Climate Change
Information, Challenges and Strategies

A WORKSHOP FOR

MISSOURI DEPARTMENT OF TRANSPORTATION

June 17, 2010

Workshop Purpose

- What is climate change?
- How will it affect state DOTs?
- Will there be federal legislation on climate change?
- How could federal climate change legislation affect Missouri DOT and other state DOTs?
- What are other states doing on climate change?
- What are proposed CEQ-NEPA requirements?
- How can state DOTs reduce transportation GHG?

Workshop Overview

I. The Importance of Climate Change to State DOTs
II. Federal Legislation
III. Planning and NEPA Issues
IV. Climate Adaptation for Transportation
V. Strategies to Reduce GHG Emissions from Transportation Sources
VI. Participant Workshop
VII. Wrap-up and Next Steps Discussion

I. The Importance of Climate Change for State DOTs

Climate Change is Important to State DOTs
TRB Executive Committee View

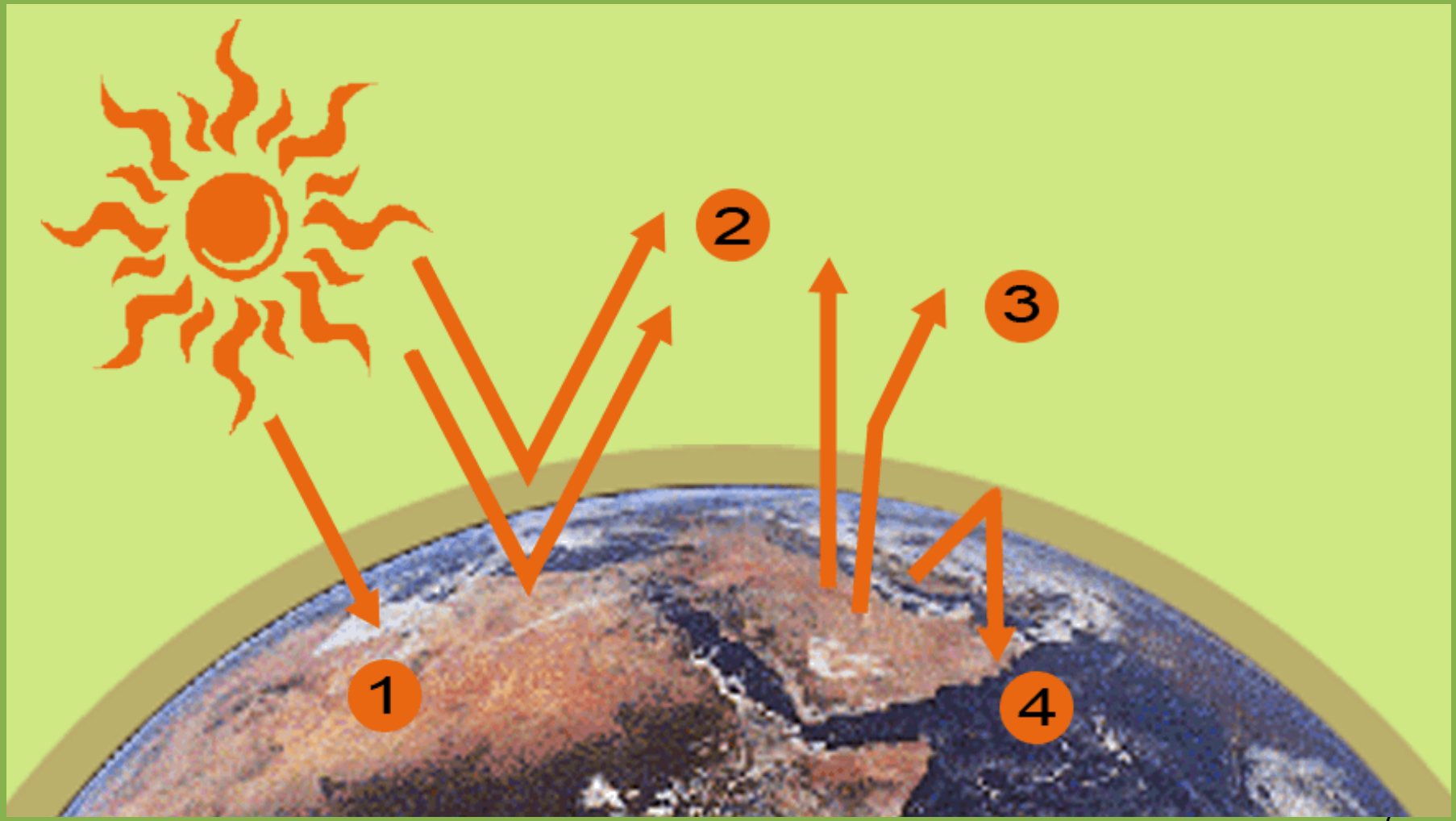
- Moving away from our dependence on oil and reducing GHG emissions will be the greatest challenge to decision-making for transportation policies, programs, and investments in the coming decades.
- Other sectors are moving on climate change policies faster than transportation
- States are adopting sweeping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

- TRB Executive Committee , June 2008

Climate Change is Important to State DOTs
Additional Reasons

- Energy constraints and costs
- Federal legislation
- Federal policies – auto standards, NEPA, transportation funding priorities, planning emphases, etc.
- Declining transportation revenues due to energy and climate policies
- Increasing scientific evidence of climate change
- Adapting to climate impacts

The “Greenhouse Effect” – How it Contributes to Climate Change



Evidence of Climate Change is Mounting

- 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 late1800s.
- **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.
- 6 of the 10 most active hurricane seasons have occurred since the mid-1990s.

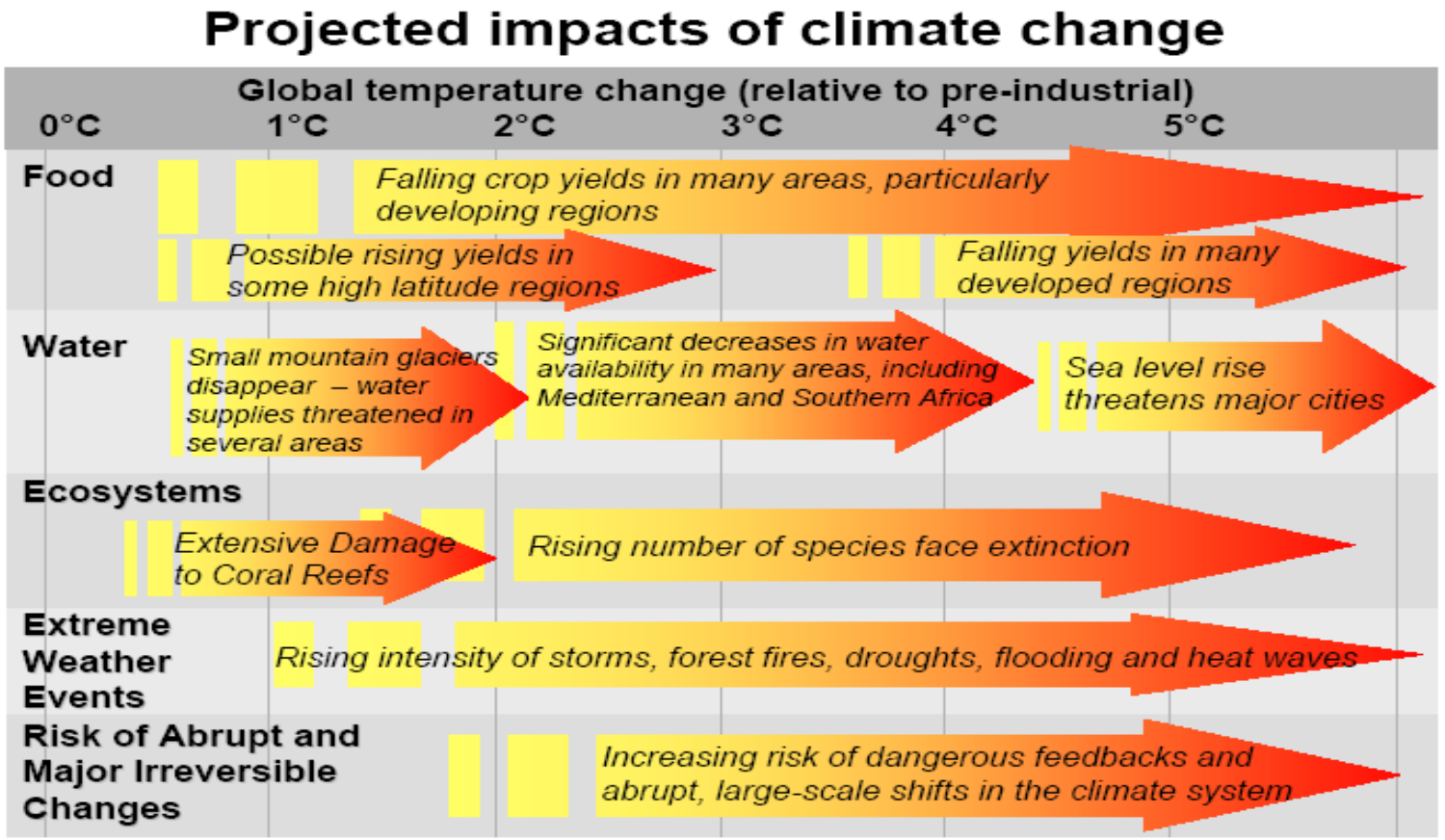
Source: EPA, Climate Change Indicators in the U.S., May 2010

Evidence of Climate Change is Mounting
(continued)

- **Average length of the growing season in the lower 48 states has increased by about two weeks since the 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.**
- 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.

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

Climate Impacts Will Intensify



Mainstream Companies Call for Congressional Action on Climate Change

The 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.

Energy Costs will Rise – Wal-Mart Perspective

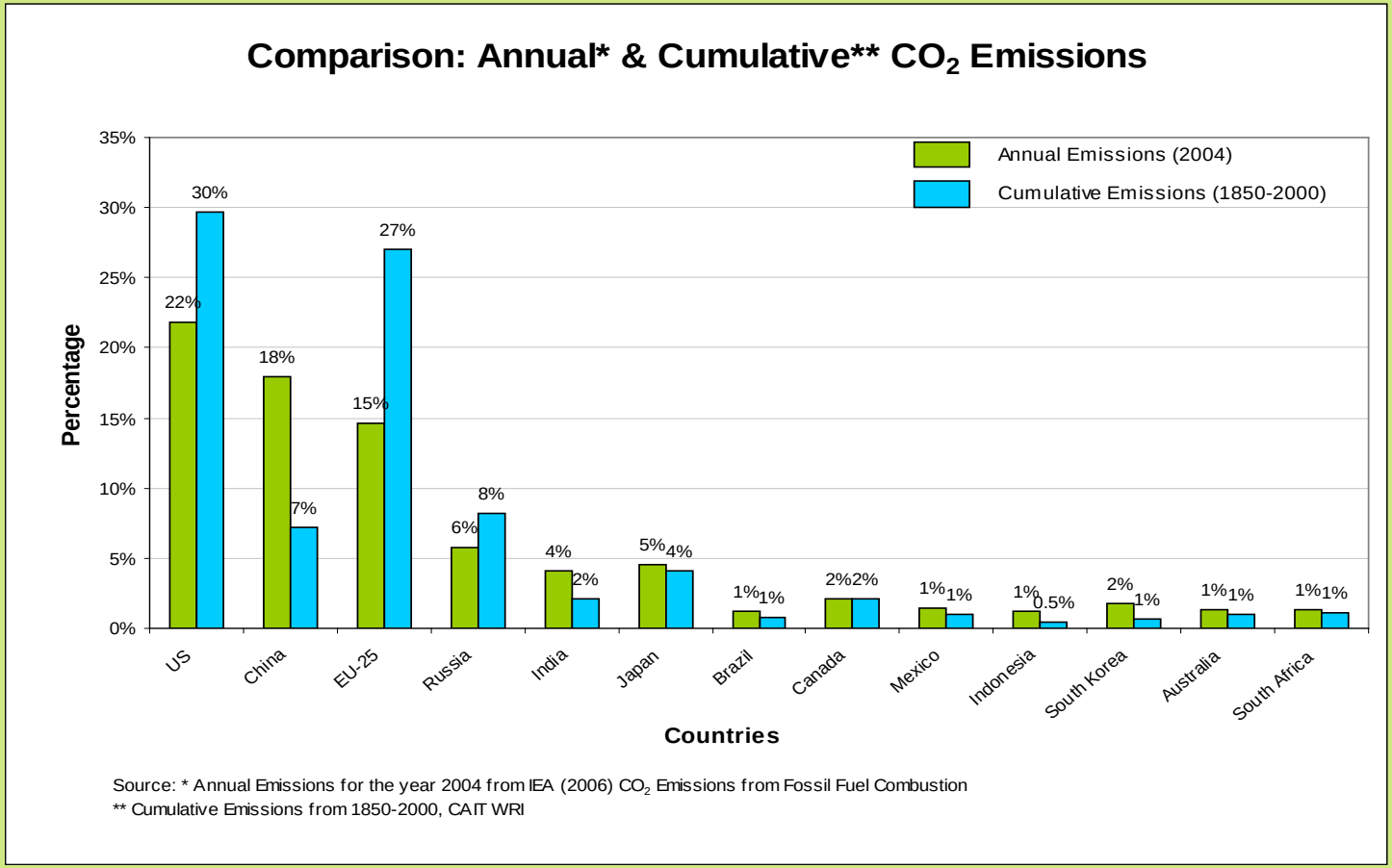
"We know we need to get ready for a world in which energy will only be more expensive."

