CLIMATE CHANGE: INFORMATION, CHALLENGES, AND STRATEGIES

A Workshop for Mississippi DOT

June 17, 2010
Workshop Purpose

- What is climate change?
- How will it affect state DOTs?
- Status of federal legislation?
- What is the Gulf Coast Study?
- What are adaptation issues for MissDOT?
- What are proposed CEQ-NEPA requirements?
- 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. Gulf Coast Study Presentation and Climate Adaptation
IV. Planning and NEPA Issues
V. Strategies to Reduce GHG Emissions from Transportation Sources
VI. Participant Workshop
VII. Wrap-up and Next Steps Discussion
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”?

1. Solar energy passes through the atmosphere
2. Some energy is reflected back out to space
3. Earth’s surface is heated by the sun and radiates the heat back out towards space.
4. GHG in the atmosphere trap some of the heat
What is the evidence on temperatures?
What are the impacts at different temperature increases?

### Projected impacts of climate change

<table>
<thead>
<tr>
<th>Global temperature change (relative to pre-industrial)</th>
<th>0°C</th>
<th>1°C</th>
<th>2°C</th>
<th>3°C</th>
<th>4°C</th>
<th>5°C</th>
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<tbody>
<tr>
<td><strong>Food</strong></td>
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<td>Falling crop yields in many areas, particularly</td>
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<td>developing regions</td>
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<td>Possible rising yields in some high latitude regions</td>
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<td>Small mountain glaciers disappear – water supplies</td>
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<td>threatened in several areas</td>
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<td>Significant decreases in water availability in many</td>
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<td>areas, including Mediterranean and Southern Africa</td>
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<td>Sea level rise threatens major cities</td>
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<td><strong>Ecosystems</strong></td>
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<td>Extensive Damage to Coral Reefs</td>
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<tr>
<td>Rising number of species face extinction</td>
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<td><strong>Extreme Weather Events</strong></td>
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<tr>
<td>Rising intensity of storms, forest fires, droughts,</td>
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<td>flooding and heat waves</td>
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<td><strong>Risk of Abrupt and Major Irreversible Changes</strong></td>
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<td>Increasing risk of dangerous feedbacks and abrupt,</td>
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<tr>
<td>large-scale shifts in the climate system</td>
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**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 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 is the evidence of climate change?

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

Source: EPA, Climate Change Indicators in the U.S., May 2010
What is the evidence of climate change?
(continued)

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

Source: EPA, Climate Change Indicators in the U.S., May 2010
How widespread are climate change concerns?

- Over 2000 leading scientists worldwide contributed to IPCC report
- 33 U.S. states have developed climate change action plans
- U.S. 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:

How is climate change affecting the Gulf Coast and Mississippi?

Gulf Coast Study, Phase I Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: 3/2008.

- Temperatures rising
- Sea levels in Gulf of Mexico likely to rise 2-4 feet over next 50-100 years
- Impact on transportation:

“The expected impacts of these climate effects on transportation are striking. An untenable portion of the region's road, rail, and port network is at risk of permanent flooding if sea levels rise by four feet. This includes more than 2,400 miles (27%) of the major roads, 9% of the rail lines, and 72% of the ports.”

“More than half (64% of interstates; 57% of arterials) of the area's major highways, almost half of the rail miles, 29 airports, and virtually all of the ports are subject to temporary flooding and damage due to increased storm intensity.”
Southeast temperatures expected to rise significantly
(number of days with peak temperatures over 90F)

Where do all those GHG come from?

Comparison: Annual* & Cumulative** CO₂ Emissions

** Cumulative Emissions from 1850-2000, CAIT WRI
What GHG 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
- Kerry-Lieberman bill: **17%** below 2005 by 2020 and **83%** below 2005 by 2050
What is transportation’s share of U.S. GHG?

