Reducing Greenhouse Gas Emissions from U.S. Transportation

Steven Plotkin, Argonne National Laboratory
(co-author is David Greene of Oak Ridge)

2011 EIA Energy Conference
May 26-27, 2011
Washington, DC
Overview

- Presentation based on recent report from the Pew Center on Global Climate Change
- Task: Assess the potential to substantially reduce transportation’s GHG emissions by 2035 & 2050.
- Base Case: Annual Energy Outlook 2010 Reference Case, extended to 2050
- Three scenarios with differing assumptions about technological progress, policy initiatives, and public attitudes
- Rely on existing studies to estimate impacts
- Scenario analysis uses Kaya method to integrate policy impacts and avoid double counting.
# Mitigation Scenario Assumptions

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>Mid</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Public Attitude</strong></td>
<td>Majority think climate change is serious; unwilling to change behavior; support modest pricing policies</td>
<td>60-75% think climate change is serious; some preference shift; support pricing policies</td>
<td>Public very concerned about climate change; preferences and habits change</td>
</tr>
<tr>
<td><strong>Towards Climate Change</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Public Policy Context</strong></td>
<td>Carbon price; RFS, biofuel subsidies, fuel economy &amp; emissions standards</td>
<td>Low + local and State governments complement federal actions</td>
<td>Mid + Treaty commits U.S. to reductions; feebates; stricter standards</td>
</tr>
<tr>
<td><strong>Rate of Technological Progress</strong></td>
<td>RDD&amp;D continues at current rate</td>
<td>Public $ on RDD&amp;D doubles; alternative vehicles costs fall dramatically; CCS is prevalent</td>
<td>NRC optimistic scenario for FCVs/EVs; clean electricity sector; highway automation</td>
</tr>
</tbody>
</table>
All 3 scenarios illustrate a large potential for transportation GHG mitigation.
We consider our scenarios to be plausible....but there are no guarantees

- In particular, the High scenario demands major improvements in biomass fuels and in batteries and/or fuel cells.....and widespread public acceptance of EVs and/or FCVs
- Maintaining high levels of RD&D is crucial; R&D success can never be guaranteed, but a portfolio approach will greatly reduce the risks of failure
- The Mid and especially the Low scenarios depend less on new technologies.....but demand changes in incentives and public attitudes
(New) passenger car and light truck fuel economy can be doubled (or more) by 2035.

- 2035 conventional midsize cars can be 50 mpg and hybrids can be 75 mpg (both on road)
- 2035 total stock fleet can be 15-40% higher fuel economy than base case rising to 35-80% by 2050
- Plug-in hybrids, EVs & FCVs can all contribute, but a 75 mpg hybrid is difficult competition to overcome:
  - Uses 187 gallons of gasoline/yr @ 14,000 miles/yr
  - < $1,000/yr in fuel costs even at $5 gasoline!

Conclusion: need dramatic cost reductions, performance improvements and public acceptance for new fuels to have a large impact
Advanced technologies (beyond HEVs) can boost MPG, but reducing GHGs further requires low-carbon fuels.

Note: a graph of well to wheel fuel economy and GHG emissions may look very different, depending on hydrogen and electricity production.
So a transition to hydrogen or electricity must deal with many issues:

- Advanced *petroleum-fueled* vehicles will be tough competition
- Without low-carbon hydrogen or electricity, EVs, PHEVs and FCVs have GHG emissions similar to advanced HEVs
- Can a transition to hydrogen occur without a firm government commitment....i.e., picking hydrogen as the “winner”?
  - Solving the “chicken and egg” problem demands a long term commitment
  - Early buyers are getting “local” vehicles only....similar to EVs, but without home refueling, perhaps with less range anxiety
  - Potential vehicle buyers must believe fueling stations are permanent
- How do EVs cope with a major traffic jam? (think DC during this winter’s afternoon snow storm)
- How does one deal with refueling EVs or FCVs in an emergency?
There are excellent options for Medium- & Heavy-Duty vehicles

- 18% of transportation GHG emissions and growing
- 2/3 of trucking’s energy use from tractor-trailers
- Recent National Academy report and others conclude that fuel use from tractor trailers can be reduced by half, other trucks by almost that much
- Technology options include sharp aerodynamic improvements; better drivetrain systems, including heat recovery and hybridization; improved tires; and better driving.
The fuel economy of most heavy trucks can be cost-effectively increased by 40-50%.

