Climate Change

Information, Challenges, and Strategies for Rhode Island DOT

April 14, 2010
Workshop Purpose

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

I. Climate Change Science, Sources, and Trends
II. The Importance of Climate Change to State DOTs
III. Climate Adaptation
IV. Planning and NEPA Issues
V. Rhode Island Plans that Support GHG Reductions
VI. Strategies to Reduce GHG Emissions from Transportation Sources
VII. Participant Workshop: Developing an Action Plan Framework
I. Climate Change – Science, Sources and Trends
What is climate change?

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

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

Many people think of climate change as an increase in temperature, or global warming.

But temperature changes reflect the complex interaction between:
- The Sun
- Oceans
- Land
- Ice
- Biosphere
- Atmosphere
How significant is man-made CO$_2$?

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

![Pie chart showing natural CO$_2$ (96.775%) and man-made CO$_2$ (3.225%)](image)

Parsons Brinckerhoff / Sarah J. Siwek & Associates, Inc. | Climate Change
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
How significant is 1 degree Celsius?

Research has identified trends and developed measures for assessing the impact:

- An increase of 1°C in a period of 100-200 years would be considered global warming. Over the course of one century, an increase of 0.4°C would be considered significant.

- Global average surface temperature has increased over the last century by about 0.61°C (1.1°F).

- It can take the Earth thousands of years to warm up or cool down just one degree, when it happens naturally.
What is the evidence on temperatures?

Source: 

Parsons Brinckerhoff / Sarah J. Siwek & Associates, Inc. | Climate Change
What are the impacts at different temperature increases?

### Projected impacts of climate change

| Global temperature change (relative to pre-industrial) |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                 | 0°C             | 1°C             | 2°C             | 3°C             | 4°C             | 5°C             |
| **Food**        |                 |                 |                 |                 |                 |                 |
|                 |                 |                 |                 |                 |                 |                 |
|                 | failing crop yields in many areas, particularly developing regions | possible rising yields in some high latitude regions |                 |                 | falling yields in many developed regions |                 |
| **Water**       |                 |                 |                 |                 |                 |                 |
|                 |                 |                 |                 |                 |                 |                 |
|                 | small mountain glaciers disappear, water supplies threatened in several areas | significant decreases in water availability in many areas, including Mediterranean and Southern Africa |                 |                 | sea level rise threatens major cities |                 |
| **Ecosystems**  |                 |                 |                 |                 |                 |                 |
|                 |                 |                 |                 |                 |                 |                 |
|                 | extensive damage to coral reefs | rising number of species face extinction |                 |                 |                 |                 |
| **Extreme Weather Events** |                 |                 |                 |                 |                 |                 |
|                 |                 |                 |                 |                 |                 |                 |
|                 | rising intensity of storms, forest fires, droughts, flooding and heat waves |                 |                 |                 |                 |                 |
| **Risk of Abrupt and Major Irreversible Changes** |                 |                 |                 |                 |                 |                 |
|                 |                 |                 |                 |                 |                 |                 |
|                 | increasing risk of dangerous feedbacks and abrupt, large-scale shifts in the climate system |                 |                 |                 |                 |                 |

**Source:**
Stern Review, 2008

Parsons Brinckerhoff / Sarah J. Siwek & Associates, Inc. | Climate Change
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 CO$_2$ 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

Parsons Brinckerhoff / Sarah J. Siwek & Associates, Inc. | Climate Change
What is the physical evidence?

Arctic sea ice is retreating – a measurable change in climate that can be seen.

Source: NASA

Parsons Brinckerhoff / Sarah J. Siwek & Associates, Inc. | Climate Change
How will climate change affect the planet?

- Rising sea levels
- Extreme weather
- Higher temperatures
- Threats to human health
- Changes in crop yields
- Precarious ecosystems
How certain are the scientists?

• “Warming of the climate system is unequivocal…”
  -- Intergovernmental Panel on Climate Change

• “An overwhelming body of scientific evidence paints a clear picture: climate change is happening, it is caused in large part by human activity, and it will have many serious and potentially damaging effects in the decades ahead.”
  -- Pew Center on Climate Change
What are the latest news stories?

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

Comparison: Annual* & Cumulative** CO₂ Emissions

Countries

US 30% 22%
China 18% 7%
EU-25 15% 6%
Russia 27% 8%
India 4% 4%
Japan 5% 5%
Brazil 2% 2%
Canada 2%
Mexico 1%
Indonesia 1%
South Korea 0.5%
South Africa 1%
Australia 1%

** Cumulative Emissions from 1850-2000, CAIT WRI
How much GHG reduction is needed?

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

- Scientists recommend 60-80% GHG reduction below 1990 level by 2050
- Many states and countries have adopted targets in this range
- President Obama’s budget: 80% GHG reduction below 2005 by 2050
- Waxman-Markey bill: 17% below 2005 by 2020 and 83% below 2005 by 2050
What are the sources of GHG emissions?

