Resilient Transportation Systems in the Face of Increasing Oil Demand

24th Annual Lake Arrowhead Symposium on Transportation, Land Use, and Environment: Resilient Cities and Regions

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Cambridge Systematics

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Will oil prices continue to rise?
The future can be hard to predict
Our energy future appears highly uncertain

- What if gasoline prices rise to $5, or $6, or $7
  - Rising world demand
  - Finite resource

- Or what if prices hold steady or even decline?
  - Resurgence in U.S. oil and natural gas production
  - Much more stringent federal fuel economy standards
  - Possible large-scale shifts to natural gas, liquid biofuels, electric vehicles, or hydrogen vehicles
Many experts expect petroleum to remain the dominant fuel through 2050

- Incumbent technology with well established fuel and vehicle supply chains
- Significant increase in economically-recoverable reserves with advent of enhanced extraction technologies
- Rapid gains in fuel economy due to much more stringent federal standards and supporting technology innovations
- Significant barriers confront all competing alternatives (natural gas, liquid biofuels, electric, and hydrogen)
Alternative fuels face an array of challenges

<table>
<thead>
<tr>
<th></th>
<th>Production</th>
<th>Distribution &amp; Refueling</th>
<th>Vehicle Cost &amp; Performance</th>
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<tbody>
<tr>
<td>Natural Gas</td>
<td>● ●</td>
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<td>Liquid Biofuels</td>
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<td>Hydrogen</td>
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Promised benefits of alternative fuels will motivate continued investment & innovation

<table>
<thead>
<tr>
<th></th>
<th>Urban Air Quality</th>
<th>GHG Emissions</th>
<th>Lower Cost of Driving</th>
<th>Domestic Production</th>
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Develop plausible long-range surface transportation energy use scenarios for the 2050 timeframe

Identify potential impacts on state DOTs given their current roles, mandates, funding, and operations

Employ robust decision-making principles to identify promising state policy options to address an evolving but deeply uncertain energy future
Research approach – analysis flow

- Influencing Variables
  - Expert Interviews
  - DOT Roles, Mandates, Funding, Ops

- Plausible Energy Futures
  - Potential Impacts
  - Policy Analysis
  - State DOT Interviews

- DOT Decision-Making Support
  - Robust Policies
  - State DOT Workshop
The future scenarios encompass energy, travel, and federal policy elements

- Fuel Sources and Vehicle Technologies in 2050
- Travel Demand in 2050
- Federal Policies in 2050
Energy factors – price of oil in 2050

Consistent with EIA low, reference, and high oil prices for 2035
Energy factors – vehicle fuel economy in 2050

Average passenger vehicle fuel economy doubles

Average passenger vehicle fuel economy quadruples
Energy factors – energy mix in 2050

• Petroleum remains dominant (> 90%)

• Biofuels claim 30% market share

• Natural gas achieves 50% market share

• Electric vehicles gain 75% market share

• Hydrogen achieves 75% market share

• Multiple fuels combine to displace 75% of petroleum use
Energy factors – energy cost of driving

Per-mile cost declines by at least a half

Per-mile cost remains similar to current cost

Per-mile cost increases by a third
Travel factors – passenger vehicle travel

Low (or zero) growth in passenger VMT
Change by 2050 = -10%

Moderate growth in passenger VMT
Change by 2050 = +60%

Rapid growth in passenger VMT
Change by 2050 = +80%

Moderate growth rate matches EIA reference case for 2035
Travel factors – truck travel

Zero growth, maintains current mode share

Moderate growth, small increase in mode share

Rapid growth, large increase in mode share

Change by 2050 = 0%

Change by 2050 = +150%

Change by 2050 = +200%

Moderate growth rate matches EIA reference case for 2035
Travel factors – transit use

Low growth transit use

Impressive growth in transit use

Dramatic growth in transit use

Mode Share in 2050 = 2%

Mode Share in 2050 = 5%

Mode Share in 2050 = 10%
State DOTs helped identify impacts and possible policy responses