-- Wal-Mart

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 labelling clothes as cold-water wash.

Sources of GHG – by Country



GHG Targets Are Daunting

- 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
- Kerry-Lieberman bill: 17% below 2005 by 2020 and 83% below 2005 by 2050

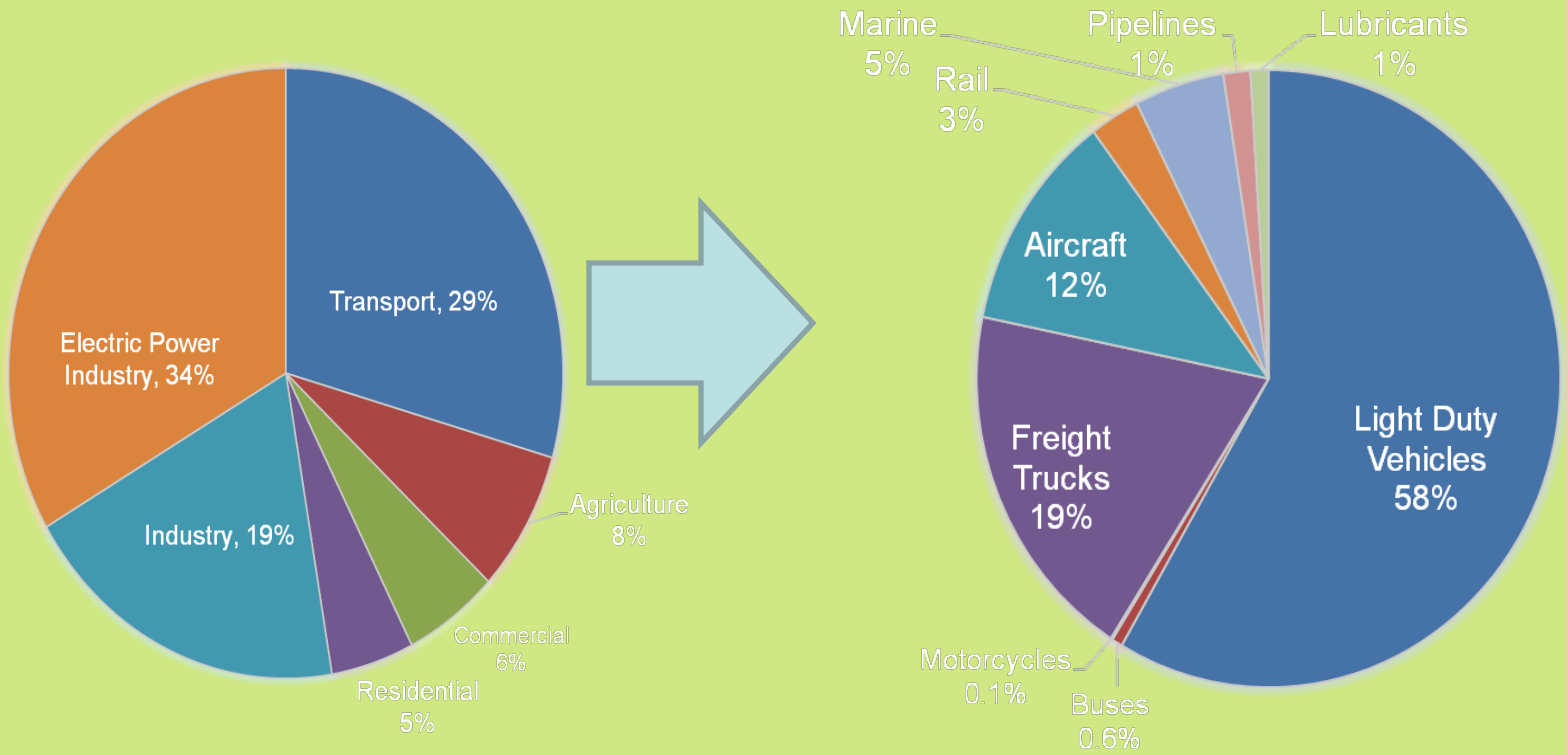
What will transportation GHG targets be?

- 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.

Transportation GHG

Source: US DOT Report to Congress, 2010



GHG Trends in U.S.

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

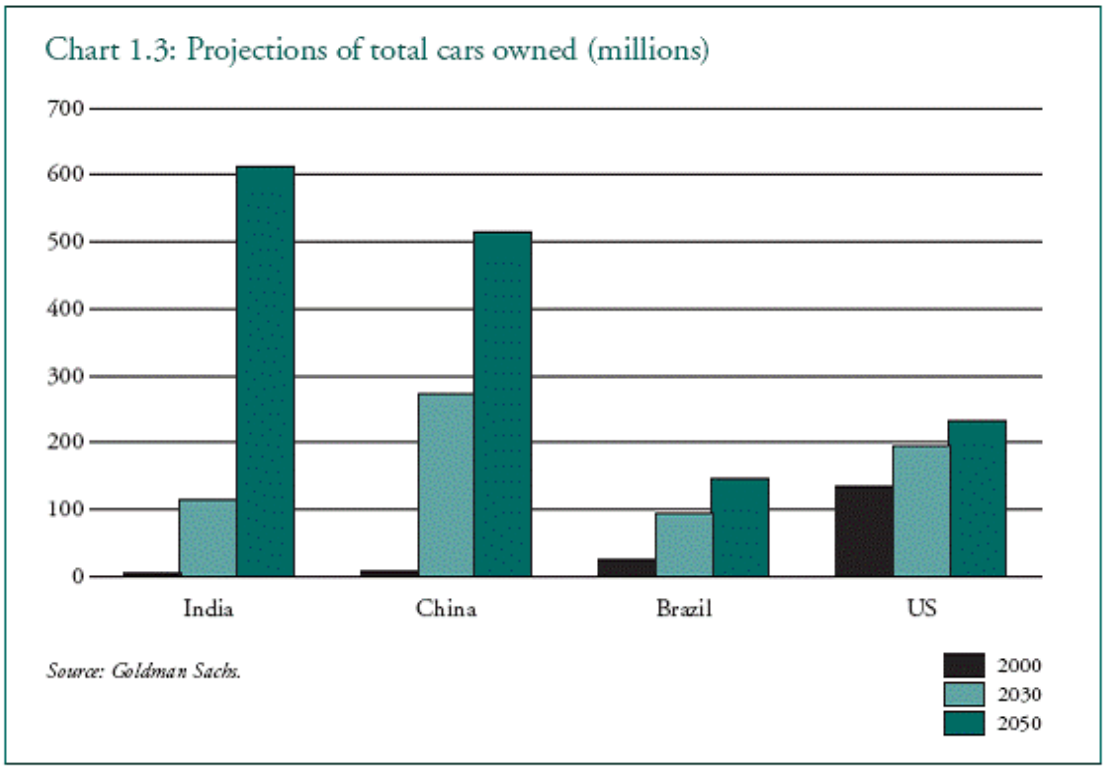
	Change, 1990-2006
All U.S. GHG Sources	15%
U.S. Transportation	27%
Light Duty Vehicles	24%
Freight Trucks	77%
Commercial Aircraft	4%

Transportation GHG Trends

- **U.S.**: GHG from all transportation modes are projected to remain almost constant through 2030 – but light duty vehicle GHGs will actually decline slightly and freight GHG will increase significantly.

- **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.

Global Trends in Car 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 by 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.

Vehicle “Decarbonization”

“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.”

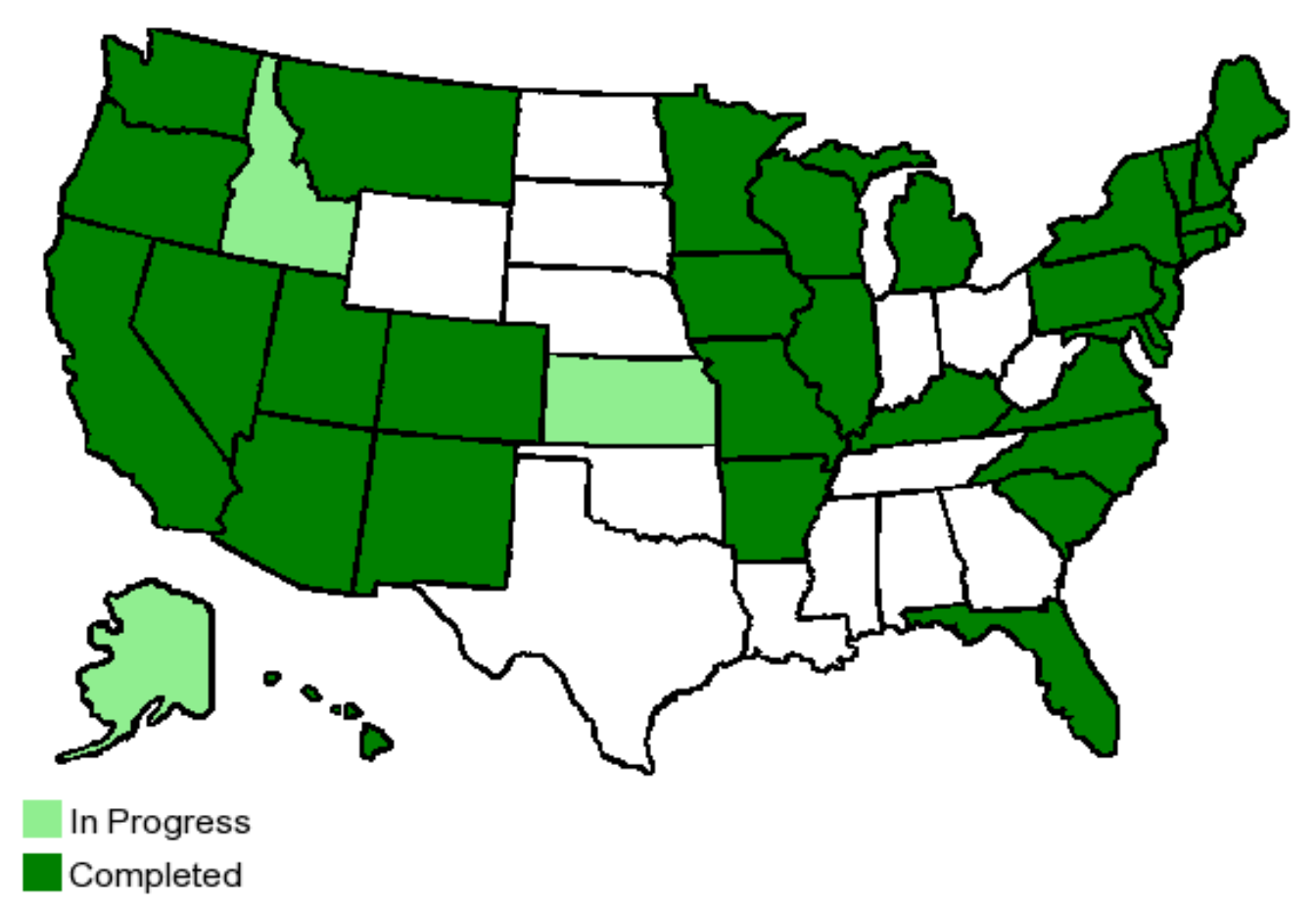
-- Sir Nicholas Stern, Stern Review to the U.K. Government, 2007

Other State DOTs – Climate Change Activities

- 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
- Florida: http://www.dep.state.fl.us/climatechange/files/action_plan/chap5_trans.pdf.

