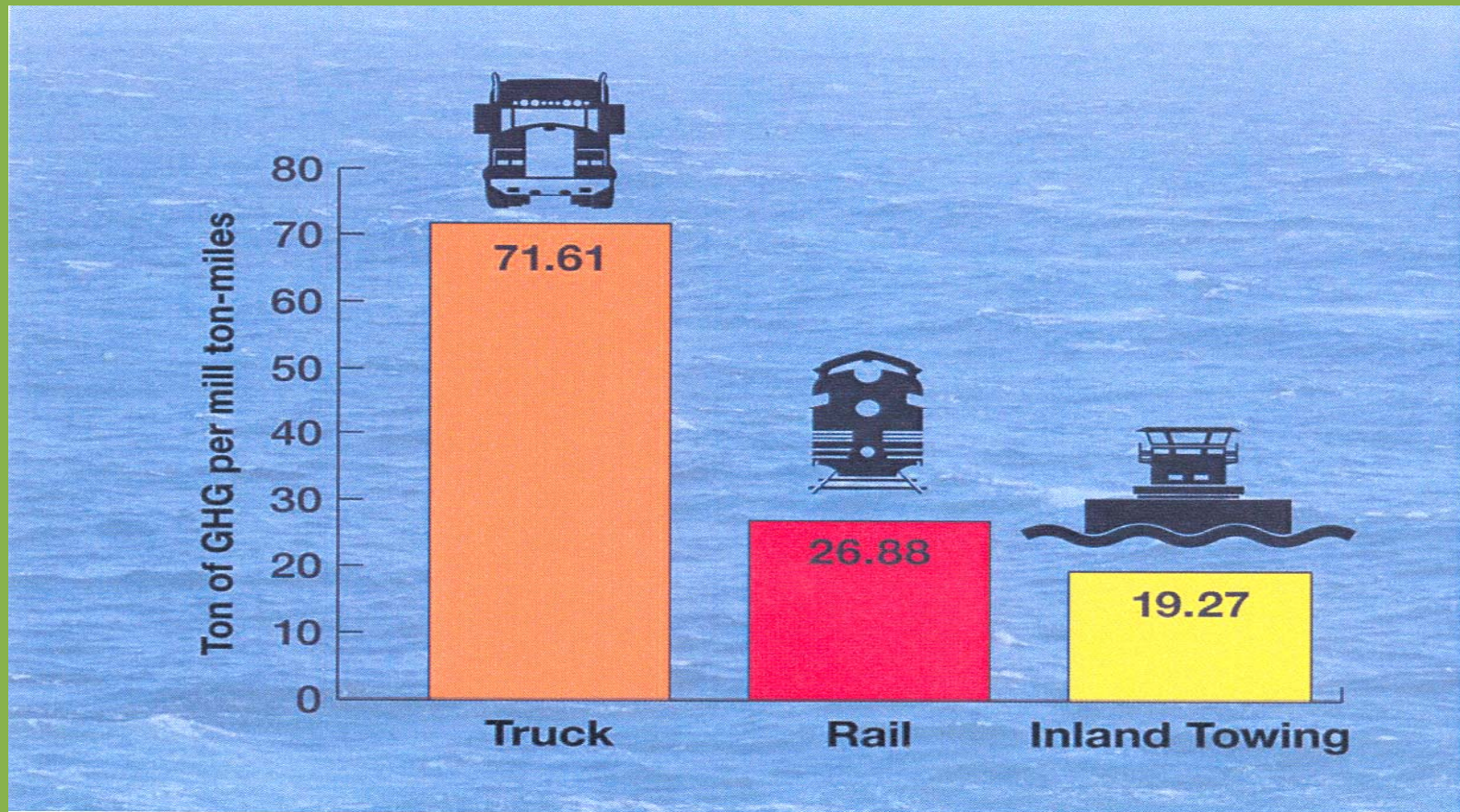


Source: History: *Transportation Energy Databook 28th Edition*
Projection: *Annual Energy Outlook 2009 Updated Reference Case d041409a*

7

Freight GHG – Barges and Rail

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
- Traffic flow improvements
- Pre-clearances at scale houses
- Truck driver training
- EPA SmartWay up-grade kits & loans & diesel retrofits

- 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
- “Black carbon” control technologies 85% retrofits

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)

33 Truck GHG “Best Practices” from NC State Report

- Off-board truck stop electrification
- Auxiliary power units for trucks
- Alternative refrigerants for trucks
- Truck aerodynamic improvements
- Wide-base truck tires
- Low-rolling resistance tires
- Hybrid trucks
- Lightweight materials
- B20 biodiesel fuel
- And more.....