Transportation = 28% of U.S. GHG
How much will transportation GHG increase?

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

Hanoi, Vietnam

Beijing, China

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

What are the global trends in vehicle ownership and use?

Source: WBCSD, 2004a. Mobility 2030: Meeting the Challenges to Sustainability
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 University and former Director of Engineering at Rolls-

Aston Advanced 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
• Substantial efforts are needed to stabilize and reduce GHG emissions
• It is a global and cumulative problem
• As underdeveloped countries develop, levels of GHG emissions increase
• Delay will magnify the challenges of GHG emission reduction
II. The Importance of Climate Change to State DOTs
A Five-Part Challenge to State DOTs

1. **Reduce transportation GHG**, especially highway GHG, 60-80% by 2050
2. **Prepare for Federal climate change legislation**
3. **Help shape sound state climate policies**
4. **Find a new revenue stream** suitable for low-carbon fuels
5. **Adapt transportation infrastructure** to rising sea levels, more severe storms, higher temperatures, and flooding
• 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 private-label CFL bulbs in Mexico, and labelling clothes as cold-water wash.

Should state DOTs take a page from Wal-Mart’s book?
Transportation is a major source of GHG

Transportation = 28% of U.S. GHG

Parsons Brinckerhoff / Sarah J. Siwek & Associates, Inc. | Climate Change
Highway Vehicles Account for 85% of Transportation CO2 Emissions – and 24% of all U.S. CO2

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

- Light Vehicles, 1187
- Heavy + Medium Duty Vehicles, 420
- Air, 187
- Waterborne, 51
- Rail, 51
- Pipeline/Other, 35
DOE Projects Slight Decline in LDV GHG Emissions

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

Parsons Brinckerhoff / Sarah J. Siwek & Associates, Inc. | Climate Change
U.S. VMT growth rates are declining– but will zero or negative VMT growth be expected?

- VMT growth has been steadily declining since the 1950s
- VMT growth slowed to about 1.5% in early 2000s
- VMT growth was actually negative in 2008
- VMT is affected by population, economy, transportation prices, demographics, land use
- AASHTO supports reducing VMT growth rate to 1% per year

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

Source: Alan Pisarski and Cambridge Systematics
VMT closely linked to disposable income

Light Duty Vehicle Miles Travelled (1 of 3)

Source: Annual Energy Outlook 2009, Reference Case d011009a

Parsons Brinckerhoff / Sarah J. Siwek & Associates, Inc. | Climate Change
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
Federal Climate Legislation and Policy are Taking Shape

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

- Major R&D to decarbonize vehicles/fuels (comparable to “man on the moon”)
- Reduce VMT growth to 1%/year
- Double transit ridership
- Increase intercity passenger rail
- $100 M/year Federal funding for coordinated land use/transportation planning
- Oppose GHG conformity requirement
Clean Air Act – EPA Finding of “Endangerment”

- EPA may act to regulate GHG under existing Clean Air Act (CAA)
- December 2009 EPA finding:
  - Atmospheric concentrations of GHG “endanger” public health and welfare (per CAA section 202(a))
  - Emissions of GHG from new motor vehicles “contribute to” air pollution which is endangering public health and welfare
- Based on this finding EPA is obligated to regulate GHG (e.g., GHG standards for autos)
- GHG conformity possible, but not likely
Federal Climate Legislation - Status

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

Source: Bill Malley, Perkins Coie
Federal Legislation –
Major Elements of Climate Bills

- **Cap-and-Trade**
  - Mandate reductions in total GHG emissions

- **Energy Production**
  - Provides incentives and other support for production of renewable energy (and maybe nuclear, oil & gas)

- **Energy Efficiency**
  - Provides incentives and tighter regulations to promote greater efficiency.

- **Transition Assistance**
  - Provides assistance to ease impact of higher energy prices on consumers and U.S. industries

Source: Bill Malley, Perkins Coie
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
How would the House and Senate bills reduce GHG emissions from transportation?

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

Source: Bill Malley, Perkins Coie
How would the House and Senate bills affect the price of transportation fuels?

- EPA makes two key assumptions:
  - Relatively low cost to adopt new technologies that reduce GHG emissions, such as carbon capture and sequestration (CCS).
  - Relatively widespread use of "offsets"
- Without these assumptions, prices could be much higher.
- EPA has not yet released an estimate of the gasoline price impacts of the Senate bill.