State Climate Action Plans

Source: Pew Center on Climate Change



State Climate 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 B (base case) to 3.9 B

State Climate Plans – Wide Variations

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 – Wide Variations

State	Year	Vehicle	Low Carbon Fuels	Smart Growth and Transit	Other
Rhode Island	2020	46%	10%	31%	14%
North Carolina	2020	35%	12%	38%	15%
South Carolina	2020	14%	55%	29%	1%
Connecticut	2020	51%	38%	8%	2%
Maine	2020	53%	25%	21%	1%
Maryland	2025	24%	12%	45%	20%
New York	2020	59%	11%	27%	4%
Pennsylvania	2025	45%	36%	18%	0%
Minnesota	2025	15%	35%	25%	25%
Vermont	2028	21%	14%	49%	17%

Summary

Climate change is important to state DOTs:

- Energy costs
- Federal legislation
- Federal policies
- Effect on transportation revenue stream
- Increasing scientific evidence
- Climate impacts on transportation infrastructure

Transportation is a large & rising share of GHG

GHG reduction targets are daunting

Many states and private companies are actively engaged in climate change

II. Federal Climate Change Legislation

Federal Climate Legislation and Policy are Taking Shape

- AASHTO position
- EPA proposed “endangerment” finding
- (section 202(a) of CAA
- “Cap and Trade” bills
- 2010 Senate Bill - Kerry-Lieberman

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.climatechange.transportation.org/

Clean Air Act – EPA 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)
- GHG conformity possible, but not likely
- Endangerment finding challenged by several states

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: Kerry-Lieberman “discussion draft” bill released May 12, 2010
- Many other bills have also been introduced
- President Obama: Strongly supports cap-and-trade legislation

Federal Legislation – Major Elements of Climate Bills

- **Cap-and-Trade**
  - Sets "cap" on GHG emissions; cap declines over time
- **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 – buildings, appliances, vehicles, etc.
- **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

2010 Senate Bill: Kerry-Lieberman – American Power Act

- "Discussion draft" released May 12, 2010
- Calls for reductions from 2005 baseline
  - 17% by 2020
  - 42% by 2030
  - 83% by 2050
- Sets national GHG emissions cap
  - Transportation fuels under the cap
  - Tptn fuel producers and importers would purchase emissions allowances at a fixed price ($12 - $25/ton carbon)
  - Tptn carbon price would increase at 3% over inflation/year)
- Imposes transportation planning requirements on states & large MPOs
- Many, many other provisions, affecting all sectors

How much revenue would K-L provide for transportation?

- K-L doesn't allocate dollars to transportation – but does allocate "percentages of allowances" which can be sold and converted into dollars
- Value of allowances will fluctuate but can be estimated
- K-L caps the value of allowances for transportation at **$6.2 billion per year** (without the cap, the value could be higher)
- AASHTO/APTA estimate that 70-90% of revenues from transportation fuels are diverted to other purposes (deficit reduction, transition assistance to households, R&D, etc.)

How could the K-L allowances revenue be used for transportation?

$6.25 billion annually -- maximum

- One-third to Highway Trust Fund up to $2.5 b/yr
- One-third to TIGER grant program $1.875 b/yr
- One third for transportation planning and implementation $1.875 b/yr

What are the K-L requirements for transportation planning?

States and large MPOs (over 200,000 population) must:

- Develop GHG targets and strategies
- Integrate GHG targets and strategies into plans
- Demonstrate progress in stabilizing and reducing GHG emissions to contribute to achievement of national targets

US EPA is to:

- Issue regulations for standardized emissions models and methods

US DOT is to:

- Determine whether state and MPO plans are “likely to achieve” GHG reduction targets
- Provide performance awards ($) for states with approved plans
- Issue regulations for GHG planning (overlaps with EPA regs)

Federal Transportation Planning Provisions are Similar to CA SB375 Law

- Proposed Federal planning provisions are similar to California's SB375 law
- SB 375 would require GHG targets for metro areas to reduce LDV GHG, planning process, prescribed methodologies, strategies, etc.
- SB 375 effect on GHG is likely to be small - 5 MMT in CA (**3% of CA's LDV GHG**) in 2020 – preliminary estimate from CARB

Federal Climate Legislation – Impact on Transportation Fuel Prices

- **How would the House and Senate bills affect the price of transportation fuels?**
  - EPA 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 2010 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.

House and Senate Bills Have Small Impact on Transportation GHG

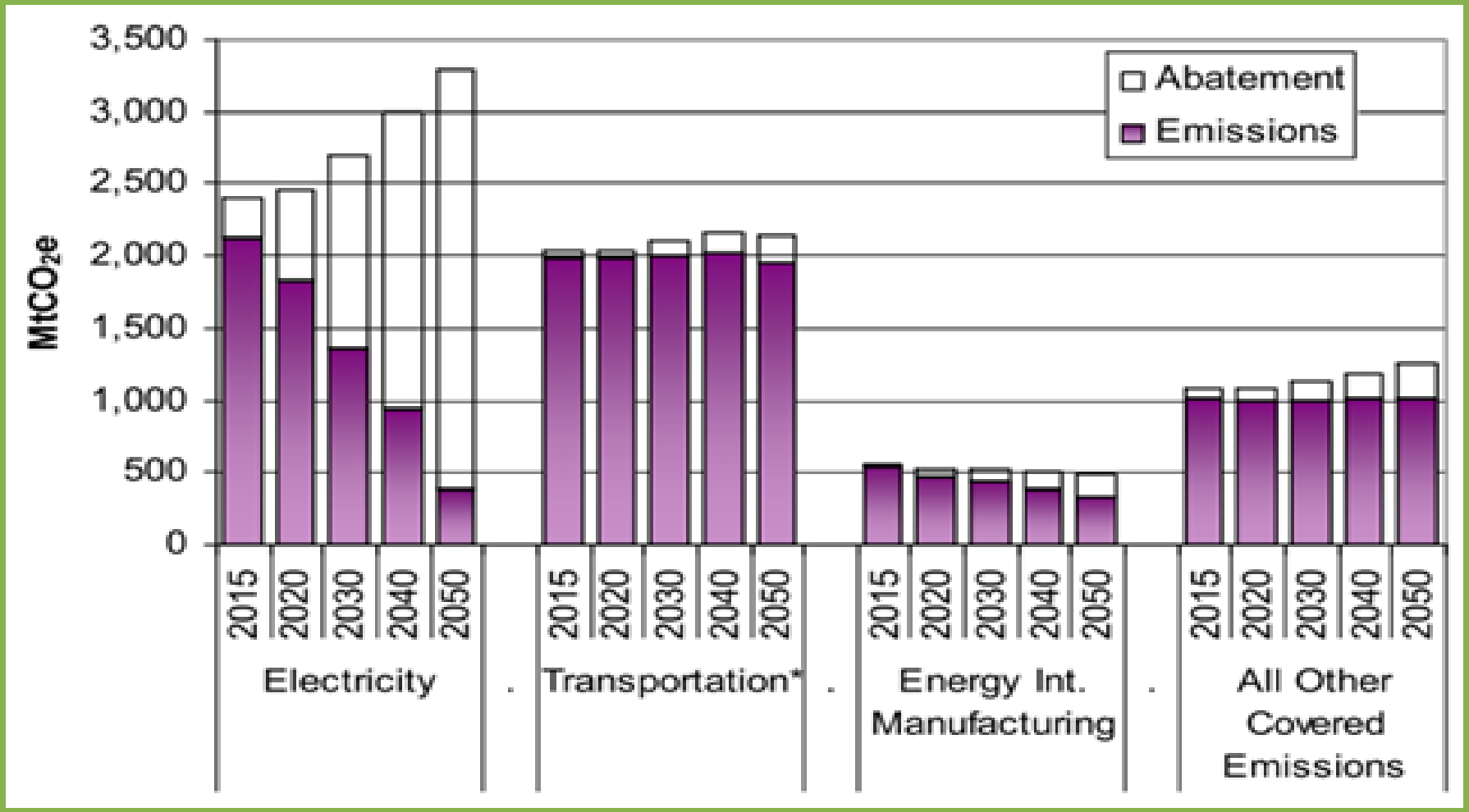
EPA projects that the price signal from cap-and-trade would have little effect on transportation emissions

"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

Estimated GHG Reductions from H.R.2454 (Waxman-Markey) – EPA Numbers



Summary

- AASHTO's position emphasizes R&D, moderating VMT, capturing revenue, and supporting transit, rail, and land use
- Federal policies are already being advanced under current laws
- Federal climate legislation is in play – many bills, many variables, uncertain timing
- Federal transportation planning requirements are similar in multiple bills
- Federal climate bills would raise gas prices and generate significant revenue from transportation fuel use -- but only small amount of revenue would be returned to transportation use – and this could pre-empt gas tax increases to solve transportation revenue gaps

III. Planning and NEPA Issues

New Federal Planning Requirements are Very Likely

- House 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 – Transportation GHG 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 passsenger? passenger only?)
7. How will through-traffic GHG be counted?
8. How will state GHG planning and MPO GHG planning mesh?

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 Can Analyze Many Different Strategies

Fuel Economy And Costs

Urban Planning

Vehicles & Fuels

NEPA: Draft CEQ Guidance

- Draft issued by CEQ on February 18, 2010
- Comments were 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, and,*
  - Consider *impact of climate change on the project*
- AASHTO provided extensive comments

CEQ Proposal: GHG Emissions to be Considered on a Project Level

- Cumulative emissions over the life of the project
- Emissions from vehicles using the highway
- Construction-related emissions
- Up-stream emissions from fueling cycle (drilling, refining, shipping, etc.) and vehicle cycle
- Others?
- Life-cycle emissions?
- Emissions effects of land use changes, roadway maintenance and lighting, etc.

CEQ Proposal: Roadway/GHG Emissions

- 25,000 metric tons = 43,000,000 VMT/year or about 120,000 VMT/day
- 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: Projects Potentially Triggering GHG Analysis Under CEQ Proposal

- 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: Future Roadway GHG Emissions

- 25,000 tons 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 are old
- 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)**	**CO2, 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: 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

AASHTO Comments on CEQ Proposal

- Planning process is the appropriate venue for developing and implementing GHG reduction strategies not project level
- Project-level analysis not meaningful
  - Inadaquate tools
  - Global emissions vs project-level analysis disconnect
  - Basis for 25,000 mmte threshold?
- Major emphasis on adaptation needed in transportation policy

NEPA: Bottom Line

It all depends…

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

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 in OR-WA

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

- Transportation planning process will need to consider GHG emissions and climate change impacts
- 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

IV. Climate Adaptation for Transportation

Why Transportation Agencies Should Plan for Adaptation

- All states
  - More severe storms
  - Increased flooding
  - Heat spikes
  - Pavement and rail buckling
  - Changes in precipitation patterns
  - Increased maintenance
- Coastal states
  - Sea level rise
  - Storm surges
  - Destruction of bridges
  - Beach erosion & permanent inundation of roads
  - Disruption of evacuation routes & road network

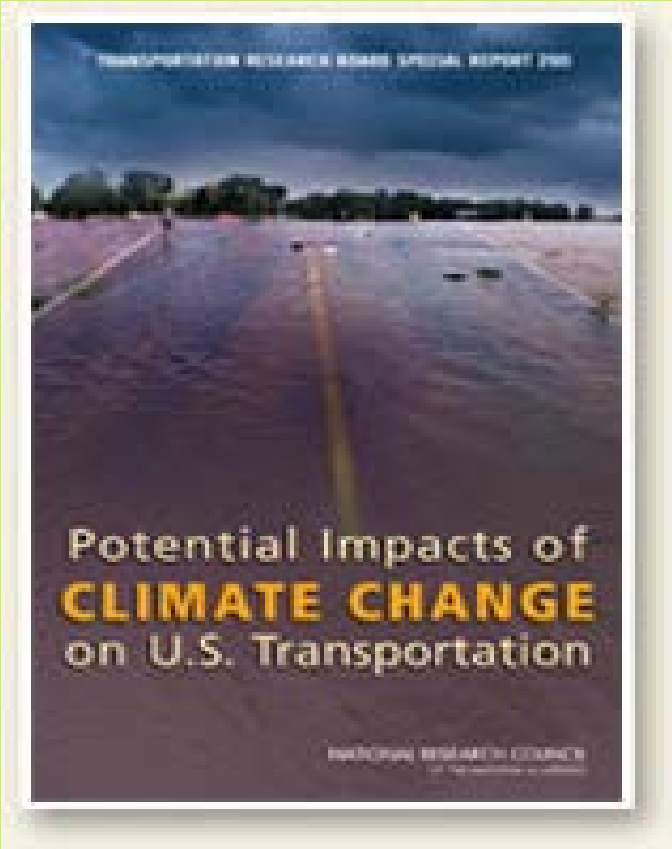
Source: http://mceer.buffalo.edu/research/Reconnaissance/Katrina8-28-05/05BiloxiBay1/09lg.jpg

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

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.