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

- Light Duty Vehicles: 58%
- Industry: 19%
- Residential: 5%
- Commercial: 6%
- Agriculture: 8%
- Marine: 5%
- Rail: 3%
- Pipelines: 1%
- Aircraft: 12%
- Freight Trucks: 19%
- Buses: 0.8%
- Motorcycles: 0.1%
- Lubricants: 1%
## What are U.S. transportation GHG trends?

- U.S.DOT Report to Congress, 2010

<table>
<thead>
<tr>
<th>Category</th>
<th>Change, 1990-2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>All U.S. GHG Sources</td>
<td>15%</td>
</tr>
<tr>
<td>U.S. Transportation</td>
<td>27%</td>
</tr>
<tr>
<td>Light Duty Vehicles</td>
<td>24%</td>
</tr>
<tr>
<td>Freight Trucks</td>
<td>77%</td>
</tr>
<tr>
<td>Commercial Aircraft</td>
<td>4%</td>
</tr>
</tbody>
</table>
How much will transportation GHG increase?

- **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.
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 by 5x greater than in the U.S.

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.”

Summary

- Climate change is real
- 60-80% GHG reduction is needed
- It is a global and cumulative problem
- In developing countries, GHG emissions will increase substantially
- Delay will magnify the difficulty of reducing GHG
- Mississippi is especially vulnerable to climate change
II. The Importance of Climate Change to State DOTs
• 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
“We know we need to get ready for a world in which energy will only be more expensive.”

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

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

Should state DOTs take a page from Wal-Mart’s book?
DOE expects slight decline in LDV GHG emissions nationally

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

![VMT Growth Rate Per Decade](chart.png)

Source: Alan Pisarski and Cambridge Systematics
VMT closely linked to disposable income
DOE expects VMT and MPG both to rise
As VMT and MPG rise, GHG is nearly flat
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
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 B (base case) to 3.9 B
### State Climate Plans – Transportation Share Of GHG Reductions Varies Widely

<table>
<thead>
<tr>
<th>State</th>
<th>Year</th>
<th>% Reduction in Transportation GHG</th>
<th>% of all GHG Reductions from Transportation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhode Island</td>
<td>2020</td>
<td>N/A</td>
<td>20%</td>
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<tr>
<td>New York</td>
<td>2020</td>
<td>18%</td>
<td>7%</td>
</tr>
<tr>
<td>Connecticut</td>
<td>2020</td>
<td>N/A</td>
<td>7%</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>2025</td>
<td>30%</td>
<td>8%</td>
</tr>
<tr>
<td>Maine</td>
<td>2020</td>
<td>23%</td>
<td>27%</td>
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<tr>
<td>Minnesota</td>
<td>2025</td>
<td>27%</td>
<td>5%</td>
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<tr>
<td>Oregon</td>
<td>2025</td>
<td>25%</td>
<td>8%</td>
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<tr>
<td>New Mexico</td>
<td>2020</td>
<td>30%</td>
<td>8%</td>
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<tr>
<td>Colorado</td>
<td>2020</td>
<td>22%</td>
<td>6%</td>
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<tr>
<td>North Carolina</td>
<td>2020</td>
<td>31%</td>
<td>11%</td>
</tr>
</tbody>
</table>
**State Climate Plans – Transportation**