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>Fuel Consumption Reduction</th>
<th>Capital Cost</th>
<th>Breakeven Fuel Price ($/gallon)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tractor-trailer</td>
<td>51%</td>
<td>$84,600</td>
<td>1.10</td>
</tr>
<tr>
<td>Class 6 box truck</td>
<td>47%</td>
<td>$43,120</td>
<td>4.20</td>
</tr>
<tr>
<td>Class 6 bucket truck</td>
<td>50%</td>
<td>$49,870</td>
<td>5.40</td>
</tr>
<tr>
<td>Class 2b pickup</td>
<td>45%</td>
<td>$14,710</td>
<td>4.80</td>
</tr>
<tr>
<td>Refuse truck</td>
<td>38%</td>
<td>$50,800</td>
<td>2.70</td>
</tr>
<tr>
<td>Transit bus</td>
<td>48%</td>
<td>$250,400</td>
<td>6.80</td>
</tr>
<tr>
<td>Motor coach</td>
<td>32%</td>
<td>$36,350</td>
<td>1.70</td>
</tr>
</tbody>
</table>

Source: National Research Council
Compact development and more transit will help, but *national* GHG impact is unclear

- Transit today provides about 1% of U.S. passenger miles.....so doubling or tripling it will make a modest change in national travel patterns...and
- On average, U.S. transit is not much more efficient than private vehicles

*But these averages hide many highly efficient systems!*
Reducing travel can be accomplished with technology and compact development

- National Academy says doubling urban density with accompanying transit improvements can yield a 5-25% reduction in vmt (the higher end is controversial)
- Land use is locally-controlled....and strongly debated
- Lots of examples of compact development, but also of continued sprawl

**Conclusion**: A nationwide push for compact development may vary greatly in effectiveness from place to place

- Technology can reduce vmt also; ITS can have a significant impact on trip-planning and route efficiency reducing VMT by almost 10%
Much can be done by changing the way vehicle travel is priced, even without increasing its cost.

<table>
<thead>
<tr>
<th>Pricing Mechanism</th>
<th>Targeted Consumer Response</th>
<th>2050 GHG Impact vs. BAU</th>
</tr>
</thead>
</table>
| Carbon Pricing Carbon-based Fuel Charge | Consume less carbon-based fuel                                                            | Efficiency +4%
|                              | VMT -2%                                                                                   |                               |
| PATP Insurance Fuel Charge  | Increase energy efficiency, reduce VMT                                                   | Efficiency +5%
|                              | VMT -1%                                                                                   |                               |
| Road user tax on energy Fuel Charge | Increase energy efficiency, reduce VMT                                                   | Efficiency +2%
|                              | VMT -1%                                                                                   |                               |
| Feebates Vehicle Purchase Subsidy/Charge | Increase vehicle efficiency and promote advanced vehicle technologies | Vehicle emissions rates -10% |
| Congestion pricing Time and place varying fees | Reduced VMT                                                                             | Up to 3% nationwide VMT reduction |
A comprehensive policy strategy is needed.

- Improving current technology – reducing vehicle loads, improving engines, etc. – still has lots of potential, but needs the right incentives
- The deepest reductions in transportation GHG emissions require a transition to electricity or hydrogen or both as a major new energy source…..and attaining such a transition will require
  - Cheaper, higher energy density batteries
  - Cheaper, more durable fuel cells
  - Advanced biofuels for vehicles that require liquid fuels
- As a consequence, sustained investment in research, development, demonstration and deployment is essential.
A comprehensive policy strategy is needed (2).

- Given high uncertainty about technology development (and uncertain public acceptance), deployment strategies must be highly adaptive.
- Creating walk-able, bike-able, communities well-served by public transit are more likely to be done for quality of life concerns, but can produce important GHG reductions as a co-benefit.
- Market and regulatory approaches are both needed...get the prices right, use fuel economy standards as well, consider feebates and other economic incentives. A pricing policy worth considering: an energy-based tax indexed to fleet efficiency, so revenues don’t disappear as efficiency increases.
The HIGH mitigation case differs from the LOW case by greater technological progress, more extensive and intensive policies, and some degree of behavioral change.

- Greater fuel economy improvement over base case:
  - LDVs: +80% vs. +35%
  - HDTs: +40% vs. +25%
  - Aircraft fuel burn: -70% vs. -40%

- Greater reductions in the carbon intensity of energy:
  - LDVs: -47% vs. -5%
  - HDVs: -38% vs. -10%
  - Aircraft: -44% vs. -10%

- Feebates and Pay-at-the-Pump insurance added to carbon pricing and an indexed road user toll on energy.

- Greater success in improving system efficiencies and reducing VMT by means of automated highways, traffic flow improvement, trip planning and routing efficiencies, land use and infrastructure development and ridesharing.

- But a LOT more uncertainty!
Conclusion: by pushing on *all* levers - improving conventional technology, moving to new fuels, and reducing travel - through a full portfolio of policies -- RD&D, pricing, targeted subsidies, fuel economy standards, land use policy, etc. - and focusing on all transport modes -- 2050 U.S. transport GHG emissions could be well below current levels, compared to a 28% *increase* for Business as Usual.

The scenarios in this analysis yield 16 to 65 percent reductions from 2010 levels.

We consider these outcomes to be *plausible*, though with increasing uncertainty from the Low to the High scenarios.
THANK YOU FOR YOUR ATTENTION

The full report can be accessed at:

www.pewclimate.org
Improving vehicle efficiency via technological change is the largest single source of CO$_2$ reductions, though more comes from the full range of other policies and strategies.