FHWA Regional Climate Change Effects Report

(Issued May 2010)

- Summarizes current science *
- 9 regions (Midwest is one of the regions)
- Projects climate *changes* by region:
  - Annual and seasonal temperature (change in ^{o}F)
  - Seasonal precipitation (% change)
  - Where information exists:
    - Sea level rise
    - Storm activity
- Short, medium and long term
- Based on low and high GHG emission scenarios
- Assistance from climate experts -- NOAA, USGS, DOE

* Science is progressing, expect information to improve over next 3-5 years

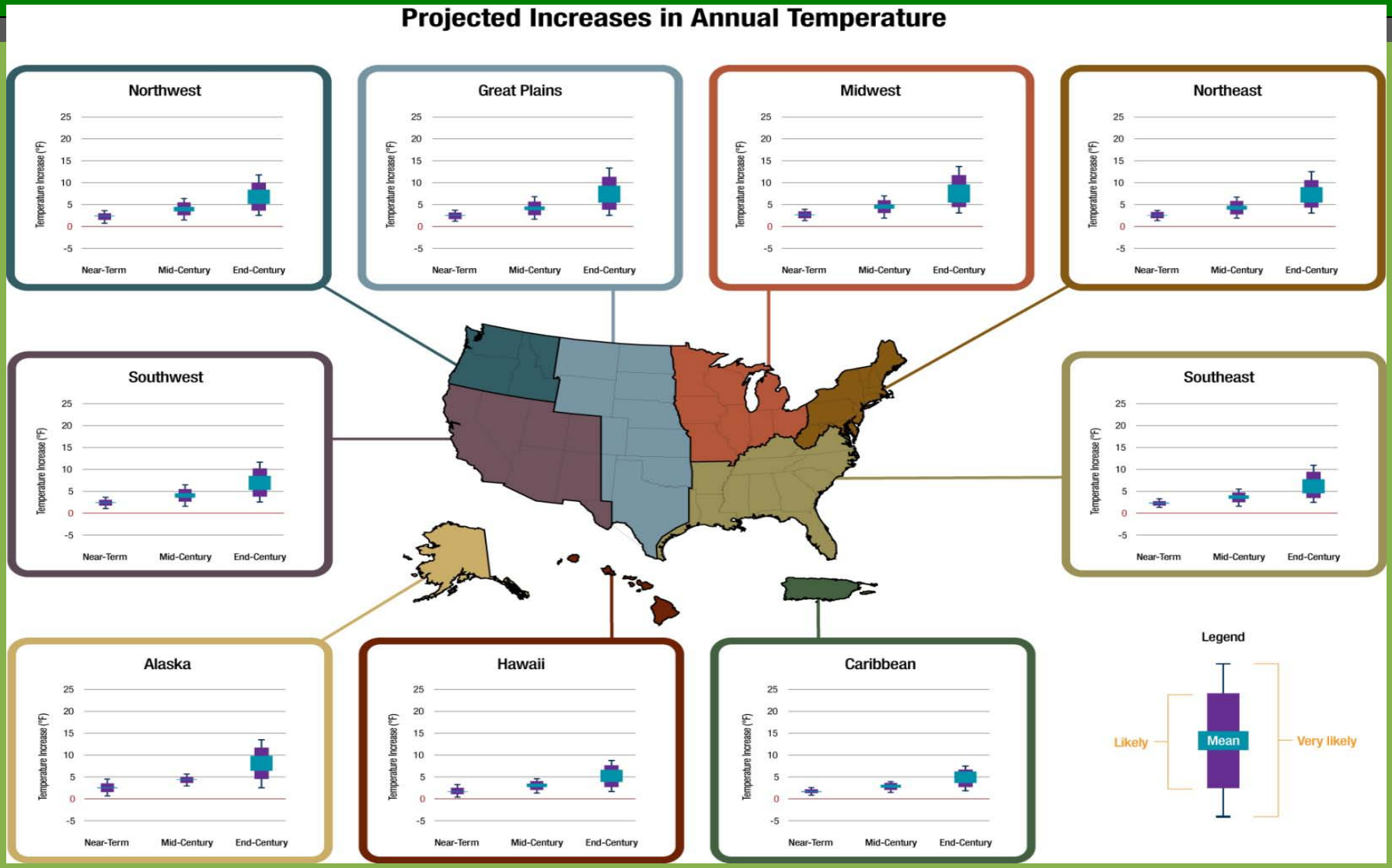
FHWA Regional Climate Change Effects Report
(Issued May 2010)

Section 3.5 – Midwest:

- 2.7 degree F increase in annual mean temperature within next 2 decades
- 4-5 degree F increase in annual mean temperatures by mid-century
- Heat waves longer, hotter, and more frequent by end of century
- 65-85 days/year over 90 degrees F by end of century
- Freezing days in MN decline from 170 (in 1961-1979) to 110 (in 2080-2099)
- Winter precipitation could increase by 8-9%
- Summer precipitation could decrease 1-4%
- Increased likelihood of summer-time drought
- Disagreement among studies on precipitation

FHWA Regional Climate Change Effects Report

(Issued May 2010)



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

What are Possible Adaptation Responses for State DOTs?

- Accommodate (maintain and manage)
  - Absorb increased maintenance / repair costs
  - Improve real-time response to severe events
- Strengthen structures / protect facilities
  - Design changes when rebuilding / new investment
  - Promote buffers, sea walls, etc.
- Relocate / avoid
  - Move key facilities
  - Site new facilities in less vulnerable locations
- Abandon and disinvest
- Enhance redundancy
  - Identify system alternatives

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

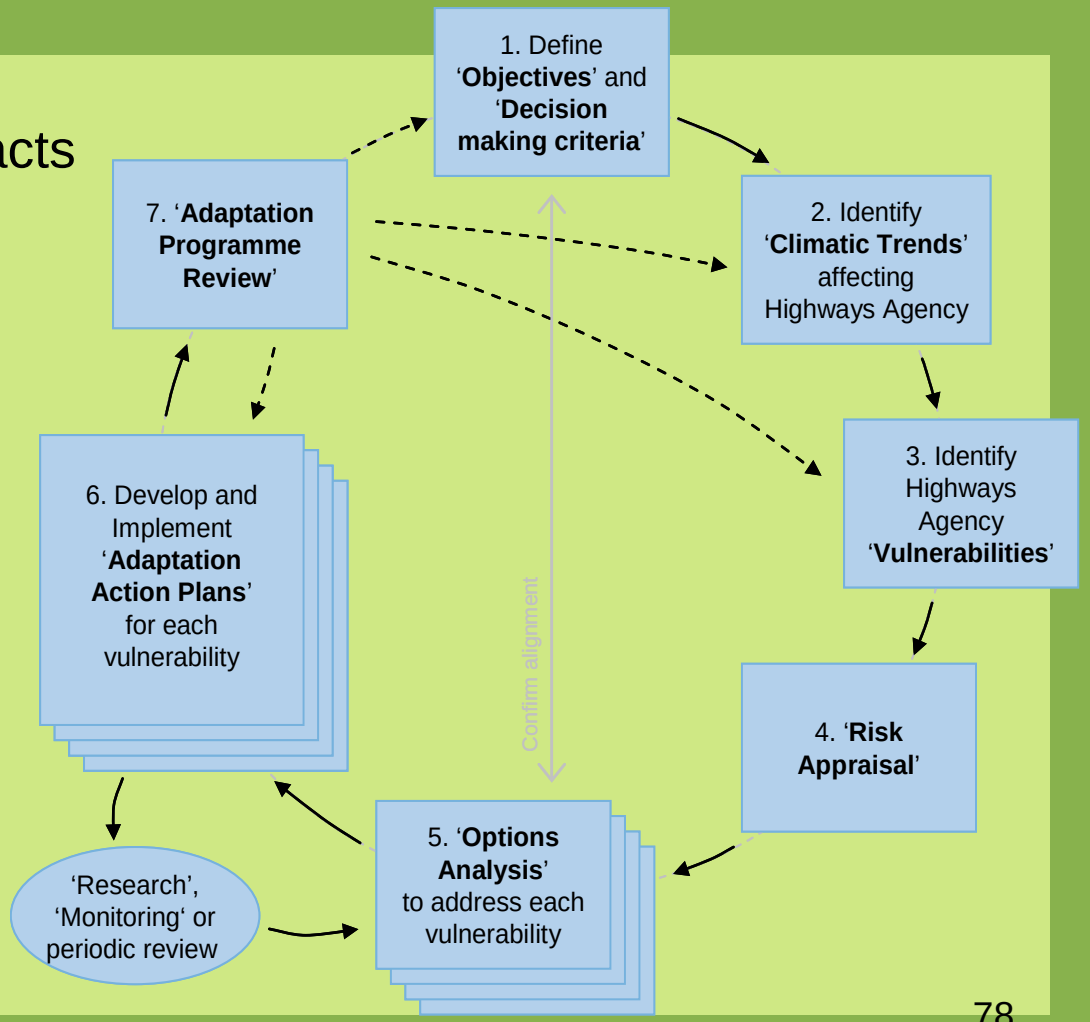
- Pavement rutting and rail buckling
- Longer construction season
- Closures and detours due to rock slides, soil erosion, flooding
- Speed reductions
- Flooding of culverts
- Change in weight restrictions
- More grass cutting/less snow plowing
- Work crew limitations during severe heat periods

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

U.K. Highways Agency Adaptation Framework

- 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**?

V. Strategies to Reduce Transportation GHG

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

2010 NHTSA/EPA Rules Significantly Reduces 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%

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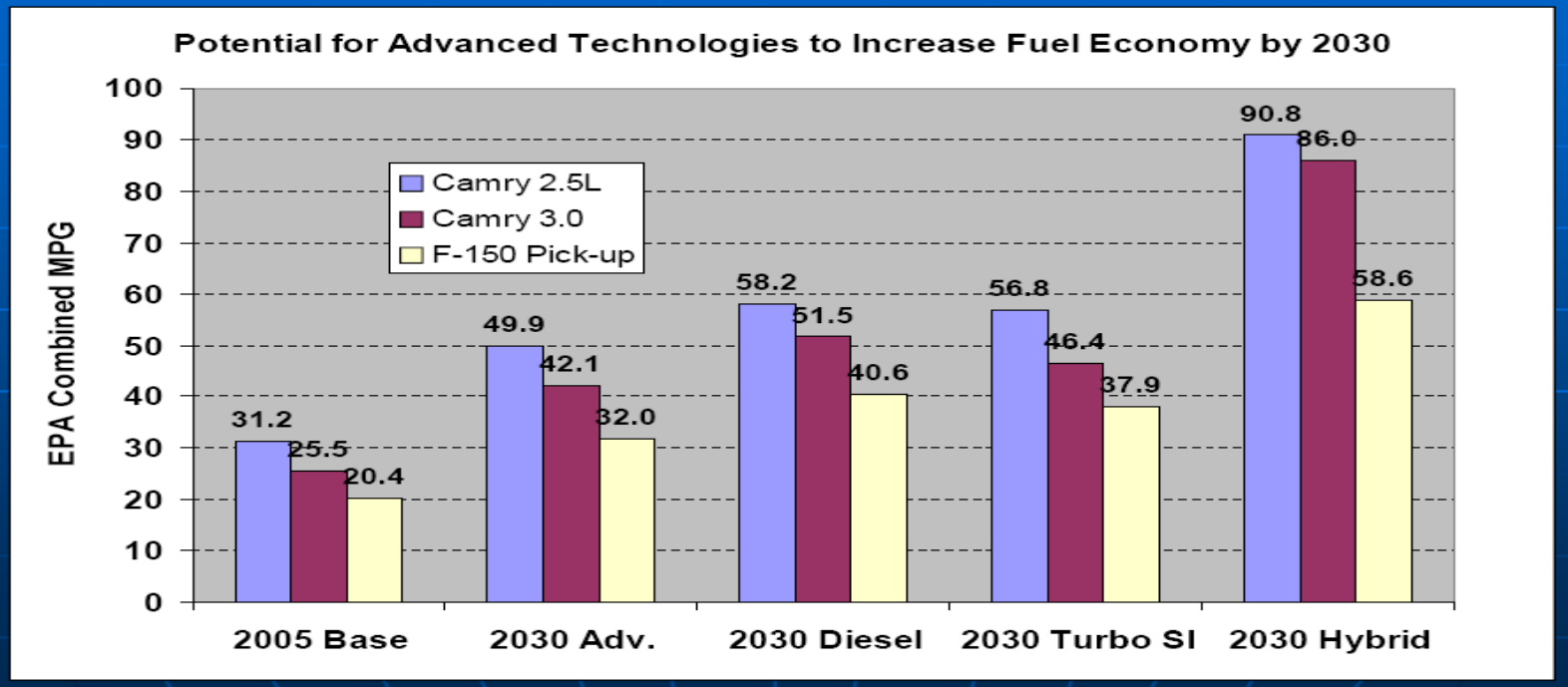
Potential Fuel Economy Increase by 2030

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.