Elements Vary All Across the Map

<table>
<thead>
<tr>
<th>State</th>
<th>Year</th>
<th>Vehicle</th>
<th>Low Carbon Fuels</th>
<th>Smart Growth and Transit</th>
<th>Other</th>
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</thead>
<tbody>
<tr>
<td>RI</td>
<td>2020</td>
<td>46%</td>
<td>10%</td>
<td>31%</td>
<td>14%</td>
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<tr>
<td>NC</td>
<td>2020</td>
<td>35%</td>
<td>12%</td>
<td>38%</td>
<td>15%</td>
</tr>
<tr>
<td>SC</td>
<td>2020</td>
<td>14%</td>
<td>55%</td>
<td>29%</td>
<td>1%</td>
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<tr>
<td>CT</td>
<td>2020</td>
<td>51%</td>
<td>38%</td>
<td>8%</td>
<td>2%</td>
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<tr>
<td>ME</td>
<td>2020</td>
<td>53%</td>
<td>25%</td>
<td>21%</td>
<td>1%</td>
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<td>MD</td>
<td>2025</td>
<td>24%</td>
<td>12%</td>
<td>45%</td>
<td>20%</td>
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<tr>
<td>NY</td>
<td>2020</td>
<td>59%</td>
<td>11%</td>
<td>27%</td>
<td>4%</td>
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<tr>
<td>PA</td>
<td>2025</td>
<td>45%</td>
<td>36%</td>
<td>18%</td>
<td>0%</td>
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<td>MN</td>
<td>2025</td>
<td>15%</td>
<td>35%</td>
<td>25%</td>
<td>25%</td>
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<tr>
<td>VT</td>
<td>2028</td>
<td>21%</td>
<td>14%</td>
<td>49%</td>
<td>17%</td>
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</tbody>
</table>
What are Other State DOTs Doing on Climate Change?

- 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
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.
III. 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/
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
- **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
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

USEPA is to:
- Issue regulations for standardized emissions models and methods

USDOT 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)
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 2010 Senate bill

Source: Bill Malley, Perkins-Coie
<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2030</th>
<th>2050</th>
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<tbody>
<tr>
<td>EPA Projection</td>
<td>$0.14</td>
<td>$0.24</td>
<td>$0.69</td>
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<tr>
<td>CRA: Base Case</td>
<td>$0.19</td>
<td>$0.38</td>
<td>$0.95</td>
</tr>
<tr>
<td>CRA: &quot;Low-Cost&quot;</td>
<td>$0.17</td>
<td>$0.34</td>
<td>$0.84</td>
</tr>
<tr>
<td>CRA: &quot;High-Cost&quot;</td>
<td>$0.36</td>
<td>$0.71</td>
<td>$1.82</td>
</tr>
<tr>
<td>CRA: &quot;No International Offsets&quot;</td>
<td>$0.52</td>
<td>$1.08</td>
<td>$2.79</td>
</tr>
</tbody>
</table>

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](http://www.epa.gov/climatechange/economics/economicanalyses.html)
Summary

• Prepare for federal legislation and requirements
• DOTs may be expected to reduce transportation GHG by 60-80% by 2050
• Many state climate action plans include “aspirational” transportation elements that have not been thoroughly analyzed or vetted
• VMT reductions may be expected or required
• Lower VMT and more fuel efficient cars will exacerbate the transportation revenue dilemma – new revenue sources will be needed
IV. Gulf Coast Study and Climate Adaptation for Transportation
FHWA Adaptation Reports and Activities

- Impacts of Climate Change and Variability on Transportation Systems and Infrastructure – The Gulf Coast Study, Phase I (SAP 4.7)
- Phase 2 of the Gulf Coast Study
- Regional Climate Change Effects report
- FHWA Adaptation Strategy
- Vulnerability/risk assessment conceptual model (& pilots)
- Peer Exchange workshops
- Climate Change and Highway Infrastructure: Impacts and Adaptation Approaches (NCHRP)
U.S. DOT / USGS Gulf Coast Study
Potential Impacts of Climate Change and Variability on Transportation Systems and Infrastructure
Why Study Impacts and Adaptation?

• As climate changes, transportation infrastructure may need to evolve to handle new conditions
• Each region has unique transportation assets and vulnerabilities
• Research on transportation impacts is limited
Why the Gulf Coast?