- Current DOT activities and structure
- DOT interviews and analysis
- Plausible futures

Impacts

Policy responses
States identified a range of potentially challenging impacts …

Problematic in all futures:

• Reduced fuel-tax revenue

Problematic in some futures:

• Higher costs for DOTs
• Increased traffic congestion
• Increased crashes and fatalities
• Tougher to meet air-quality standards
• Pressure to mitigate GHG emissions
• Greater demand for alternative modes
States and DOTs have many potential policy responses

**Revenue**
- Tolls, mileage fees
- Fuel taxes
- Registration fees
- Beneficiary fees
- General revenue
- Private capital

**DOT cost**
- Efficiency
- Reduced scope

**Auto and truck travel**
- Road expansion
- Freight investments
- Congestion pricing
- ITS
- TSM&O
- Safety measures

**Alternative travel modes**
- TDM
- Transit investments
- Land use strategies

**Energy and emissions**
- Vehicle feebates
- Carbon pricing
- Fuel mandates
- Fuel production
- Agency energy use
Framework for evaluating potential policies

Mitigating Potential Impacts

- Increased revenue
- Reduced costs
- Reduced traffic
- Improved safety
- Reduced local air pollutants
- Reduced GHG emissions
- Improved alternative modes

Shaping the Future

- Reduced oil consumption
- Adoption of lower-carbon alternative fuels
- Low energy-cost of travel

General Merits

- Economy / efficiency
- Environment & public health
- Equity

Potential Barriers

- Cost
- Public acceptance
- Technical risk
- Legislative requirements
- Institutional restructuring
When to pursue policies for potential but uncertain future challenges?

Robust Decision Making Supports Improved Planning for an Uncertain Future
Uncertainty is problematic for traditional planning methods

Plan Tailored to “Most Likely” Future

Success!

Failure!

Plausible Future

Plausible Future

“Most Likely” Future

Plausible Future

Unanticipated Future
Robust decision making is explicitly designed to address uncertainty
Key robust decision making concepts

- **Robust strategies**: actions that should perform well regardless of how the future unfolds
- **Adaptive strategies**: actions that can evolve over time with new information to increase robustness
- **Hedging strategies**: actions with long required lead times that may be useful in some futures but not others
- **Shaping strategies**: actions intended to increase or decrease the likelihood of certain plausible futures
- **Signposts**: new information showing that a given future is either more or less likely, which may trigger the activation of an adaptive strategy
Adaptation is a foundation for robust plans.

Robust Decision Making

- Initiate Robust Near-Term Policies

Signpost Observed

- Trigger Adaptive Policies

Time

- Plausible Future
- Likely Future
- Plausible Future
- Plausible Future
- Plausible Future
Robust decision making preserves maximum flexibility for future planners

- **Do now what needs to be done now**
  - Pursue policies that will be beneficial regardless of how the future unfolds
  - Pursue hedging strategies, if needed
  - Pursue shaping strategies, if desired

- **Prepare for an uncertain future**
  - Develop signposts and adaptive strategies to be triggered, or not, as more information about how the future is unfolding becomes available
Approach to identifying robust strategies

- Mitigation Strategies
  - Performs well (no regrets) across plausible futures?
    - Yes → Near-term robust strategy (low risk)
    - No → Strategies to mitigate impacts or shape future
      - Reliable signposts?
        - Yes → Sufficient lead time?
          - Yes → Deferred adaptive strategy (low risk)
          - No → Near-term hedging and shaping strategies (higher risk)
        - No → Shaping Strategies