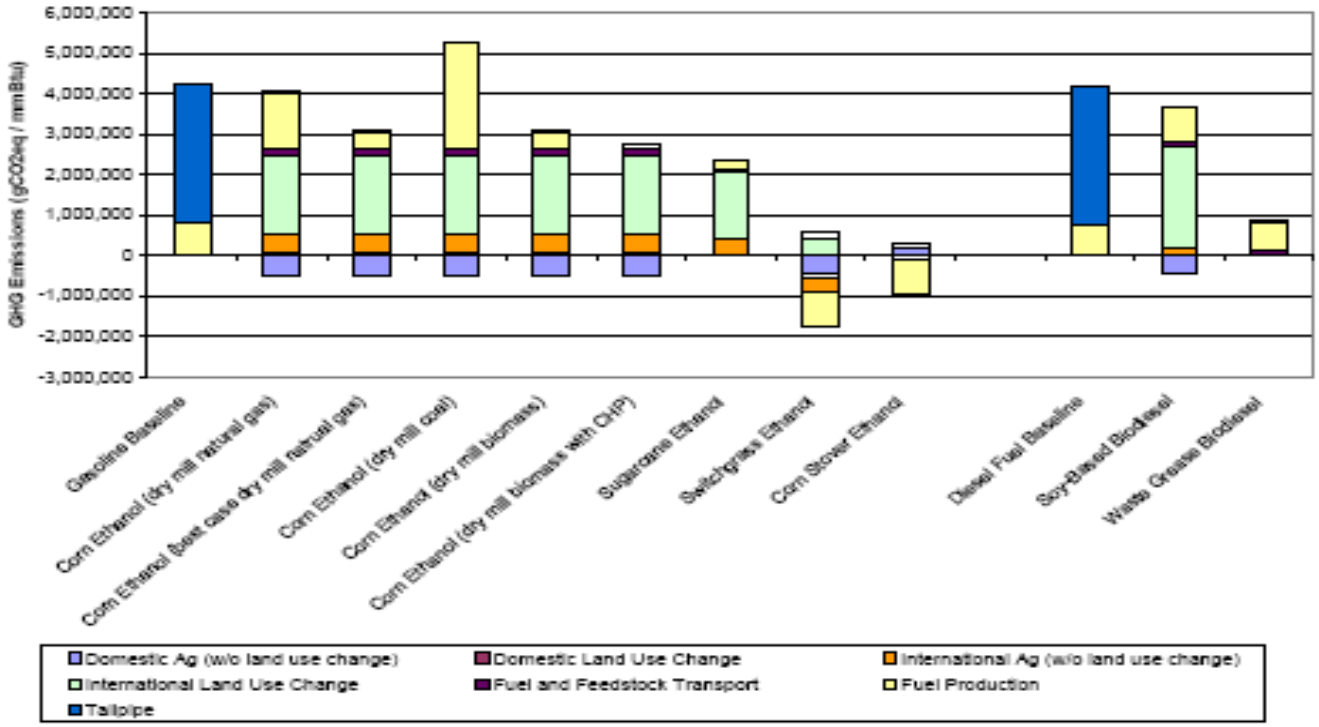
Source: Kasseris & Heywood, SAE Technical Paper 2007-01-1605, April, 2007.

Low Carbon Fuels

- Many different low-carbon fuel possibilities:
  - Corn ethanol - Sugar cane ethanol - Diesel
  - 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."

GHG Intensity of Different Fuels

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



Renewable Fuel Standard

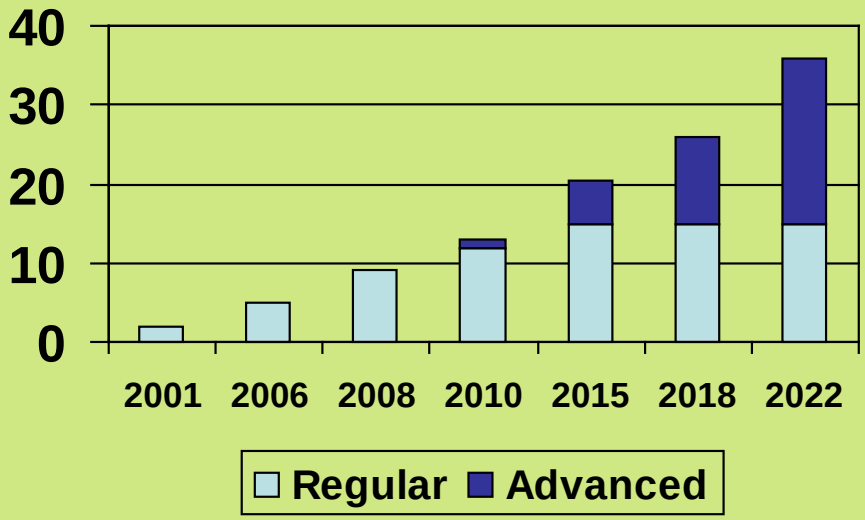
EISA of 2007 requires use of 36 billion gallons of biofuels by 2022.

- 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)

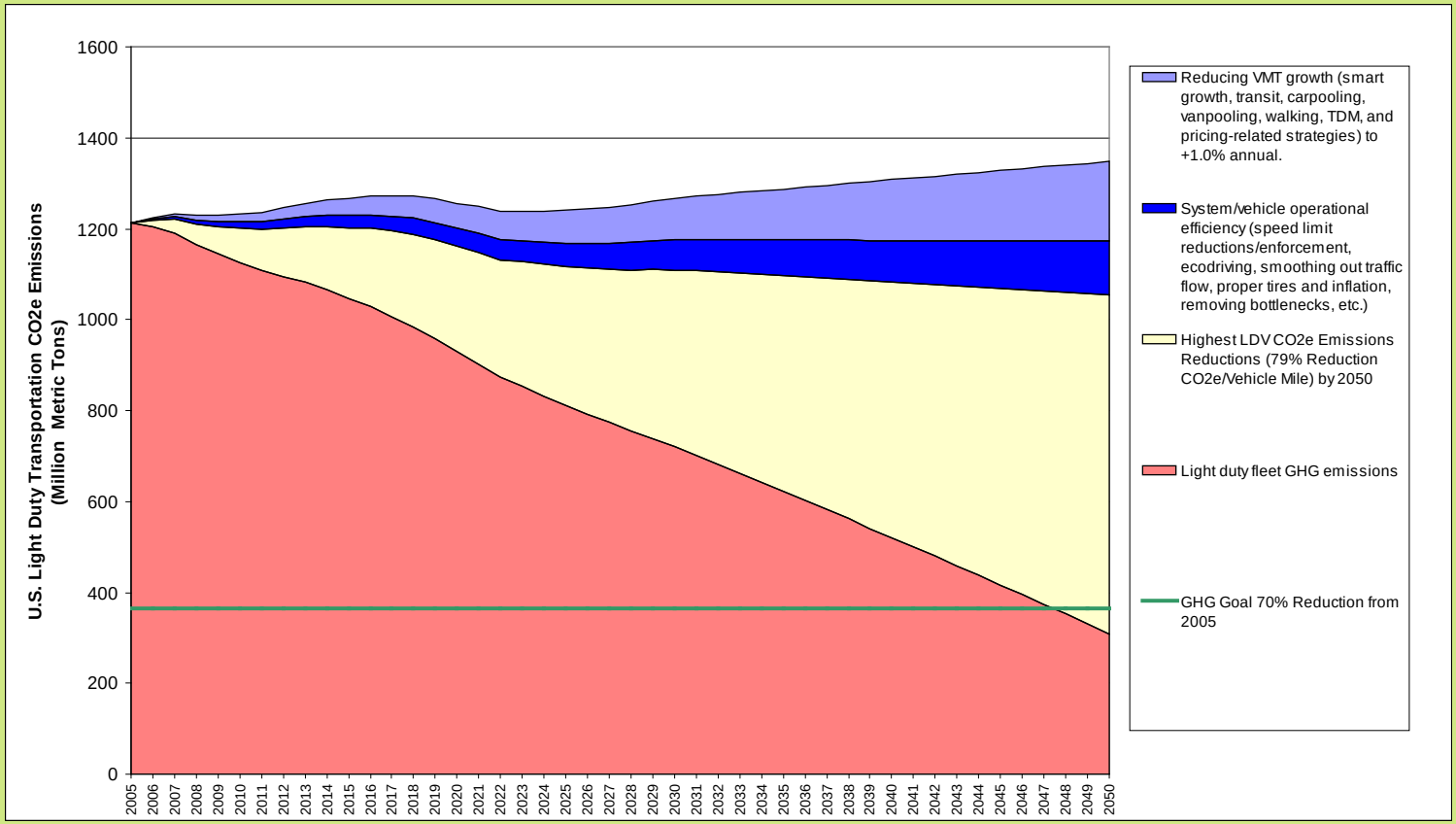
Source: Bill Malley, Perkins-Cole



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 f**uels/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



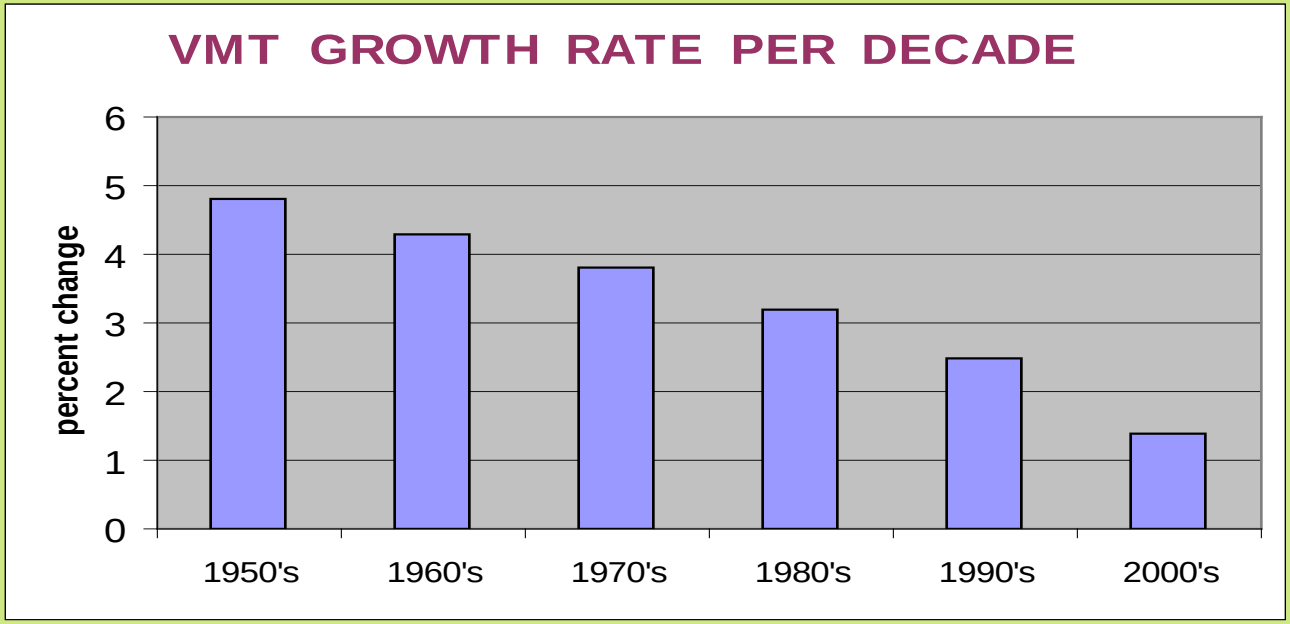
Many Strategies to Reduce LDV VMT

- 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.