Source: Bill Malley, Perkins-Coie
# Federal Climate Legislation – Impact on Transportation Fuel Prices

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPA Projection</td>
<td>$0.14</td>
<td>$0.24</td>
<td>$0.69</td>
</tr>
<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>

Federal Climate Legislation - Impact on Transportation GHG

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

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

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

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

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

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

- Modal funding and policy emphases to support GHG goals
- Explicit or implicit VMT reduction goals?
- Compact land use planning incentives?
- GHG reduction targets?
- GHG conformity requirements?
- GHG performance measures?
- GHG planning requirements?
- GHG environmental review requirements?
- Adaptation planning requirements?
- Adaptation funding?
State Climate Action Plans

Source: Pew Center on Climate Change

Parsons Brinckerhoff / Sarah J. Siwek & Associates, Inc. | Climate Change
• Highly “aspirational”
• Managed by state environmental agencies
• Steering Committees included multiple environmental advocates and rarely had transportation agency reps
• State DOT involvement was at a technical advisory level, whose input was often rebuffed
• Example: VT strategies would reduce 2030 VMT from 10.5 billion (base case) to 3.9 billion VMT
## State Climate Plans – Transportation Share Of GHG Reductions Varies Widely

<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>
</tr>
<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>
</tr>
<tr>
<td>Minnesota</td>
<td>2025</td>
<td>27%</td>
<td>5%</td>
</tr>
<tr>
<td>Oregon</td>
<td>2025</td>
<td>25%</td>
<td>8%</td>
</tr>
<tr>
<td>New Mexico</td>
<td>2020</td>
<td>30%</td>
<td>8%</td>
</tr>
<tr>
<td>Colorado</td>
<td>2020</td>
<td>22%</td>
<td>6%</td>
</tr>
<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>
</tr>
</thead>
<tbody>
<tr>
<td>RI **</td>
<td>2020</td>
<td>46%</td>
<td>10%</td>
<td>31%</td>
<td>14%</td>
</tr>
<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>
</tr>
<tr>
<td>CT</td>
<td>2020</td>
<td>51%</td>
<td>38%</td>
<td>8%</td>
<td>2%</td>
</tr>
<tr>
<td>ME</td>
<td>2020</td>
<td>53%</td>
<td>25%</td>
<td>21%</td>
<td>1%</td>
</tr>
<tr>
<td>MD</td>
<td>2025</td>
<td>24%</td>
<td>12%</td>
<td>45%</td>
<td>20%</td>
</tr>
<tr>
<td>NY</td>
<td>2020</td>
<td>59%</td>
<td>11%</td>
<td>27%</td>
<td>4%</td>
</tr>
<tr>
<td>PA</td>
<td>2025</td>
<td>45%</td>
<td>36%</td>
<td>18%</td>
<td>0%</td>
</tr>
<tr>
<td>MN</td>
<td>2025</td>
<td>15%</td>
<td>35%</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>VT</td>
<td>2028</td>
<td>21%</td>
<td>14%</td>
<td>49%</td>
<td>17%</td>
</tr>
</tbody>
</table>
What are other state DOTs doing on climate change?

- New York: [http://www.nysdot.gov/nasto/repository/WS4d Zamurs%20_AASHTO_0.ppt](http://www.nysdot.gov/nasto/repository/WS4d Zamurs%20_AASHTO_0.ppt)
GHG reduction debates overshadow 2 more challenges bearing down on state DOTs

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

- Reduce transportation GHG, especially highway GHG, 60-80% by 2050
- Prepare for Federal climate legislation
- Help shape state climate action policies
- Find a new revenue stream suitable for a world of new low-carbon fuels
- Adapt transportation infrastructure to rising sea levels, more severe storms, higher temperatures, and flooding
IV. Climate Adaptation for Transportation
Why Transportation Agencies Should Plan for Adaptation

• **Sea level rise & storm surges**
  – Destruction of bridges
  – Erosion & permanent inundation of roads
  – Disruption of evacuation routes & road network
  – Bridge clearance limitations

• **Other types of impacts**
  – Increased flooding
  – Pavement and rail buckling
  – Increased flooding
  – More severe inland storms
  – Increased maintenance

Source: http://mceer.buffalo.edu/research/Reconnaissance/Katrina8-28-05/05BiloxiBay1/091g.jpg
“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
Rhode Island’s Vulnerability – 2010 Report by Brown University

Summary: Preliminary Assessment of Rhode Island’s Vulnerability to Climate Change and its Options for Adaptation Action

February 2010

By Brown University

Available at: http://envstudies.brown.edu
Rhode Island’s future climate could be like:

– New Jersey
– Virginia
– Georgia

Is RI’s transportation system designed for those climate conditions?

Source: Preliminary Assessment of RI’s Vulnerability to Climate Change and Options for Adaptation Action, Brown University, Feb 2010.
# Potential Effects of Climate Change on Rhode Island

<table>
<thead>
<tr>
<th>Climate Parameter</th>
<th>Late century High emissions</th>
<th>Late century Low emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer temperature rise</td>
<td>6°F to 14°F</td>
<td>3°F to 7°F</td>
</tr>
<tr>
<td>Winter temperature rise</td>
<td>8°F to 12°F</td>
<td>5°F to 8°F</td>
</tr>
<tr>
<td>Days over 90°F (per year)</td>
<td>60 days</td>
<td>30 days</td>
</tr>
<tr>
<td>Days over 100°F (per year)</td>
<td>14-28 days</td>
<td>3-9 days</td>
</tr>
<tr>
<td>Sea Level Rise</td>
<td>10 - 23 in</td>
<td>7 - 14 in</td>
</tr>
<tr>
<td>Sea-surface temperature rise</td>
<td>6°F to 8°F</td>
<td>4°F to 5°F</td>
</tr>
<tr>
<td>Intensity increase once-a-yr extreme precipitation events</td>
<td>10% more rain</td>
<td>20% more rain</td>
</tr>
</tbody>
</table>