• Nationally significant
  – 60% nation’s petroleum imports
  – Largest concentration of marine freight facilities in the U.S.
  – Major urban centers
• Extensive intermodal network
  – 17,000 miles of highway; 83.5B VMT per year
  – 4 out of 5 top tonnage ports; 1,000 freight handling terminals
  – 6 of 7 Class I railroads
  – 3,800 aircraft at 61 airports
  – 56M passengers at 3 largest airports (2005)
• Engaged decision-makers
Overall Climate Change Effects - Key Drivers for Analysis

- Accelerated relative sea level rise
- Increased storm surge and storm intensity
- Changes in temperature
- Changes in precipitation
Relative sea level will likely rise 1 to 6 feet; a 2-to 4-foot increase is probable
  - Massive inundation due to relative sea level rise
  - Relative sea level includes:
    • Climate-induced impacts of thermal expansion and ice melt; and
    • Sinking land masses (subsidence) in the central Gulf Coast
  • Hurricane vulnerability is bad today and may worsen
    - Potential for 5–20% increase in storm intensity due to climate change
Trends in Climate and the Natural Environment
Temperature and Precipitation

- Average temperature is likely to increase by 2°- 4° F by 2050
  - More hot days: # of days > 90° F may increase by 50%
  - Extreme daily high temps will also increase
- Models show mixed results for changes in average precipitation
  - Intensity of rainfall events, however, will likely increase

The impacts worsen as GHG concentrations increase across the range of IPCC scenarios.
Trends in Climate and the Natural Environment

- The central Gulf Coast is particularly vulnerable to climate change over the next 50-100 years
- Climate change impacts need to be integrated with other coastal / environmental effects
- The timing of impacts is not clear; abrupt change cannot be ruled out
Implications for…

• Highways and transit
• Rail
• Ports and waterways
• Airports
• Emergency management
• Long-range planning and investment
Relative sea level rise (due to climate change and subsidence) of 4 feet could permanently flood:

- 24% of interstate miles, 28% of arterial miles, New Orleans Transit
- 72% of freight, 73% of non-freight facilities at ports
- 9% of the rail miles operated, 20% of the freight facilities, no passenger stations
- 3 airports
- Temporary flooding in low-lying areas due to increased heavy downpours will broaden affected areas
Highways Vulnerable to Relative Sea Level Rise

Baseline (Present Day) 4 Feet of Sea Level Rise

Source: Cambridge Systematics analysis of U.S. DOT Data.
Vulnerability Due to... Storm Surge

- As witnessed by the 2005 hurricane season, transportation in the central Gulf Coast is already vulnerable to large hurricanes.
- That vulnerability will be exacerbated if hurricane intensity increases, absent adaptation strategies.
- Examined effect of 18 and 23 ft storm surge.
Vulnerability Due to… Storm Surge

- Transportation infrastructure that is vulnerable to 18 feet of storm surge includes:
  - 51% of interstate miles, 56% of arterial miles, and most transit authorities
  - 98% of port facilities vulnerable to surge and 100% to wind
  - 33% of rail miles operated, 43% of freight facilities
  - 22 airports in the study area at or below 18 feet MSL
  - Potentially significant damage to offshore oil & gas facilities
Freight Rail Lines Vulnerable to Storm Surge of 18 feet
Caveats – Relative SLR and Storm Surge

- Analysis of impacts is based on land elevation rather than the height of facilities
- Analysis does not consider the presence of possible protective structures (levees, sea walls, etc.)
- A small flooded segment may render a larger portion of the infrastructure inoperable, due to the connectivity of the intermodal system
  - Many transportation facilities depend on local roads (not elevated)
Hurricane Katrina Damage to Highway 90 at Bay St. Louis, MS

As temperatures increase, operations will be affected:

- Potential rise in maintenance and construction costs
- Increased use of energy for refrigerated storage
- Potential rise in rail buckling
- May result in impacts to aircraft performance and runway utilization
What Are Possible Adaptation Responses?

- **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 Transportation Planning

- Climate change is rarely considered today, but the longevity of infrastructure argues for its integration.
- Current practice focusing on a 20-year time frame is not well-suited to the assessment of climate impacts.

**Climate Impacts Engineering and Design**

- Construction
- Facility Service Life

**Transport Planning Process**

- Project Concept
- Adopted Long-Range Plan
- In Service

Years: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100
Transportation Planning: Preparing for change...