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
AASHTO supports reducing VMT growth rate to 1% per year



Cautionary Note on VMT as GHG Metric

- Does not take into account:
  - Type of fuel
  - Fuel efficiency of vehicle
  - Passenger vs freight trip
  - Number of passengers per vehicle
- As light duty passenger fuel economy increases, cost effectiveness diminishes
  - TCM lessons from 1990s – marginal emission reductions, increasing costs as technology improves

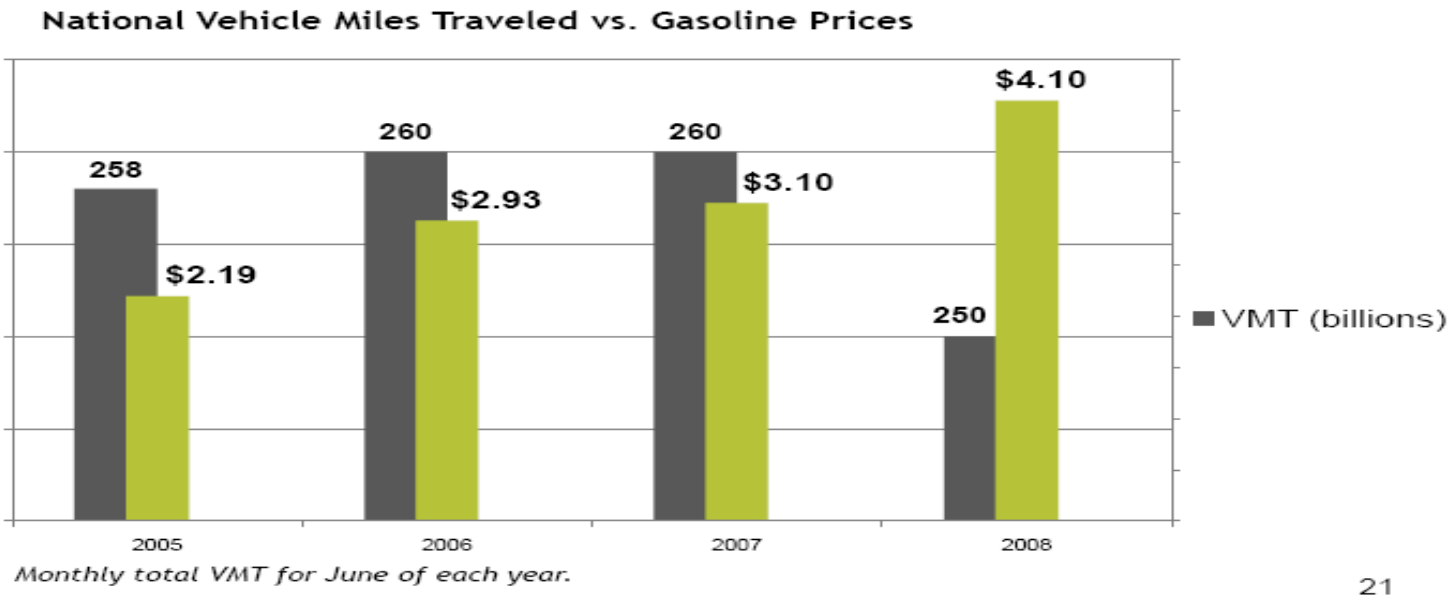
Pricing – A Necessary and Powerful Tool

- Without price signals, reducing driving extremely difficult
- 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



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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
- *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
- DOE: Bus transit has higher GHG/passenger mile traveled than average auto use in the U.S.
- Transit GHG benefits are realized with highly patronized services in high volume corridors -- a market limited to high volume, generally densely developed corridors.

GHG/Passenger Mile for Different Modes

	Occupancy	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

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

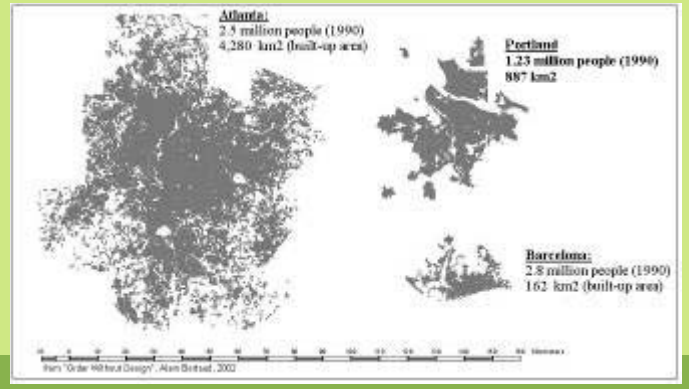
- "Growing Cooler" finds compact development can achieve 3.5-5% reduction in transportation GHG, 2007-2050
- GC's assumptions of land use change are very aggressive:
  - 67% of all development in place in 2050 will be constructed or rehabbed after 2005
  - 60-90% of that development is compact (comparable 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% household 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



“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 – 16% GHG Reduction from Maximum Intensity 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 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

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 CO_2/yr)
- Roundabouts (multiple benefits)
- Reducing car and truck idling
- Work zone management to smooth flow
- Encouraging eco-driving

EcoDriving – 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 City of 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
  - Community EcoDriving?
  - Educational Tools
  - 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.

UC Riverside – Traffic Congestion and Its Impact on GHG Emissions – Can ITS Help?

Studied congestion and impact on CO2, used detailed energy and emissions models linked to real-world conditions

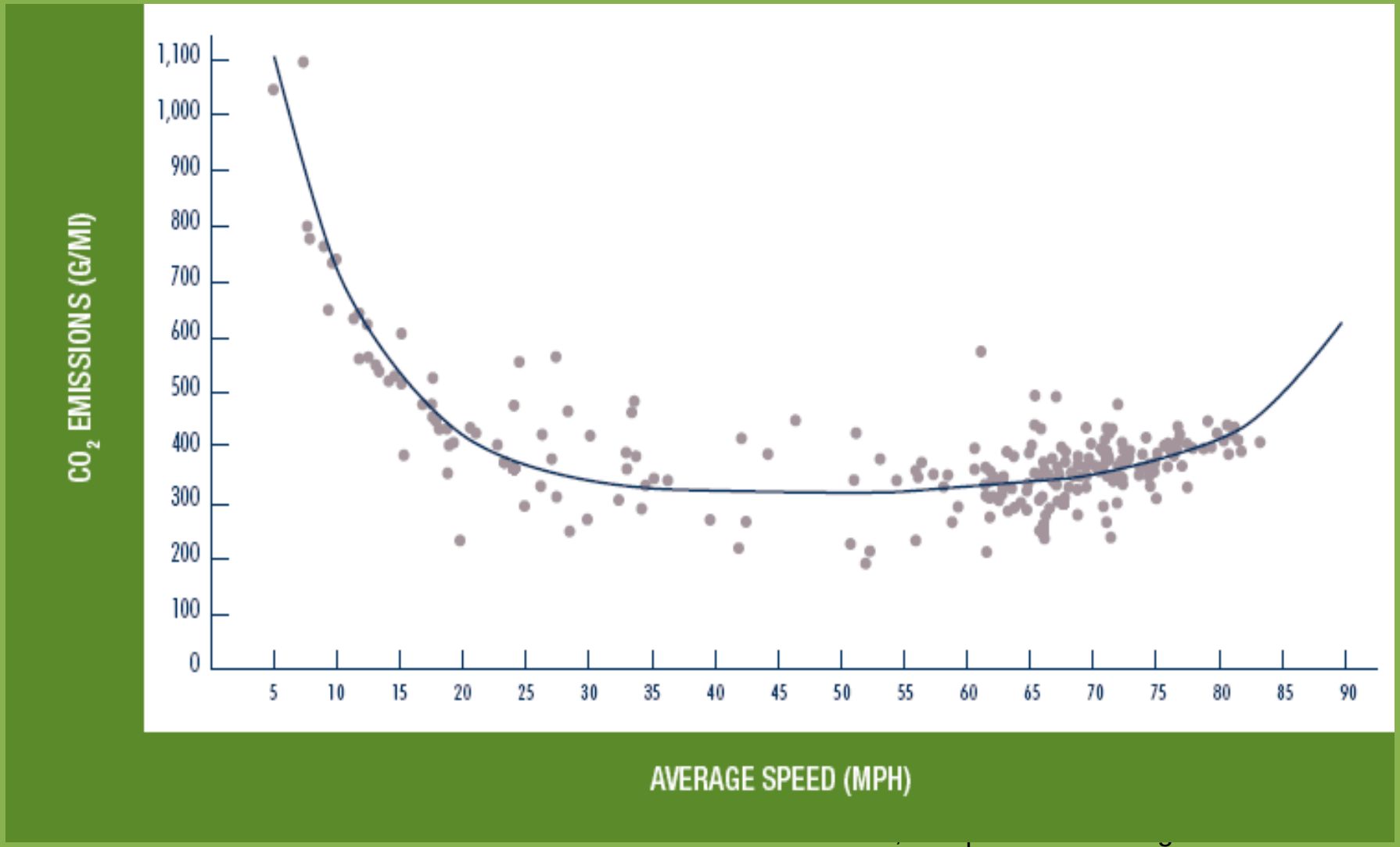
CO2 emissions can be reduced with three strategies

- 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.