Source: *Preliminary Assessment of RI’s Vulnerability to Climate Change and Options for Adaptation Action*, Brown University, Feb 2010.
Potential Effects of Climate Change on Providence

Effect of 2-meter and 3-meter sea level rise on Providence, viz a viz poverty

Source: Preliminary Assessment of RI's Vulnerability to Climate Change and Options for Adaptation Action, Brown University, Feb 2010.
Potential Impact of Climate Change on U.S. Transportation (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.
Design standards will need to be re-evaluated and new standards developed as progress is made in understanding future climate conditions and the options for addressing them.

Transportation planners will need to consider climate change and its effects on infrastructure investments. Planning timeframes may need to extend beyond the next 20 or 30 years.

Institutional arrangements for transportation planning and operations will need to be changed to incorporate cross jurisdictional and regional cooperation.
States Focusing on Climate Adaptation

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

- California
- Pennsylvania
- Maryland
- Washington
- Hawaii
- Alaska
- Florida
- Massachusetts
- North Carolina
Implications for Design

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

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

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

• Monitor bridges through the Bridge Inspection program and Scour program to ensure safety and develop measures (armoring) to protect the structure until proposed replacement.

• Projects addressed on a case-by-case basis where flooding issues have been identified.

• Bridge projects with low-chord below 10-year flood are subject to more intense review. Two foot clearance preferred but ROW, Environmental, Cultural impacts must be considered.
MASSDOT: Mid-Term Recommendations Being Considered for Coastal Areas

- Mapping – Using Light Detection and Ranging (LIDAR) survey to map coastal assets
- Develop GIS based asset inventory
- Perform Sea Level Rise Vulnerability Assessment
- Identify & Prioritize Critical Transportation Assets
- Develop design requirements on a project-by-project and priority basis
MASSDOT: Mid-Term Recommendations Being Considered for Inland Areas

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

- Continue development of engineering standards with FHWA and AASHTO

- Progressively adapt standards as:
  - More data becomes available
  - Climate change impacts are realized
  - Climate change events are predicted with greater accuracy
  - Universal models are developed
U.K. Highways Agency Adaptation Strategy Model

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

1. Define 'Objectives' and 'Decision making criteria'
2. Identify 'Climatic Trends' affecting Highways Agency Adaptation Programme Review
3. Identify Highways Agency 'Vulnerabilities'
4. 'Risk Appraisal'
5. 'Options Analysis' to address each vulnerability
6. Develop and Implement 'Adaptation Action Plans' for each vulnerability
7. 'Adaptation Programme Review'

‘Research’, ‘Monitoring’ or periodic review

'Options Analysis' to address each vulnerability

2. Identify 'Climatic Trends' affecting Highways Agency

3. Identify Highways Agency 'Vulnerabilities'

4. 'Risk Appraisal'

5. 'Options Analysis' to address each vulnerability

6. Develop and Implement 'Adaptation Action Plans' for each vulnerability

7. 'Adaptation Programme Review'

1. Define 'Objectives' and 'Decision making criteria'

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
• Gulf Coast and **low lying coastal areas especially vulnerable**
• **Risk assessment and prioritization** is key
• Transportation planners need to **be aware of and adapt to climate change impacts** on our transportation infrastructure
• Looming in future: where **not to build or re-invest**?
IV. Planning and NEPA Issues
New Federal Planning Requirements are Very Likely

- House-passed Cap-and-Trade bill includes new planning requirements for climate change
- Oberstar’s draft bill for transportation authorization includes new planning requirements for climate change
- Various Senate bills include new planning requirements for climate change
- Most of the provisions in the different bills are virtually identical
• **TARGETS AND STRATEGIES:** States and TMA MPOs must develop GHG reduction targets and strategies, as part of transportation plans

• **PROGRESS:** States and TMA MPOs must “demonstrate progress in stabilizing and reducing” GHG emissions

• **METHODOLOGIES:** EPA must issue regulations on transportation GHG goals, standardized models, methodologies, and data collection

• **CERTIFICATION:** US DOT shall not certify state or MPO plans that fail to “develop, submit or publish emission reduction targets and strategies”

• **PERFORMANCE REQUIREMENTS:** US DOT must establish requirements, including performance measures, “to ensure that transportation plans… sufficiently meet the requirements…, including achieving progress towards national transportation-related GHG emissions reduction goals.”
Transportation Planning Ground Rules will be Critical – Methods, Tools, etc.