- A robust transportation systems requires reliability under a range of conditions
- It is useful to examine the vulnerability of the intermodal system in addition to specific facilities
- Use of new approaches to decision-making
  - Scenario planning
  - Integration of climate change with other regional dynamics
  - Risk assessment approach
  - Probabilistic rather than deterministic approach
  - Consider both incremental and abrupt change
A Risk Assessment Approach to Transportation Decisions

Risk Assessment
- Exposure
- Vulnerability
- Resilience

Adaptation Response
- Accommodate
- Protect
- Relocate

Greater Resilience
But Need More Than Just Degree of Risk to Prioritize Investments…

Exposure and Vulnerability

High Risk / Low Importance

Low Risk / Low Importance

Low Risk / Critical Importance

Highest Priority: High Risk / Critical Importance
Potential for Costly Impacts
Gulf Coast Study, Phase 2

- Process for assessing critical transportation infrastructure, projecting climate change effects, evaluating vulnerability, and conducting detailed engineering assessments for vulnerable assets in Mobile
  - Lessons learned and replicable processes that could inform similar analyses in other MPOs
  - Transferrable tools and resources to assist MPOs nationwide
  - Timeframe: 2010-2012
Focus on a single Metropolitan area in the Gulf Coast Region: Mobile, AL MPO
- Identify "critical assets" in Mobile region
- Evaluate projected climate change effects & stressors
- Determine vulnerability of specific assets, given projected climate effects; conduct vulnerability assessment & detailed engineering analyses of adaptation approaches for selected assets
- Develop risk assessment tools & approaches
- Work with stakeholders in Mobile throughout project; take lessons learned & identify tools to make process, lessons learned, & methods accessible to other MPOs.
- Include major findings in a final report
GC2: General Timeline

- **Early 2010**: Determine the new climate stressors the transportation system will face.
- **Early 2011**: Identify most critical transportation links & assets.
- **Early 2012**: Determine vulnerability of critical assets to expected climate stressors.
- **Late 2012**: Develop tools to identify and manage climate-related risks.

*Working with Mobile MPO & other key groups*
Task 1:
Identify Critical Transportation Systems

- ICF and PB will develop a preliminary list of critical assets
  - Review MPO Model & other available modal or special purpose models
    - Enhance models as needed to identify critical infrastructure & assess vulnerability
    - Re-run model as needed to test critical links (stress on rest of system if one link down)
  - Review plans & programs, interview staff
  - Collect & review asset data & asset management tools in use
Task 1: Identify Critical Transportation Systems

- Score and rank critical assets
- Send draft critical asset list to climate workgroup to request feedback

Diagram:

- Task 1.1: Transportation Modeling
  - Model review, enhancement
  - Model analysis

- Task 1.2: Plan Review
  - Plan and program review
  - Add’l document review

- Task 1.3: Asset Characteristics
  - Collect asset data
  - Configure asset mgmt tools

- Task 1.4: Document Critical Assets
  - Critical systems
  - Critical links and nodes

Public Agency and Private Sector Coordination and Public Outreach (Task 5)
Task 2: Identify Climate Impacts

- Obtain climate/weather data: past conditions and future scenarios
- Quantify relationships between climate and local transportation infrastructure and services
- Technical memo summarizing findings by asset category and climate effect, for review by asset managers
Task 2: Identify Climate Impacts

• How has the transportation system been affected during recent extreme weather events?
• How have the different transportation modes been affected by:
  – Hurricanes?
  – Extreme heat episodes?
  – Unusual cold temperature events?
  – Unusual precipitation patterns (excessive rain or drought)?
Tasks 3 & 4: Vulnerability & Risk Management

• Task 3: Determine Vulnerability for Key Links & Assets in Each Mode
  – Apply Task 2 results to critical structures identified in Task 1 to determine link- and asset-specific vulnerability
  – Assess role of each asset in system vulnerability
  – Multiply criticality & vulnerability scores to create a prioritized list of structures
  – Conduct engineering analysis and assessment