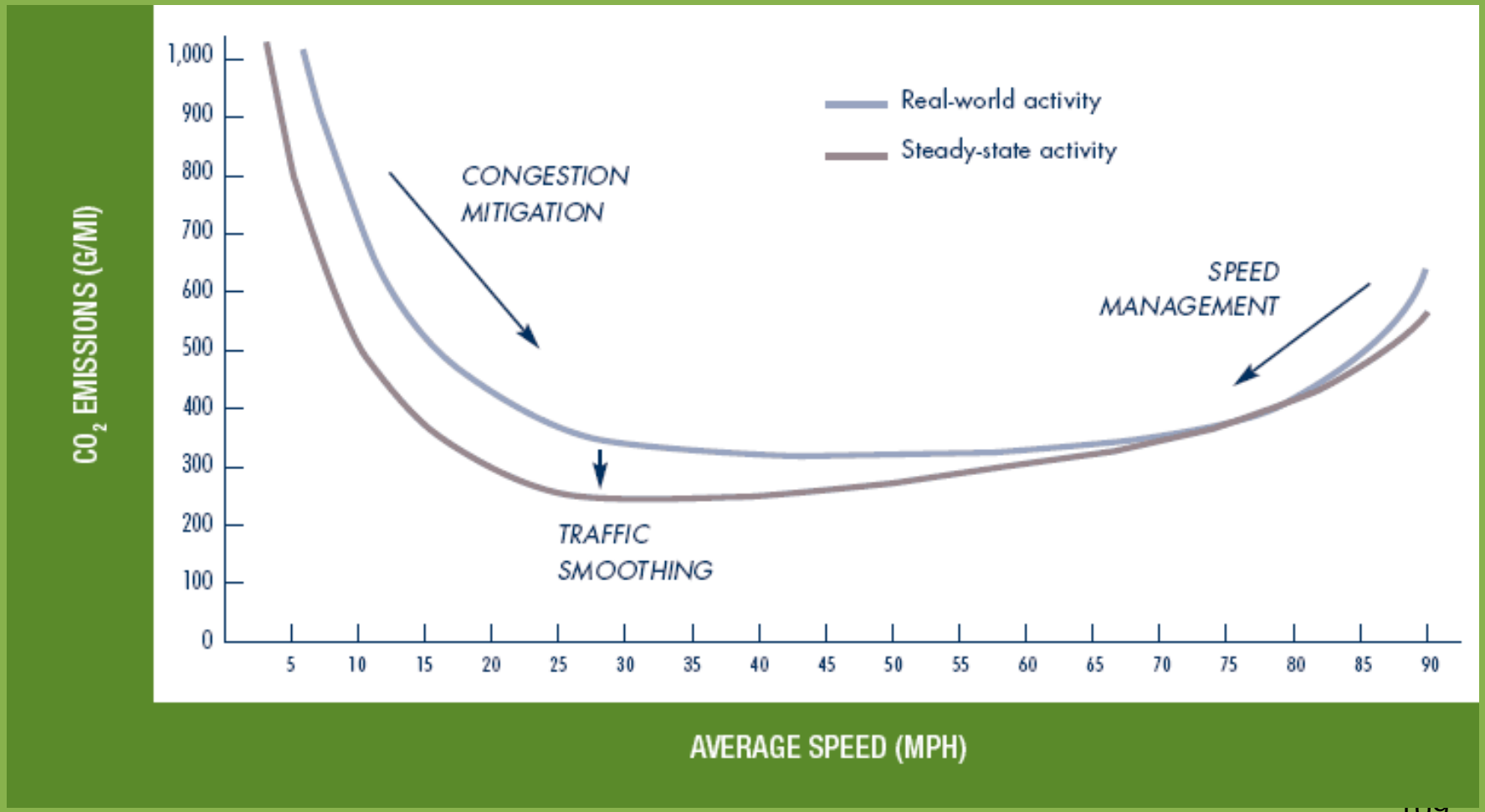
Speed Has Big Effect on GHG

Source: Barth and Boriboomsomsin, UC Riverside

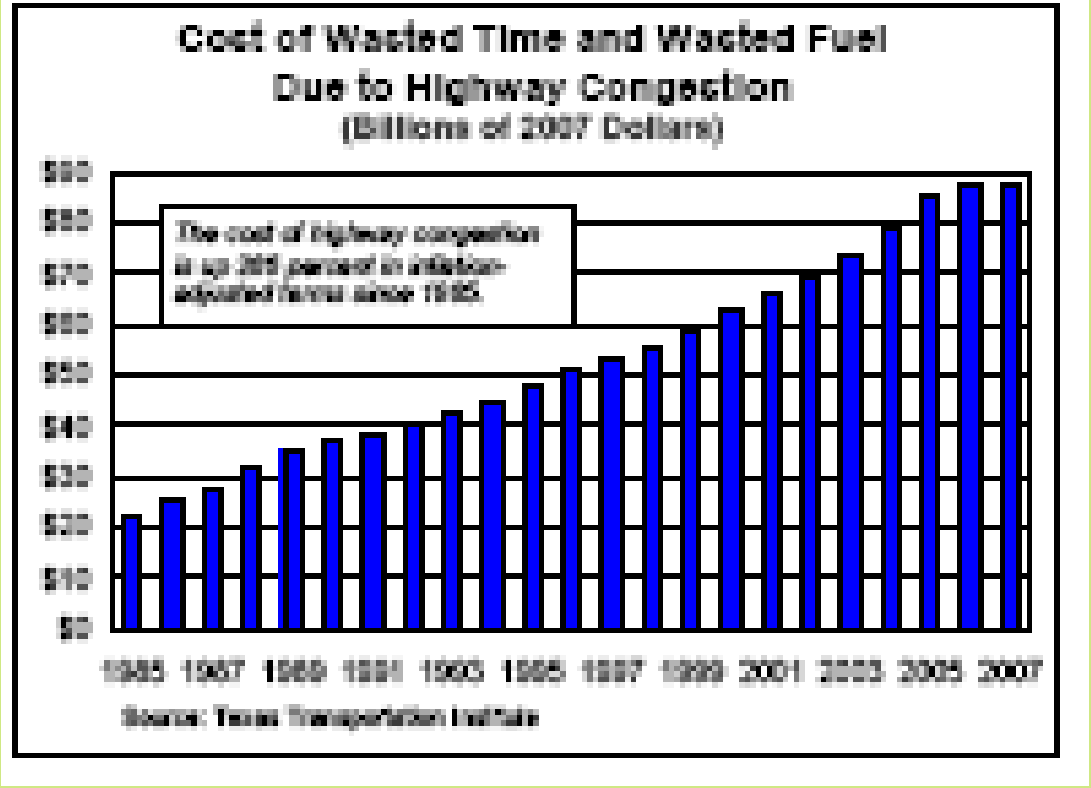


3 Traffic Operations Strategies to Reduce GHG

Source: Barth and Boriboomsomsin, UC Riverside



Cost of Congestion



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

Traffic Signal Timing – Portland, OR

- Began 2002
- 10-year project
- Climate Trust pays for project using CO2 offsets from project
- Improves signal timing on 17 major arterials
  - Optimize traffic flow
  - Reduce idling, acceleration, C02 emissions and emissions from criteria pollutants
- Model for traffic signal offset projects

http://www.climatetrust.org/traffic_signals.html

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

FHWA- Carbon Sequestration Pilot Program

- Pilot established in 2008
- 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
- Webinar Wednesday, July 14 to discuss findings

- http://www.fhwa.dot.gov/hep/climate/carbon_sequestration/index.htm

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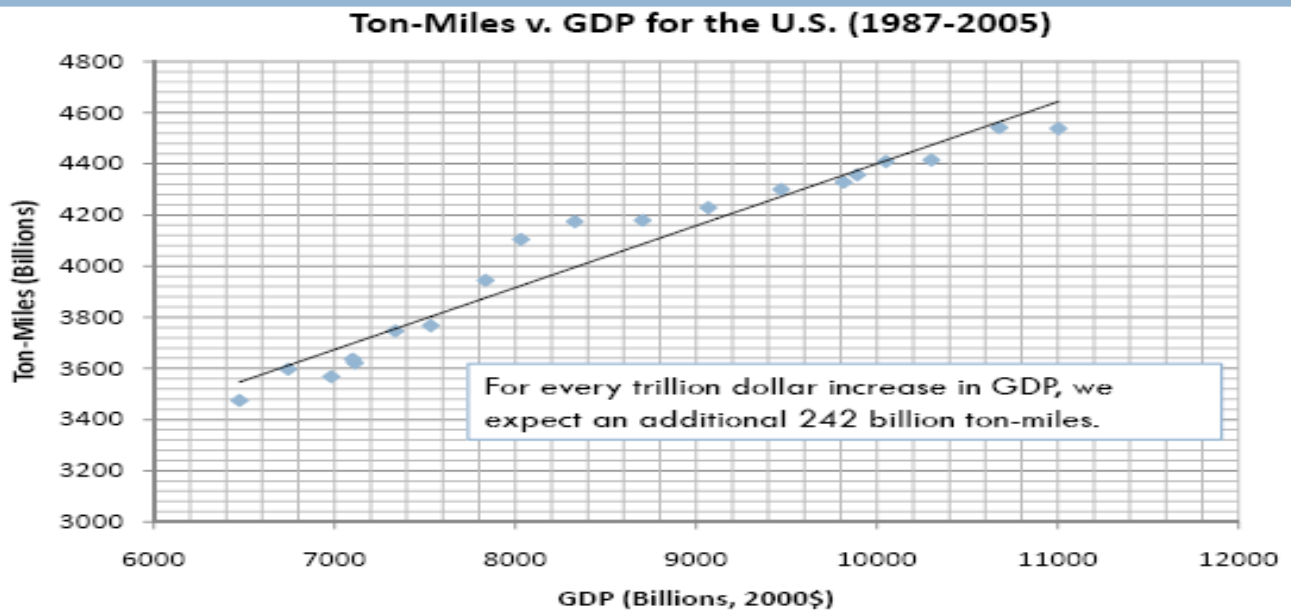
Freight GHG/GDP Trends

Goods Movement and GDP



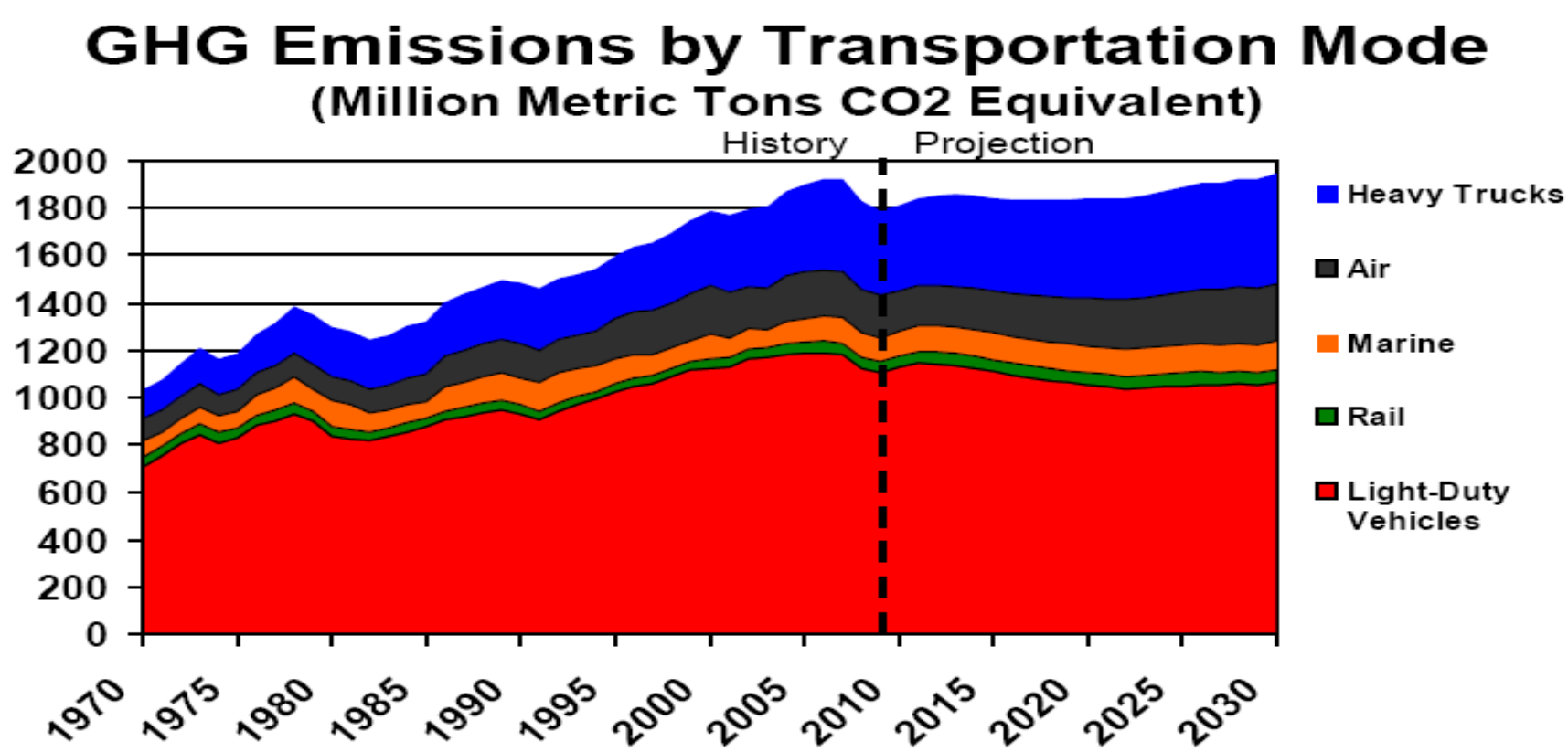
Source: Corbett and Winebrake, 2009.

J. Winebrake, Asilomar, 2009.

GHG, Diesel and Black Carbon

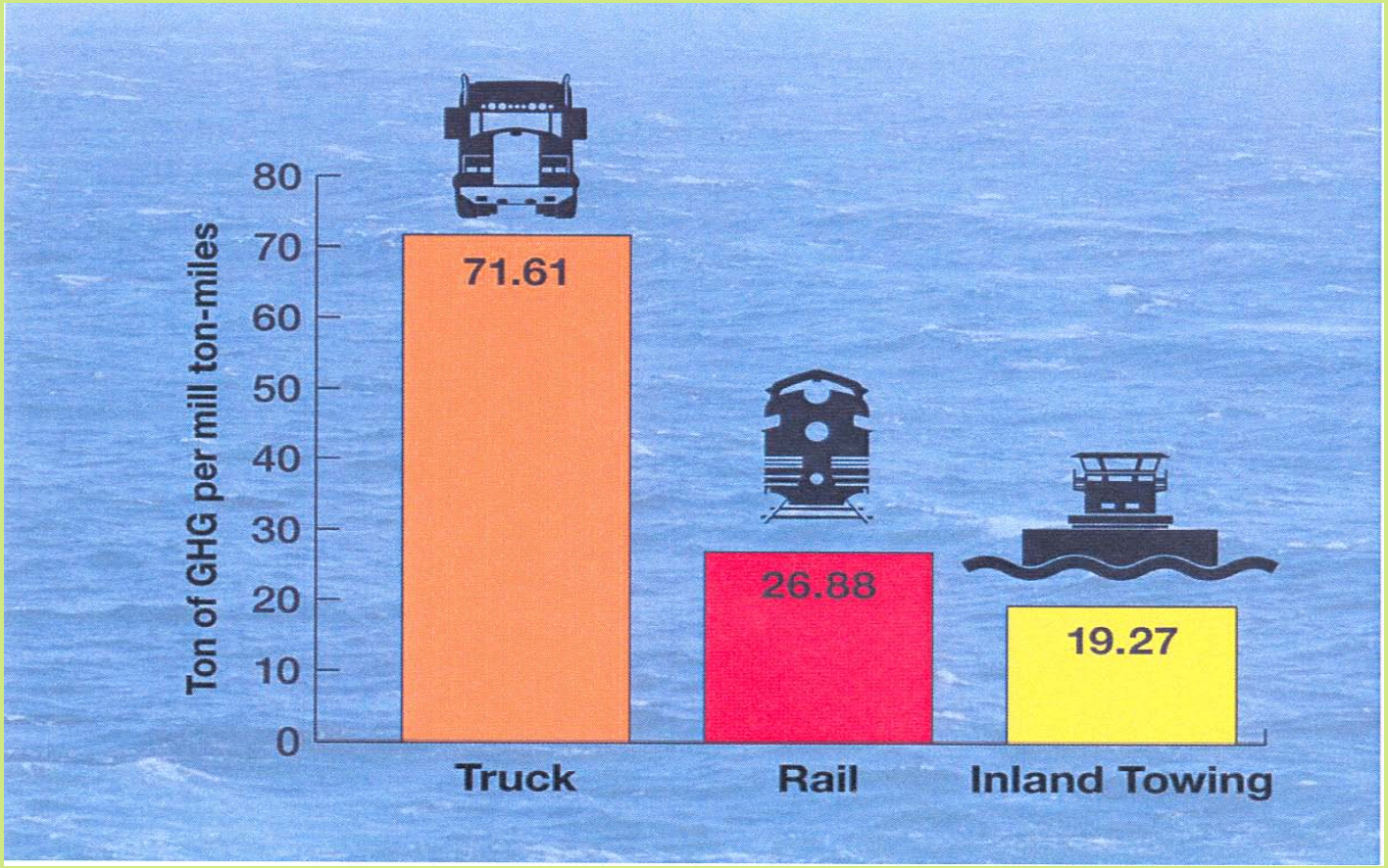
- Black carbon is a major contributor to climate change, diesel engines a primary source of BC
- Black carbon particles absorb sunlight, generate heat in the atmosphere, warms the air
- CO2 has long atmospheric lifetime; black carbon remains in atmosphere only a few weeks
  - Reducing black carbon provides immediate reduction in the rate of warming along with public health benefits.
- Freight strategies that impact diesel engines reduce black carbon and PM and provide immediate benefits.