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

- EPA GHG calculator (converts GHG tons to equivalencies in terms of annual operation of cars, power plants, etc.)
  
  http://www.epa.gov/cleanenergy/energy-resources/refs.html#vehicles

- EPA GHG calculator for households (enter HH activity data to get GHG)
  
  http://www.epa.gov/climatechange/emissions/ind_calculator.html

- University of Vermont Transportation Research Center (GIS-based travel demand model/carbon calculator)
  
  VMT calculation spreadsheet

- GreenSTEP statewide transportation GHG estimator
  

- Summary and assessment of GHG methodologies
  
  http://www.commerce.wa.gov/site/1277/default.aspx
One Emerging Tool: GreenSTEP

**GreenSTEP** = **Greenhouse gas State Transportation Emissions Planning model**

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

- 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)

1x 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

- **1990 to 2040**
- **Yearly Data**
- **Categories:**
  - Med Lt Veh Eff
  - High Lt Veh Eff
  - High Cost & Med Lt Veh Eff
  - High Cost & High Lt Veh Eff
- **Graph Details:**
  - X-axis: Year
  - Y-axis: Pounds CO2 Equivalents

### Urban Planning

- **1990 to 2040**
- **Yearly Data**
- **Categories:**
  - Med Lt Veh Eff
  - High Lt Veh Eff
  - High Cost & Med Lt Veh Eff
  - High Cost & High Lt Veh Eff
- **Graph Details:**
  - X-axis: Year
  - Y-axis: Pounds CO2 Equivalents

### Vehicle Tech & Fuel

- **1990 to 2040**
- **Yearly Data**
- **Categories:**
  - Med Lt Veh Eff
  - High Lt Veh Eff
  - High Cost & Med Lt Veh Eff
  - EV & High Lt Veh Eff
- **Graph Details:**
  - X-axis: Year
  - Y-axis: Pounds CO2 Equivalents

*Note: Graphs show trends and data over time for different strategies.*

*Parsons Brinckerhoff / Sarah J. Siwek & Associates, Inc. | Climate Change*
NEPA Analysis of Climate Impacts

- **Draft NEPA Guidance** Issued by CEQ on February 18, 2010.

- Comments due: May 24, 2010

- Proposal: Calls for consideration of both:
  - project impact on GHG and
  - impact of climate on project
NEPA: Draft CEQ Guidance

- If a proposed action **causes direct emissions of 25,000 metric tons of CO2 equivalent GHG annually**, a quantitative and qualitative assessment may be helpful.
- Agencies **should consider global context** and ensure that useful information is provided for specific actions that cause 25,000 metric tons CO2-equivalent.
- Seeks comment on how agencies “**can tailor the amount of documentation for NEPA proportionate to the importance of climate change to the decision-making process**.”
What highway projects might exceed CEQ’s reference point of 25,000 tons GHG/year in direct emissions?

- A ___ mile project constructing a new highway would likely exceed 25,000 tons/year of GHG in direct construction emissions.
- A highway project that “induces” **49 million new VMT/year** would likely exceed 25,000 tons/year of added GHG, if vehicles average 20 MPG*
- If/when vehicles average 30 MPG, a highway project would have to “induce” **74.5 million new VMT/year** to exceed 25,000 metric tons/year of GHG*

*To the extent a new highway project relieves congestion, it may achieve operational GHG reductions that offset some or all GHG associated with “induced” demand.

*Calculation of “induced” demand should not count VMT that simply shift from other parts of the region.
• Consider quantifying those emissions (over 25,000 metric tons CO2-equivalent annually)
  – Where reporting protocols exist, use them (e.g. Mandatory EPA requirements for stationary sources, etc.)
  – Where protocols do not exist, use interagency process under NEPA
  – Consider
    • Direct and indirect effects
    • Energy use
    • Mitigation opportunities
    • If a determination that a cumulative assessment of effects of GHG emissions useful
      – Assess annual and cumulative emissions of the proposed action and compare to alternatives
NEPA: Draft CEQ Guidance

• Adaptation Planning
  – Discusses **climate change effects that should be considered in project development** such as flooding in low lying areas, development of coastal infrastructure
  – Also discusses **reasonably foreseeable future condition** with no action

• Guidance also provides references to useful materials and links.
Recent History – Court Rulings on NEPA/GHG

3 cases overturned FONSI/EA/EIS for lack of climate analysis:
- Center for Biological Diversity et al. v. NHTSA
- Mid States Coalition for Progress v. Surface Transportation Board
- Border Power Plan Working Group v. DOE

4 cases upheld lack of climate analysis or sufficiency of analysis:
- Audubon v. DOT, 2007
- Friends of the Earth v. Mosbacher, 2007
- Mayo Foundation v. Surface Transportation Board, 2006
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