• Task 4: Develop Risk Management Tools
  – Could be GIS maps of infrastructure overlaid with vulnerable infrastructure; Excel-based or web-based decision-support tool; or a guidance document detailing best practices for MPOs to assess climate-related risks & identify transportation options
  – Consistent with tools & approaches in use within region; developed in consultation with MPO, region, and state
FHWA Climate Change Effects Report

- Provides information on climate change projections for transportation decision makers
- Summarizes current science
  - Science is progressing, expect information to improve over next 3-5 years
- Short, medium and long term
- Based on low and high GHG emission scenarios
- Assistance from Climate experts -- NOAA, USGS, DOE
FHWA Climate Change Effects Report

- 9 regions (6 continental US, Alaska, Hawaii, Caribbean)
- Projected changes by region:
  - Annual, Seasonal Temperature (change in °F)
  - Seasonal Precipitation (% change)
  - Where information exists:
    - Sea level rise
    - Storm activity
- Regional focus, also includes information at the international, national and State and local levels (as available)
FHWA Climate Change Effects Report

Three sections

• Report
• Regional maps (Appendix B)
• Climate Effects Typology (Appendix C)
Annual Temperature Change (°F)
Regional Climate Change Effects: Temperature

Southeast

Projected Change in Winter Temperature (°F)

Temperature Increase (°F)

Near-Term  Mid-Century  End-Century

Projected Change in Summer Temperature (°F)

Temperature Increase (°F)

Near-Term  Mid-Century  End-Century
Regional Climate Change Effects:
Precipitation

**Southeast**

*Projected Change in Spring Precipitation (%)*

*Projected Change in Summer Precipitation (%)*
“Impacts of Climate Change and Variability on Transportation Systems and Infrastructure – The Gulf Coast Study, Phase I”

Synthesis and Assessment Product 4.7
http://www.climatescience.gov/Library/sap/sap4-7/final-report/

Federal Highway Administration Climate Change Website:

Robert.Kafalenos@dot.gov
FHWA, Sustainable Transport & Climate Change Team
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 and 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
Potential Impact of Climate Change on U.S. Transportation (TRB Special Report 290)

Transportation Research Board
Division on Earth & Life Studies
National Research Council
• 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.
• **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
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**?
V. Planning and NEPA Issues
Federal Legislation – Transportation Planning Provisions (proposed)

- **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 –
Many GHG Issues and Implications

- GHG planning will be impacted by both state and federal policies
- Both state DOTs and MPOs will be affected
- Inventories of transportation GHG will probably be required
- GHG reduction targets will probably be required
- Methodologies to predict GHG for different plans and strategies will be needed
- Many Clean Air Act planning issues will carry over into GHG planning – modeling limitations, induced demand, VMT reduction expectations, uncertainties about travel behavior, land use expectations, etc.
- A major new issue – high degree of uncertainly about future potential new technology and fuels to reduce GHG
- Another key issue -- whether/how to include “upstream” and “life cycle” GHG of transportation
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 \textit{direct} emissions of 25,000 metric tons or more of CO2-equivalent \textit{on an annual basis}, \textit{and},
  – Consider \textit{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.
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

<table>
<thead>
<tr>
<th>Type of Improvement</th>
<th>Construction Energy Consumed per Rural(^a)-Lane-Mile ((10^9 \text{ Btu/mi}))</th>
<th>CO2, tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>New construction</td>
<td>12.70</td>
<td>637</td>
</tr>
<tr>
<td>Relocation</td>
<td>10.50</td>
<td>526</td>
</tr>
<tr>
<td>Reconstruction</td>
<td>5.20</td>
<td>261</td>
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<tr>
<td>Restoration and rehabilitation</td>
<td>2.30</td>
<td>115</td>
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<tr>
<td>Resurfacing</td>
<td>0.75</td>
<td>38</td>
</tr>
<tr>
<td>Major widening</td>
<td>5.00</td>
<td>251</td>
</tr>
<tr>
<td>Minor widening</td>
<td>1.90</td>
<td>95</td>
</tr>
<tr>
<td>New Bridges</td>
<td>192</td>
<td>9624</td>
</tr>
<tr>
<td>Bridge Replacement</td>
<td>222</td>
<td>11128</td>
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<tr>
<td>Major rehabilitation</td>
<td>134.4</td>
<td>6737</td>
</tr>
<tr>
<td>Minor rehabilitation</td>
<td>11.91</td>
<td>597</td>
</tr>
</tbody>
</table>