Potential State DOT Strategies to Reduce HDV/MDV Truck GHG Emissions

- Speed management, traffic flow improvement, and bottleneck reductions that reduce inefficiencies in truck travel
- Programs to clear traffic incidents quickly and reduce construction zone congestion that tie up trucks
- Incentives for truck owners to retrofit or upgrade trucks to reduce GHG emissions. PM reductions also reduce black carbon.
- Support for efficient intermodal freight facilities and efficient access to seaports, rail, and marine facilities
- Programs to support freight logistics (e.g., efficient clearance at border crossings)

Potential State DOT Strategies to Reduce HDV/MDV Truck GHG Emissions (continued)

- Truck stop electrification (to reduce engine idling)
- Other programs and policies to reduce truck idling
- Truck driver training/educational programs for low-GHG driving practices
- Infrastructure changes to allow for doublestack trains
- Improvements to highway-rail grade crossings
- Support for R&D and regulations to develop and deploy technology and fuel improvements that reduce freight GHG.

Diesel Retrofits Reduce PM and Black Carbon

- Black carbon is emitted during burning of fossil fuels
- EPA conducting study on impact on GHG – due early 2011
- Diesel emissions considerable, smoke and soot
- A “forcing” agent in heating up climate, blocking sunlight
- Today’s particulate filters for on road and off road engines reduce PM up to 99%, including reductions in black carbon

Diesel Retrofits Reduce PM and Black Carbon

- On-road 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 and locomotives could be promising as state DOTs work to reduce emissions to meet potential planning requirements

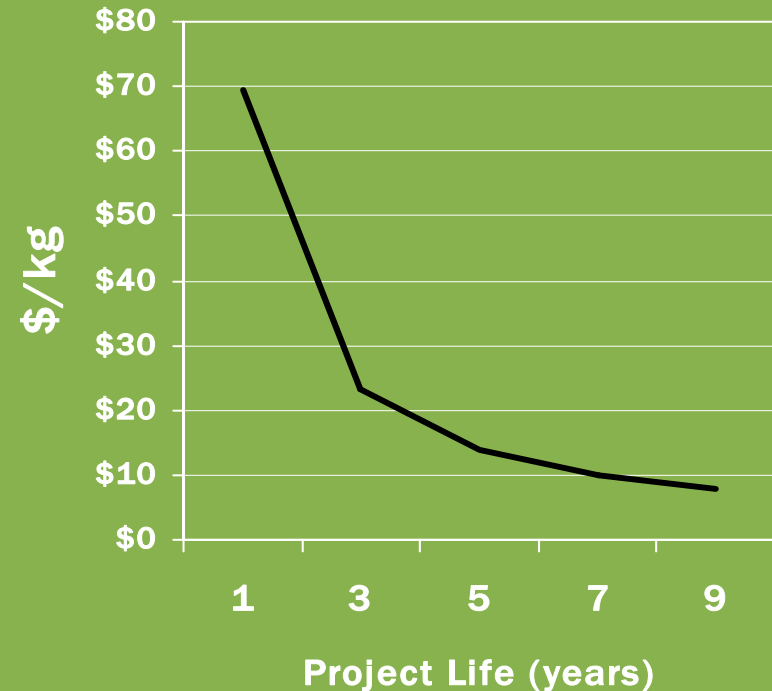
The Diesel Locomotive Retrofit Process

- Each existing locomotive is stripped from the deck up, removing the large, single diesel engine
- Three smaller, ultra-clean diesel generators are fitted onto the platform, along with control and operating equipment
- An immediate emissions reduction of 86% ozone precursors, 76% Particulate Matter, and a 25% fuel savings, with a corresponding 25% reduction in greenhouse gas CO₂ emissions, is realized following this diesel retrofit

Diesel Locomotive Retrofit Project Cost-Effectiveness

- Each locomotive diesel retrofit provides annual reductions equal to 16,100 kg/yr ozone precursors and 417 kg/yr particulate matter
- The project cost-effectiveness varies with the life of the project. Over five years, the cost-effectiveness of ozone precursor reductions is \$13.91/kg of ozone precursor reduction

Cost Effectiveness of Ozone
Precursor Reductions



A Retrofit Locomotive

- 86% reduction in ozone precursors
- 76% reduction in PM
- 25% reduction in fuel consumption



Construction, Maintenance, & Agency Operations Strategies

- Significant sources of GHG and energy use
- Many opportunities to reduce GHG and energy cost from current system:
 - LED traffic lights
 - Low carbon pavement
 - Energy-efficient buildings
 - Reduced roadside mowing
 - Solar panels on ROW
 - Alt fuels and hybrid vehicles in DOT fleets
 - Alt fuel buses