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

Source: Colin McConnaha, Parametrix, Inc.
Summary

• CEQ Draft Guidance will impact required NEPA Analysis
• Consider both
  * impact of project on GHG; and
  * impact of climate change on project
• Tools will be needed to evaluate GHG emissions
• Documentation will be important
• Mitigation actions can be helpful
V. Rhode Island Plans that Support GHG Reductions
Rhode Island Plans that Support GHG Reduction

To be presented by representatives of Rhode Island state government
VI. Strategies to Reduce GHG from Transportation
Five GHG Reduction “Legs”

Transportation GHG reduction has 5 legs:

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

Examples:

- Higher CAFE standards 380 gm/mile to 250 gm/mile 2016
- CA’s low carbon fuel standard
- Less travel, could be in part due to land use changes
- Signalization, ITS, Eco-driving
- Materials, maintenance practices
Vehicle/Fuel Improvements Will be the **Dominant** Source of GHG Reductions for LDVs

By 2020-2030:

- 50% cut in GHG/mile is feasible from conventional technologies and biofuels
- Compare these GHG rates in U.S. and Europe:
  
<table>
<thead>
<tr>
<th>Grams/mile</th>
<th>Year/Standard</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>380</td>
<td>2009 in the U.S.</td>
<td>U.S.</td>
</tr>
<tr>
<td>250</td>
<td>2016 under new Obama standard</td>
<td>U.S.</td>
</tr>
<tr>
<td>256</td>
<td>2007 actual in the E.U.</td>
<td>E.U.</td>
</tr>
<tr>
<td>209</td>
<td>2012 under E.U. regulation</td>
<td>E.U.</td>
</tr>
<tr>
<td>153</td>
<td>2020 under E.U. regulation</td>
<td>E.U.</td>
</tr>
</tbody>
</table>

- LDV purchase cost will rise, but fuel savings will be greater than vehicle cost increase
- Win-win-win: reduces energy use, reduces GHG, saves money
Recently Announced NHTSA/EPA Rule Significantly Reduce Highway GHG Below Baseline

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

<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>
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.

Potential for Advanced Technologies to Increase Fuel Economy by 2030

Even Greater Vehicle “Decarbonization” is Necessary

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

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

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

GHG Intensity of Different Fuels

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

- Many different low-carbon fuel possibilities:
  - Corn ethanol
  - Sugar cane ethanol
  - Diesel
  - Cellulosic biofuel
  - Algae biofuels
  - Electricity from renewable energy or nuclear power
  - Electricity from utilities with carbon capture & storage
  - Hydrogen

- Carbon intensity measured as GHG/unit of energy – must account for “life-cycle” emissions

- California LCFS:
  - Adopted in 2008
  - Aims to reduce carbon intensity of passenger vehicle fuels by 10% by 2020
  - Measures carbon-intensity on a life-cycle basis – "from field to wheel."
Renewable Fuel Standard

  - 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

![Biofuel Usage Chart]

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, ecodriving, 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.
Pricing – A Necessary and Powerful Tool

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

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

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

National Vehicle Miles Traveled vs. Gasoline Prices

Monthly total VMT for June of each year.

2005: 258, $2.19
2006: 260, $2.93
2007: 260, $3.10
2008: 260, $4.10

VMT (billions)
Carpooling and Vanpooling

- **Important but underappreciated** (7 times as many PMT for work trips nationally are in carpools and vanpools as on transit)
- **Low cost** for government, wide availability, saves users money
- **Effective in all kinds of areas** – rural, small urban areas, suburban, urban
- **Nearer-term payoff** than most transportation strategies
- **Atlanta MPO and WASHCOG pay for commuters to carpool** ($3/day Atlanta, $2/day WASHCOG)
Transit Helps Reduce GHG – but has Small Impact Nationally

- Transit serves many goals and has broad support.
- But transit serves just 1% of PMT and 0% of freight
- DOE: *Bus transit has higher GHG/passenger mile traveled than average auto use in the U.S.*
- APTA studies: (a) *Transit reduced GHG by 6.9 MMT in 2005; or (b) by 35 MMT in 2005.* This is 0.3% to 1.7% of U.S. transportation GHG
- Transit GHG benefits are realized with highly patronized services in high volume corridors -- a market limited to high volume, generally densely developed corridors.
## CO₂e Emissions Per Passenger Mile for Various Modes

### NATIONAL AVERAGE

<table>
<thead>
<tr>
<th>Mode</th>
<th>Energy Intensities</th>
<th>Load Factor</th>
<th>CO₂e</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Btu or kWhr per</td>
<td></td>
<td>(Estimated</td>
</tr>
<tr>
<td></td>
<td>vehicle mile)</td>
<td>Persons</td>
<td>Pounds CO₂e</td>
</tr>
<tr>
<td></td>
<td>(Btu or kWhr per</td>
<td>Per Vehicle</td>
<td>Per Passenger</td>
</tr>
<tr>
<td></td>
<td>passenger mile)</td>
<td></td>
<td>Mile)</td>
</tr>
<tr>
<td>Single Occupancy Vehicle (SOV) LDVs</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>