\(^a\) 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

• Planning process is the appropriate venue for developing and implementing GHG reduction strategies not project level
• Project-level analysis not meaningful
  – Inadequate tools
  – Global emissions vs project-level analysis disconnect
  – Basis for 25,000 mmte threshold?
• Major emphasis on adaptation needed in transportation policy
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
- Mayo Foundation v. Surface Transportation Board, 2006
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

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
• 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.
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

Individual Household Level

- Synthetic Household Generation
- Urban area land use and transportation system characteristics
- Household vehicle ownership
- Household vehicle travel
- Household vehicle characteristics

Aggregate Level

- Demand management program adjustments to VMT
- Heavy vehicle VMT
- MPG adjustments due to congestion
- Fuel consumption by type
- CO2 equivalent emissions by fuel type (including well to wheels)

Adjust household income due to travel cost change
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**

![Graph showing Pounds CO2 Equivalents over years from 1990 to 2040.](image)
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
VI. Strategies to Reduce Transportation GHGs
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 Rule Significantly Reduces Highway GHG Below Baseline

### EPA MY2012-2016 GHG Standards Projections Based on Public Target

<table>
<thead>
<tr>
<th></th>
<th>Fuel Economy</th>
<th>Greenhouse Gas Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011 CAFE standard</td>
<td>27.3 mpg</td>
<td>325 gpm</td>
</tr>
<tr>
<td>2016 target GHG standard</td>
<td>(34-35.5 mpg)</td>
<td>250 gpm</td>
</tr>
<tr>
<td>% GHG reduction</td>
<td>--</td>
<td>23%</td>
</tr>
</tbody>
</table>
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.

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

  - 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

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

Reducing VMT growth (smart growth, transit, carpooling, vanpooling, walking, TDM, and pricing-related strategies) to +1.0% annual.

System/vehicle operational efficiency (speed limit reductions/enforcement, ecdriving, smoothing out traffic flow, proper tires and inflation, removing bottlenecks, etc.)

Highest LDV CO2e Emissions Reductions (79% Reduction CO2e/Vehicle Mile) by 2050

Light duty fleet GHG emissions

GHG Goal 70% Reduction from 2005
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.
Cautionary Note on VMT as 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

National Vehicle Miles Traveled vs. Gasoline Prices

<table>
<thead>
<tr>
<th>Year</th>
<th>VMT (billions)</th>
<th>Gasoline Price ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>258</td>
<td>2.19</td>
</tr>
<tr>
<td>2006</td>
<td>260</td>
<td>2.93</td>
</tr>
<tr>
<td>2007</td>
<td>260</td>
<td>3.10</td>
</tr>
<tr>
<td>2008</td>
<td>250</td>
<td>4.10</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Mode</th>
<th>Energy Intensities (Btu or kWh per vehicle mile)</th>
<th>Load Factor</th>
<th>Co₂e (Estimated Pounds Co₂e Per Passenger Mile)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NATIONAL AVERAGE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Occupancy Vehicle (SOV) LDV’s</td>
<td>5,987</td>
<td>1.00</td>
<td>0.99</td>
</tr>
<tr>
<td>Personal Trucks at Average Occupancy</td>
<td>6,785</td>
<td>1.72</td>
<td>0.71</td>
</tr>
<tr>
<td>Transit Bus</td>
<td>37,310</td>
<td>8.80</td>
<td>0.71</td>
</tr>
<tr>
<td>Cars at Average Occupancy</td>
<td>5,514</td>
<td>1.57</td>
<td>0.58</td>
</tr>
<tr>
<td>Electric Trolley Bus</td>
<td>5.2</td>
<td>13.36</td>
<td>0.52</td>
</tr>
<tr>
<td>High Occupancy Vehicle (HOV) LDVs at 2+ Occupancy</td>
<td>5,987</td>
<td>2.10</td>
<td>0.47</td>
</tr>
<tr>
<td>Intercity Rail (Amtrak)</td>
<td>54,167</td>
<td>20.50</td>
<td>0.39</td>
</tr>
<tr>
<td>Light and Heavy Rail Transit</td>
<td>62,797</td>
<td>22.50</td>
<td>0.39</td>
</tr>
<tr>
<td>Motorcycles</td>
<td>2,226</td>
<td>1.20</td>
<td>0.37</td>
</tr>
<tr>
<td>Commuter Rail</td>
<td>92,739</td>
<td>31.30</td>
<td>0.36</td>
</tr>
<tr>
<td>Vanpool</td>
<td>8,048</td>
<td>6.10</td>
<td>0.21</td>
</tr>
<tr>
<td>Walking or Biking</td>
<td>-</td>
<td>1.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>
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
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