Solar Panels for Highway Lighting

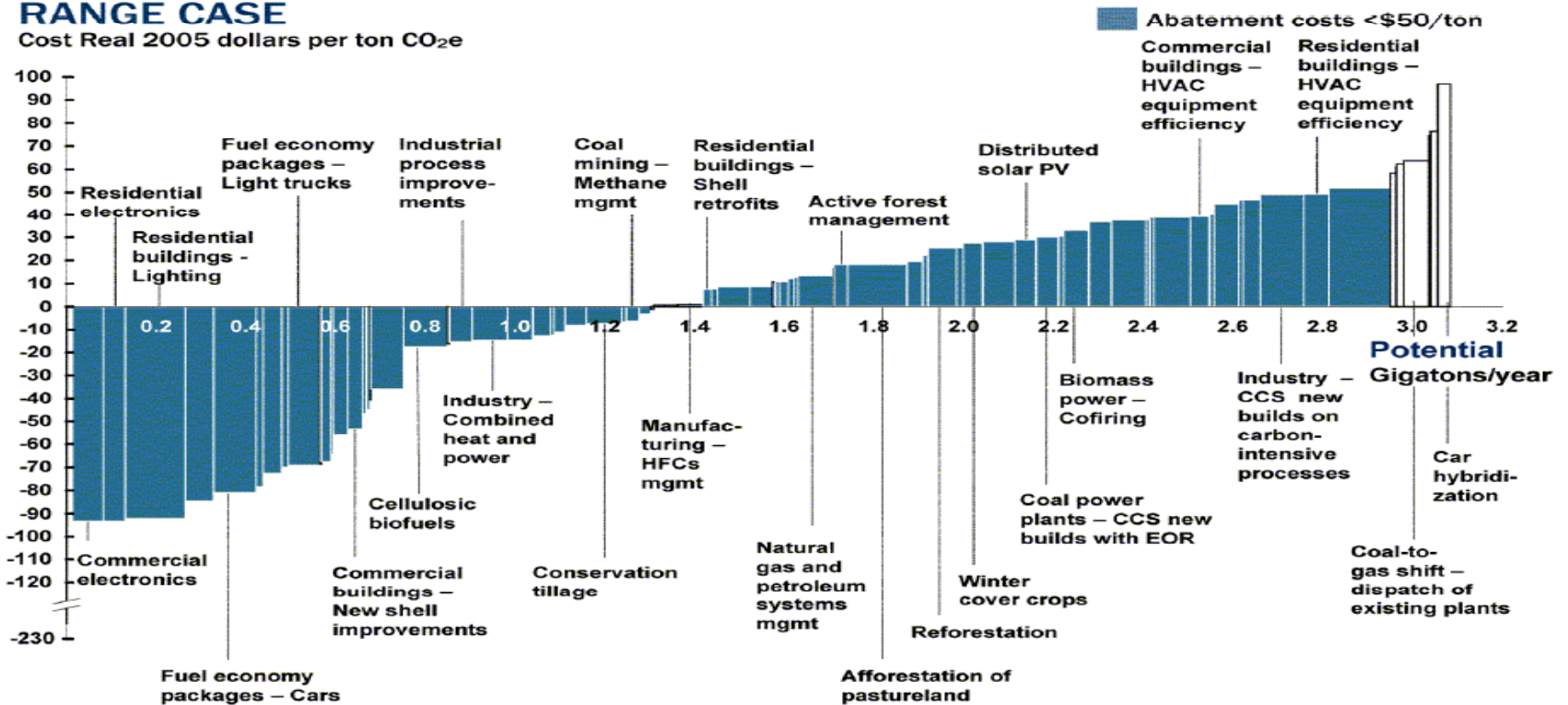
- 594 solar panels produce 122,000 KWH/year to light interchange
- Avoids nearly 43 metric tons of GHG/year from normal electricity
- \$1.28 M project in operation for over a year
- PPP of OR DOT, PGE, and US Bank, using state and federal tax credits
- Could be a model for other DOTs
- ORDOT planning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

McKinsey: Available Technologies can Reduce 3 Billion Tons GHG/Year at < \$50/ton

(compare to projected 9.7 billion tons economy-wide in 2030)