### REGIONAL EXAMPLE (SEATTLE/PUGET SOUND REGION)

<table>
<thead>
<tr>
<th>Mode</th>
<th>Energy Intensities</th>
<th>Load Factor</th>
<th>CO₂e</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Btu or kWhr per</td>
<td></td>
<td>(Estimated</td>
</tr>
<tr>
<td></td>
<td>vehicle mile)</td>
<td>Persons</td>
<td>Pounds CO₂e</td>
</tr>
<tr>
<td></td>
<td>(Btu or kWhr per</td>
<td>Per Vehicle</td>
<td>Per Passenger</td>
</tr>
<tr>
<td></td>
<td>passenger mile)</td>
<td></td>
<td>Mile)</td>
</tr>
<tr>
<td>Cars (64%) and Personal Trucks (36%) at Average Occupancy</td>
<td>5,987</td>
<td>1.34</td>
<td>0.74</td>
</tr>
<tr>
<td>King County Metro Diesel and Hybrid Buses</td>
<td>33,024</td>
<td>11.57</td>
<td>0.47</td>
</tr>
<tr>
<td>Sound Transit Buses</td>
<td>33,024</td>
<td>13.12</td>
<td>0.42</td>
</tr>
<tr>
<td>King County Electrically-Powered Trolley Buses</td>
<td>5.33</td>
<td>12.12</td>
<td>0.11</td>
</tr>
</tbody>
</table>

Parsons Brinckerhoff / Sarah J. Siwek & Associates, Inc. | Climate Change
Land Use Effect on GHG is Modest – and Depends on Assumptions

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

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

Less VMT via Land Use: The 8 "D"s

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

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

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2020 Compass</th>
<th>2020 TVF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metro</td>
<td>84%</td>
<td>83%</td>
<td>60%</td>
</tr>
<tr>
<td>Small Cities</td>
<td>5%</td>
<td>4%</td>
<td>7%</td>
</tr>
</tbody>
</table>

Treasure Valley Futures (Trends)
## Development Patterns compared to Low Density

<table>
<thead>
<tr>
<th>Development Pattern</th>
<th>Economic Vitality</th>
<th>Quality of Life</th>
<th>Mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micropolitan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transit Oriented Corridor</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Economic Vitality**
  - Downtown Vitality
  - New Jobs by Town
  - Job Agglomeration
  - Fiscal Benefit Index
  - Compact Area/Access
  - Distribution of DU’s
  - Commercial Strip
  - Viewshed Impact
- **Quality of Life**
  - Safety
  - Accessibility
- **Mobility**
  - Rte 1 Level of Service
  - O&D Travel Times
  - Transit Ridership
  - Walkability

- **Implements**
  - Improves
  - Improves Significantly
  - Worsens
  - Varies
  - Varies Widely

---

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

• Suburban to urban
• Doubling jobs
• Adding 10X housing
• New land use plan
• Adding street connectivity with redevelopment
• New implementing authority
Preliminary assessment:

- Greenhouse Gas emissions 16% less per capita
- 2.5 billion lb. annual reduction
- Results from
  - Compact development
  - Fewer auto trips
  - Greater transit use
“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.
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 fully implemented at 65 cents/mile in 120 metro areas
- $400 permit fee to park on neighborhood streets
- $1.2 trillion transit expansion
- Bike lanes every 1/4 mile
- New and increased parking fees
- 90% of new urban development is compact, in dense Census tracts, with high quality transit
- Heavier and longer trucks allowed (up to 139,000 lbs)
- Eight more freight strategies
- Eco-driving by 20% of drivers
- Speed limit reductions
- Top 200 bottlenecks improved to LOS D
- And more…
Vehicle/System Operations to Reduce GHG

Potential for 10-20% LDV GHG reduction by:
- Managing speed (35-55 MPH is optimal)
- Speed limits/enforcement (could reduce fuel use 2-4%)
- Eliminating bottlenecks
- “Active” traffic management to smooth traffic flow
- Improving signal timing (could reduce 1.315 MMT CO₂/yr)
- Roundabouts (multiple benefits)
- Reducing car and truck idling
- Work zone management to smooth flow
- Encouraging eco-driving
Eco-Driving – 15% GHG Reduction Potential

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

Traffic Operation Strategies To Reduce CO₂

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, CO2 emissions and emissions from criteria pollutants
- Model for traffic signal offset projects
- [http://www.climatetrust.org/traffic_signals.html](http://www.climatetrust.org/traffic_signals.html)
Goods Movement and GDP


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

Source: Corbett and Winebrake, 2009.
Truck GHG is 20% of U.S. Transportation GHG – and Rising
Truck GHG is Growing Faster than Other Transportation GHG

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

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

Parsons Brinckerhoff / Sarah J. Siwek & Associates, Inc. | Climate Change
Freight GHG – Barges and Rail
Source: Texas Transportation Institute and Center for Ports and Waterways
Freight GHG Strategies in State Climate Action Plans