Truck GHG is Growing Faster than Other Transportation GHG

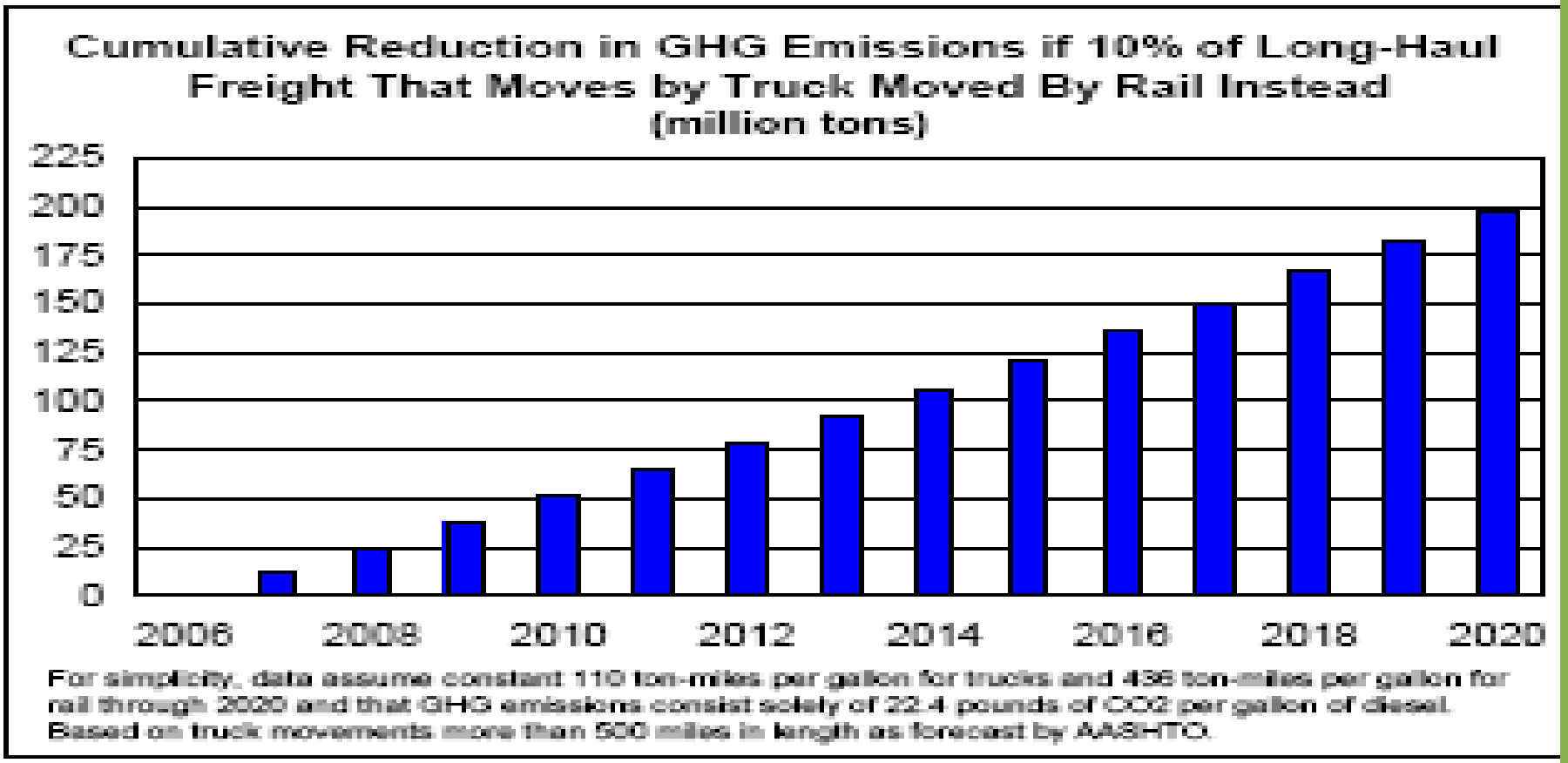


Freight GHG – Barges and Rail

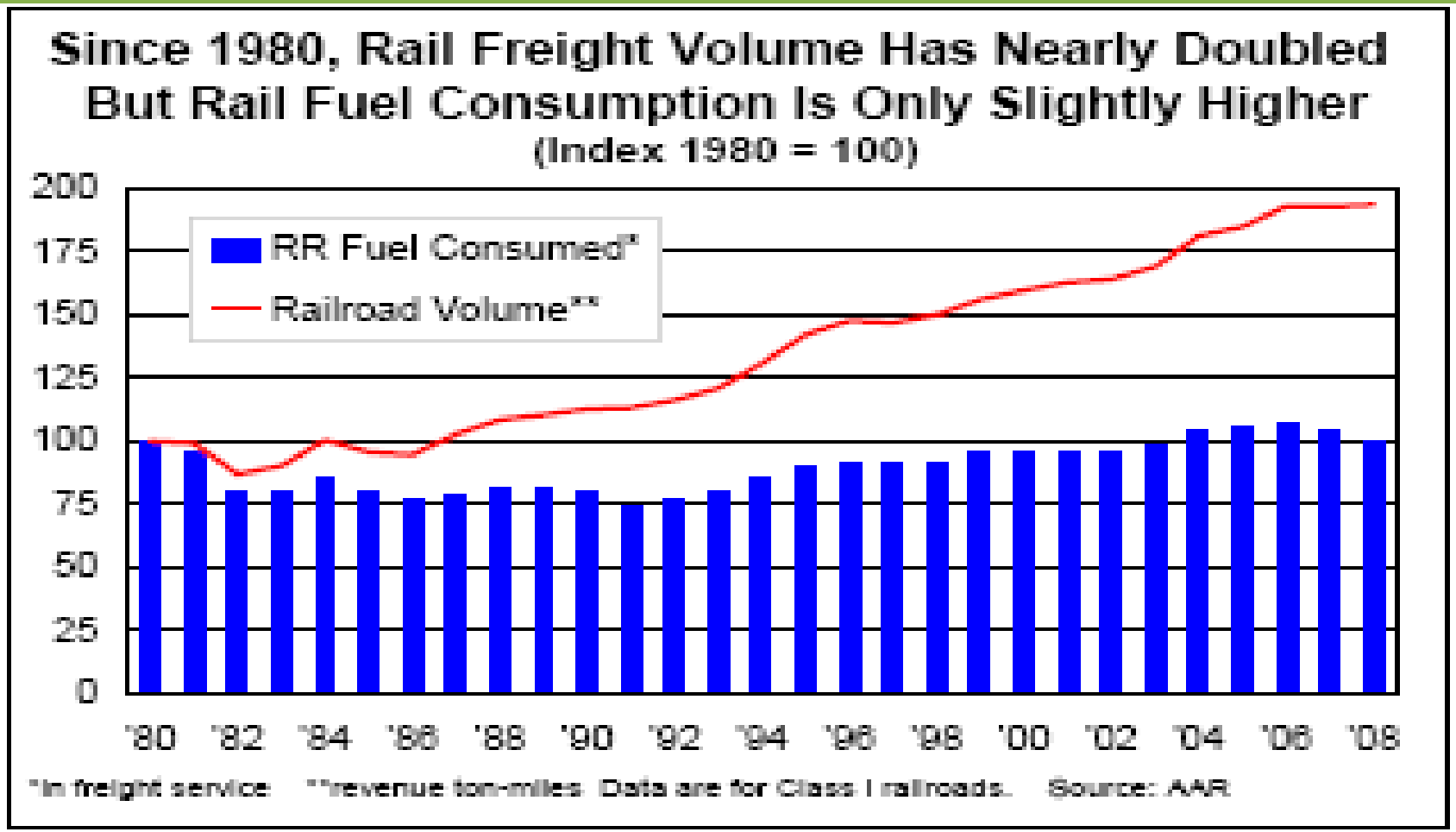
Source: Texas Transportation Institute and Center for Ports and Waterways



Freight Rail Can Relieve Congestion



Rail Fuel Efficiency has Improved



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)

Diesel Retrofits Reduce PM and Black Carbon

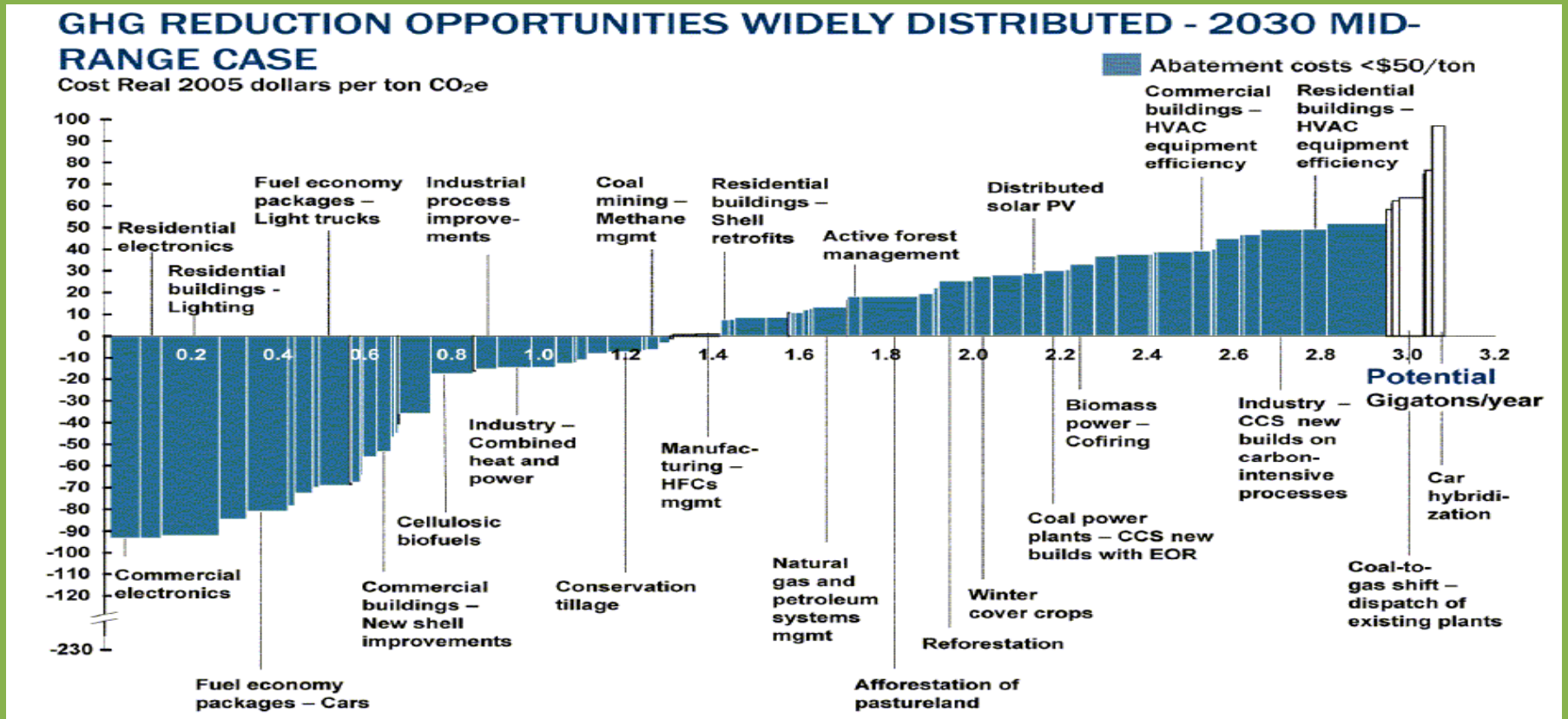
- On-road diesel truck retrofits reduce PM 99% = 2007 EPA standards and also reduce black carbon
- Locomotive retrofits reduce PM and black carbon
  - Achieve over 76% PM and 25% fuel efficiency
- Cost-effective way to reduce emissions and save energy immediately.
- Retrofits of construction equipment, state fleets 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 CO_2 emissions, is realized following this diesel retrofit
- Very cost-effective CMAQ project

Cleaner Locomotive

McKinsey: Technologies can Reduce 3 billion Tons GHG/Year at <$50/ton



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.

European View of Transport GHG

(European Council of Ministries 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
- Retrofit legacy fleets to reduce PM and black carbon
- Implement wide-ranging freight technology and logistics improvements

VI. Participant Workshop

Participant Workshop

A working session in break-out groups to identify an initial set of activities for Missouri DOT to pursue:

(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://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”

AASHTO Resources

- **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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