GHG REDUCTION OPPORTUNITIES WIDELY DISTRIBUTED - 2030 MID-RANGE CASE

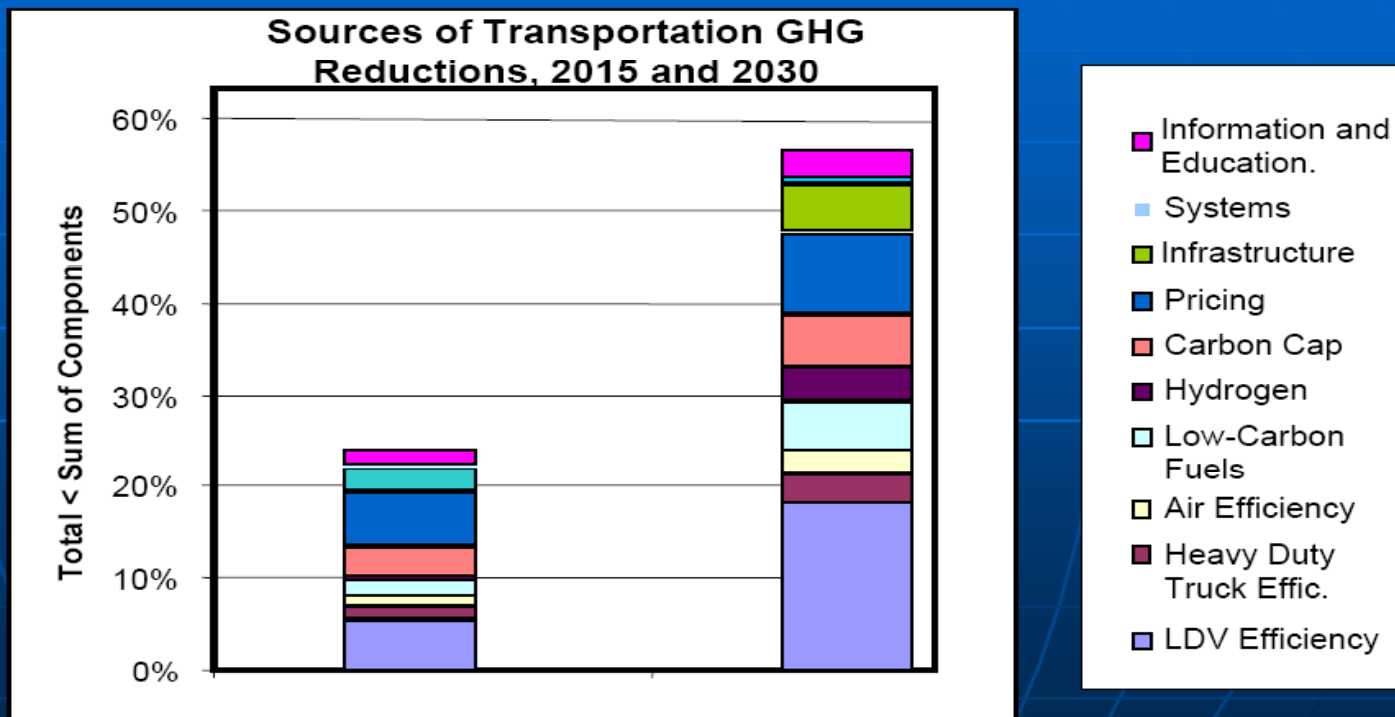
Cost Real 2005 dollars per ton CO_{2e}



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.

One Scenario to Achieve 50% Transport GHG Reduction by 2030

Greene & Schafer (Pew Center, 2003) concluded that a comprehensive, tailored set of strategies could cut U.S. transportation emissions in half by 2030.



Source: Greene and Schafer, Pew Center on Global Climate Change, May 2003.

European View of Transport GHG Strategies

(European Council of Ministers of Transport, 2006)

- “The most effective measures available include *fuel taxes, vehicle and component standards, differentiated vehicle taxation, support for eco-driving and incentives for more efficient logistic organization, including point of use pricing for roads.*”
- “More integrated transport and spatial planning policies might contain demand for motorized transport.”
- Mode shifts ... cannot ... form the corner-stone of effective CO2 abatement policy and the prominence given to modal shift policies is at odds with indications that most modal shift policies achieve much lower abatement levels than measures focusing on fuel efficiency.”
- “Ultimately higher cost energy sources will be required if there are to be further cuts in transport sector CO2 emissions.”

Summary

Many strategies are needed to reduce transport GHG. No silver bullet. Will need full mix of strategies including:

- Maximize energy efficiency of current vehicle technology
- Decarbonize vehicles and fuels world-wide
- Adopt pricing measures to reward conservation and tech innovation
- Push “eco driving” and system/speed management
- Adopt more efficient land use
- Support carpools & vanpools, biking, walking, transit use, trip chaining, telecommuting
- Adopt low carbon, energy-conserving strategies in construction, maintenance, and agency operations
- Implement wide-ranging freight technology and logistics improvements

VII. Participant Workshop



Participant Workshop

A working session in break-out groups to identify an initial set of activities for West Virginia DOT to get started with:

- (a) GHG reduction strategies and framework;
- (b) Climate adaptation planning;
- (c) Public communication strategies;
- (d) Outreach/collaboration with other agencies and organizations.