- Anti-idling programs
- Truck stop electrification
- Speed limit enforcement
- Freight villages/consolidation centers
- Feeder barge container service
- Traffic flow improvements
- Pre-clearances at scale houses
- Truck driver training
- EPA SmartWay up-grade kits & loans & diesel retrofits

- Incentives to retire older trucks
- Freight logistics improvements
- Shifting freight from truck to rail
- Hybrid power trucks
- Low-viscosity lubricants
- Single wide-base tires
- Automatic tire inflation systems
- “Black carbon” control technologies 85% retrofits

Detailed info available in NCHRP 20-24(59), Appendix C
“Best Practices Guidebook for GHG Reductions in Freight Transportation”

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

- Off-board truck stop electrification
- Auxiliary power units for trucks
- Alternative refrigerants for trucks
- Truck aerodynamic improvements
- Wide-base truck tires
- Low-rolling resistance tires
- Hybrid trucks
- Lightweight materials
- B20 biodiesel fuel
- And more....
Potential State DOT Strategies to Reduce HDV/MDV Truck GHG Emissions

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

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

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

- On-road diesel truck retrofits reduce PM 99% = 2007 EPA standards and also reduce black carbon
- Locomotive retrofits reduce PM and black carbon
  - Achieve over 76% PM and 25% fuel efficiency
- Cost-effective way to reduce emissions and save energy immediately.
- Retrofits of construction equipment and locomotives could be promising as state DOTs work to reduce emissions to meet potential planning requirements
The Diesel Locomotive Retrofit Process

- Each existing locomotive is stripped from the deck up, removing the large, single diesel engine.
- Three smaller, ultra-clean diesel generators are fitted onto the platform, along with control and operating equipment.
- An immediate emissions reduction of 86% ozone precursors, 76% Particulate Matter, and a 25% fuel savings, with a corresponding 25% reduction in greenhouse gas CO$_2$ emissions, is realized following this diesel retrofit.
• Each locomotive diesel retrofit provides annual reductions equal to 16,100 kg/yr ozone precursors and 417 kg/yr particulate matter.

• The project cost-effectiveness varies with the life of the project. Over five years, the cost-effectiveness of ozone precursor reductions is $13.91/kg of ozone precursor reduction.
A Retrofit Locomotive

- 86% reduction in ozone precursors
- 76% reduction in PM
- 25% reduction in fuel consumption
Construction, Maintenance, & Agency Operations Strategies

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

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

www.oregonsolarhighway.com
McKinsey: Available Technologies can Reduce 3 Billion Tons GHG/Year at < $50/ton
(compare to projected 9.7 billion tons economy-wide in 2030)

--- McKinsey & Company

Parsons Brinckerhoff / Sarah J. Siwek & Associates, Inc. | Climate Change
Greene & Schafer (Pew Center, 2003) concluded that a comprehensive, tailored set of strategies could cut U.S. transportation emissions in half by 2030.

Source: Greene and Schafer, Pew Center on Global Climate Change, May 2003.
“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.”
Many strategies are needed to reduce transport GHG. No silver bullet. Will need full mix of strategies including:

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

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

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

- AASHTO: http://realsolutions.transportation.org/Pages/default.aspx
- 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”
The Primer

- AASHTO "Primer on Transportation and Climate Change"
  - http://downloads.transportation.org/ClimateChange.pdf
Real Transportation Solutions for Greenhouse Gas Emissions Reductions

Automobiles and light-duty trucks contribute 26.5 percent of the greenhouse gases in the United States. States are looking at the best way to reduce these emissions while maintaining the transportation needed for people and businesses to depend upon. We are committed to doing our part to help achieve the goal of reducing U.S. greenhouse gas (GHG) emissions 80 percent by 2050. Our strategies include:

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


Parsons Brinckerhoff / Sarah J. Siwek & Associates, Inc. | Climate Change
"Potential Impacts of Climate Change on U.S. Transportation"

"Climate Change 101"

http://www.pewclimate.org/global-warming-basics
• **AASHTO Climate Change Steering Committee**: CCSC acts as a focal point and coordinating body for AASHTO’s activities related to climate change. CCSC members act as the focal point for AASHTO on climate change policy issues and provide oversight and guidance to AASHTO’s Climate Change Technical Assistance Program.

• **AASHTO Technical Assistance Program on Climate Change**: This is a new, voluntary program that provides timely information, tools and technical assistance to assist AASHTO members in meeting the difficult challenges that arise related to climate change.

For more information on AASHTO’s Climate Change Steering Committee and Climate Change Technical Assistance Program, please contact:
Shannon Eggleston at AASHTO (202) 624-3649
seggleston@aashto.org
Contact Info for Workshop Instructors

Cynthia J. Burbank
Parsons Brinckerhoff
burbank@pbworld.com
202-661-9262

Sarah J. Siwek
Sarah J. Siwek & Associates
ssiwek@aol.com
310-417-6660 x224