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
“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
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 by 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
  - 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](http://www.its.uci.edu/its/whatsnew/barth2.pdf)
Effect of Speed on GHG

Traffic Operation Strategies To Reduce CO$_2$
Cost of Congestion

Cost of Wasted Time and Wasted Fuel
Due to Highway Congestion
(Billions of 2007 Dollars)

The cost of highway congestion is up 265 percent in inflation-adjusted terms since 1985.

Source: Texas Transportation Institute
• 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
Portland, OR Traffic Signal Timing Project

- Began 2002, 10-year project
- Climate Trust funded project and pays for CO2 offsets from project
- Improve 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

Freight – Ton-Mile/GDP Trends

Goods Movement and GDP


For every trillion dollar increase in GDP, we expect an additional 242 billion ton-miles.

Source: Corbett and Winebrake, 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

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

Source: History: Transportation Energy Databook 28th Edition
Projection: Annual Energy Outlook 2009 Updated Reference Case d041409a
Freight GHG – Barges and Rail
Source: Texas Transportation Institute and Center for Ports and Waterways
Freight Rail Can Relieve Congestion

![Graph showing cumulative reduction in GHG emissions if 10% of long-haul freight that moves by truck moves by rail instead.](image)

For simplicity, data assume constant 110 ton-miles per gallon for trucks and 436 ton-miles per gallon for rail through 2020 and that GHG emissions consist solely of 22.4 pounds of CO2 per gallon of diesel. Based on truck movements more than 500 miles in length as forecast by AASHTO.
Rail Fuel Efficiency has Improved

Since 1980, Rail Freight Volume Has Nearly Doubled But Rail Fuel Consumption Is Only Slightly Higher (Index 1980 = 100)

- RR Fuel Consumed*
- Railroad Volume**

*In freight service   **revenue ton-miles  Data are for Class I railroads.  Source: AAR
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 CO₂ emissions, is realized following this diesel retrofit
• Very cost-effective CMAQ project
Cleaner Locomotive
McKinsey: Available Technologies can Reduce 3 Billion Tons GHG/Year at < $50/ton (compare to projected 9.7 billion tons economy-wide in 2030)

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 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
Retrofit legacy fleets to reduce PM and black carbon
Implement wide-ranging freight technology and logistics improvements
VII. Participant Workshop
A working session in break-out groups to identify an initial set of activities for Mississippi 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.
Resources -- Websites

- AASHTO: http://climatechange.transportation.org/
- Intergovernmental Panel on Climate Change (IPCC): http://www.ipcc.ch/
- The Pew Center on Global Climate Change: http://www.pewclimate.org/
- EPA Climate Change Program http://www.epa.gov/climatechange/
Resources – Key Documents

- AASHTO, “Primer on Transportation and Climate Change,” 2008
- Pew Center on Climate Change, “Climate Change 101”
• **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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