INFORMATION RESOURCES



Resources -- Websites

- AASHTO: <http://realsolutions.transportation.org/Pages/default.aspx>
- 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”

The Primer


<http://downloads.transportation.org/ClimateChange.pdf>

Primer on Transportation and Climate Change

April 2008




AASHTO - Real Transportation Solutions



Real Transportation Solutions for Greenhouse Gas Emissions Reductions

Autos and light-duty trucks contribute 16.5 percent of the greenhouse gases in the United States. States are looking at the best ways to reduce these emissions while sustaining the transportation services people and businesses depend upon. We are committed to doing our part to help achieve the goal of reducing U.S. greenhouse gas (GHG) emissions 80 percent by 2050. Our strategies include:

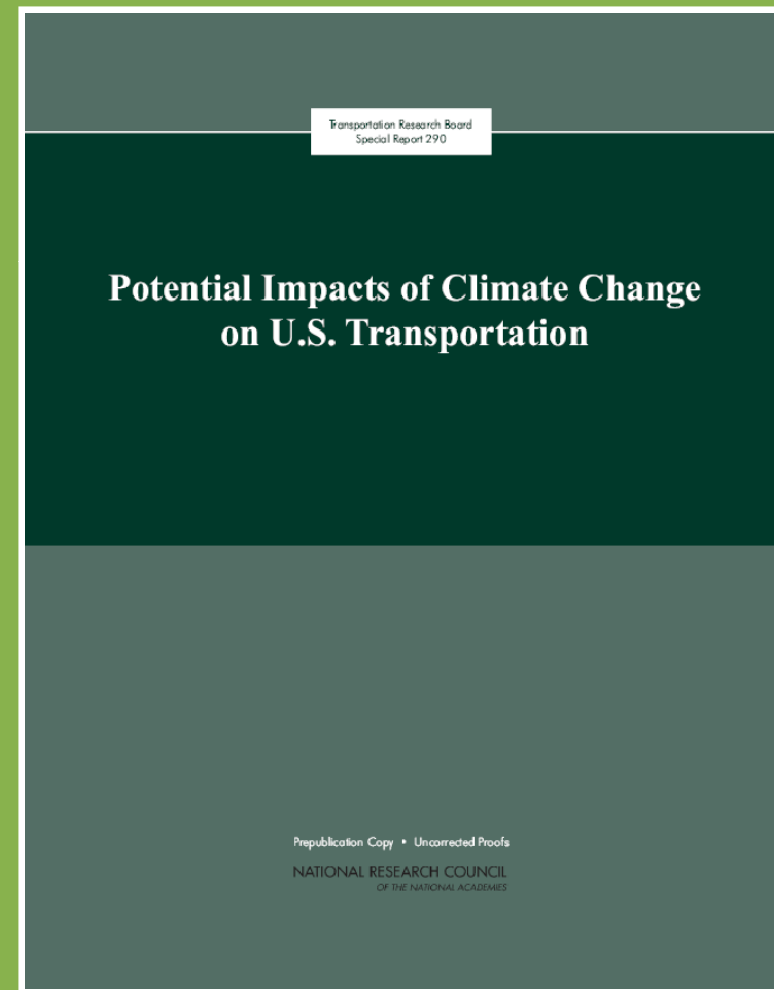
1. **Smarter Travel:** Reduce the rate of growth in the number of vehicle miles traveled (VMT) in the United States.
2. **Better Cars:** Increase vehicle fuel efficiency.
3. **Better Fuels:** Shift to fuels that produce low or zero carbon dioxide emissions.
4. **Optimize the System:** Improve the efficiency and operation of our roads.



<http://www.transportation1.org/RealSolutions/RealSolutionsReport.pdf>

TRB Special Report 290

<http://onlinepubs.trb.org/onlinepubs/sr/sr290.pdf>



Pew Center on Global Climate Change

<http://www.pewclimate.org/global-warming-basics>

CLIMATE CHANGE 101 Understanding and Responding to Global Climate Change

Overview

Science and Impacts

Technological Solutions

Business Solutions

International Action

State Action

Local Action



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:

Shannon Eggleston at AASHTO (202) 624-3649

seggleston@aaashto.org

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