- Shaping Strategies
  - No
A robust planning framework for states

<table>
<thead>
<tr>
<th>Low Risk (Robust)</th>
<th>Higher Risk</th>
</tr>
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<tbody>
<tr>
<td><strong>Near-Term Action</strong></td>
<td></td>
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<tr>
<td>Mitigation strategies to address revenue and cost concerns</td>
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<tr>
<td><strong>Deferred Action</strong></td>
<td></td>
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<tr>
<td>Mitigation strategies with modest lead time for less certain impacts (adaptive)</td>
<td></td>
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<tr>
<td>Associated signposts</td>
<td></td>
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<tr>
<td>Mitigation strategies with longer lead time for less certain impacts (hedging)</td>
<td></td>
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<tr>
<td>Strategies for sustainable energy future (shaping)</td>
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Integrated framework for robust long-term plans

- **Near-term strategies** to address highly probably impacts

<table>
<thead>
<tr>
<th>Objective</th>
<th>Most promising strategies</th>
<th>Optional high-impact strategies</th>
<th>Optional low-impact strategies</th>
</tr>
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<tbody>
<tr>
<td>Stabilize or increase DOT revenues and/or decrease DOT costs</td>
<td>✓ Fuel taxes</td>
<td>✓ Carbon pricing</td>
<td>✓ Private capital</td>
</tr>
<tr>
<td></td>
<td>✓ Tolling or MBUF</td>
<td>✓ Congestion pricing</td>
<td></td>
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<tr>
<td></td>
<td>✓ Registration fees</td>
<td></td>
<td>✓ Agency energy use</td>
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<td></td>
<td>✓ Beneficiary fees</td>
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<td>✓ DOT efficiency</td>
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<td>✓ Land use</td>
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Integrated framework for robust long-term plans

• **Deferred adaptive strategies and near-term hedging strategies to address uncertain impacts**

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<tr>
<td>Mitigate traffic congestion</td>
<td>✓ Congestion pricing</td>
<td>✓ ITS</td>
<td>✓ TSM&amp;O</td>
</tr>
<tr>
<td></td>
<td>✓ Goods movement</td>
<td></td>
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<tr>
<td></td>
<td>✓ TDM</td>
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<td></td>
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<tr>
<td></td>
<td>✓ Public transportation</td>
<td></td>
<td></td>
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<tr>
<td>Improve traffic safety</td>
<td>✓ Traffic safety</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>✓ ITS</td>
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Integrated framework for robust long-term plans

- **Deferred adaptive strategies and near-term hedging strategies to address uncertain impacts**

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</table>
| Improve air quality and/or reduce GHG | ✓ Vehicle feebates  
✓ Carbon pricing  
✓ Goods movement  
✓ TDM  
✓ Land use | ✓ Fuel mandates and programs  
✓ Public transportation | ✓ Alternative fuels production and distribution  
✓ Agency energy use |
| Improve non-automotive travel options | ✓ Public transportation  
✓ TDM  
✓ Land use  
✓ Traffic safety | ✓ Congestion pricing  
✓ ITS | ✓ TSM&O |
Integrated framework for robust long-term plans

- **Shaping strategies to influence future transportation energy outcomes**

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<tr>
<td>Promote a more sustainable energy future</td>
<td>✓ Vehicle feebates</td>
<td>✓ Carbon pricing</td>
<td>✓ Alternative fuels production and distribution</td>
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# Addressing potential impacts relating to cost and higher demand for alternative modes

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<tr>
<td>Near-term robust strategies to address potential cost concerns</td>
<td>Near-term hedging strategies to address higher demand for alternative modes</td>
</tr>
<tr>
<td>• Various revenue options</td>
<td>• Land use</td>
</tr>
<tr>
<td>• DOT efficiency</td>
<td></td>
</tr>
<tr>
<td><strong>Deferred Action</strong></td>
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<td>Deferred strategies to address higher demand for alternative modes</td>
<td></td>
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<tr>
<td>• Public transportation</td>
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But must we wait?

• Public transportation and TDM are viewed as safe to defer from the perspective of uncertain future impacts associated with alternate plausible ENERGY futures

• There may be many other reasons—e.g. equity, livability, sustainability—for pursuing these aggressively now…
Thanks!

For more, see: http://www.trb.org/Energy/Blurbs/170763.aspx