ACTUAL RESULTS WILL VARY
FIVE QUESTIONS

1. Why eco-driving?
2. What are eco-driving behaviors?
3. How much do they save?
4. How are they promoted?
5. What is a policymaker to do?
1. WHY ECO-DRIVING?

- **Social Goals**
  - Fuel economy
    - U.S. Corporate Average Fuel Economy (CAFE) standards
  - Emissions: Clean air and climate
    - Local attainment plans
    - Zero emission vehicle credits
  - Safety
    - Social cost of traffic accidents

- **Private Goals**
  - Private cost: Fuel, accidents
  - Self-identity: Efficient, thrifty, environmentally-conscious
2. WHAT ARE ECO-DRIVING BEHAVIORS?

Premise: Behaviors excluded by US CAFE test procedures

- Sources of variation in “Actual results will vary”?

- What do we mean by “behavior”?
  - A behavior analytic approach
    - Function: its effect/what it does (most important)
    - Topography: its observable form/what it looks like
    - Context: who emits the behavior, when, and where
## Categories of Eco-Driving Behavior

<table>
<thead>
<tr>
<th>Category</th>
<th>Function: Why</th>
<th>Topography: What</th>
<th>Context: Who, when, where</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driving</td>
<td>Operate the vehicle to provide mobility services</td>
<td>Accelerating; cruising; decelerating; waiting; parking</td>
<td>Driver, en route, in-vehicle</td>
</tr>
<tr>
<td>Cabin Comfort</td>
<td>Comfort, communications, entertainment</td>
<td>Using HVAC, windows, auxiliary electronics</td>
<td>Driver and passengers; en route; in vehicle</td>
</tr>
<tr>
<td>Trip Planning</td>
<td>Routing from point A to point B</td>
<td>Selecting travel routes and time (road type, grade, right turns, congestion, trip-chaining)</td>
<td>Driver; pre-trip and en route; in vehicle</td>
</tr>
<tr>
<td>Load Management</td>
<td>Be prepared for cargo and passengers</td>
<td>Managing cargo weight and aerodynamics (racks, etc.)</td>
<td>Driver or surrogate; pre-trip; home</td>
</tr>
<tr>
<td>Fueling</td>
<td>Fuel vehicle</td>
<td>Selecting fuel; preventing evaporation; PEV charging (frequency, level, and source)</td>
<td>Driver or surrogate; pre-trip(s); gas or charging station</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Maintain vehicle</td>
<td>Changing oil; selecting oil; inflating tires; selecting tires; getting engine tuned</td>
<td>Driver, surrogate, or professional; intervals based on use; auto shop</td>
</tr>
</tbody>
</table>
3. HOW MUCH CAN ECO-DRIVING SAVE?

\[ I = \sum \left( t \cdot \frac{p}{n} \right) \]

I = impact  
\( t \) = technical potential (savings impact of the behavior)  
\( p \) = behavioral plasticity: proportion of population that can be induced to take the action  
\( n \) = total population that could possibly take the action  
\( k \) = each eco-driving behavior  

Adapted from Stern, 2011, *American Psychologist*
Sivak and Schoettle, 2012, *Transport Policy*

- Estimates *technical potential* \( (t) \) for multiple behaviors \( (k > 1) \)
- *Neglecting* eco-driving = 45% *decrease* in fuel economy
  - Most influential behaviors: **Driving**
    - “Aggressive driving”
      - Including frequency + intensity of pedal use; not using cruise control
    - Cruising speed (particularly excessively high speeds)
HOW MUCH CAN ECO-DRIVING SAVE?

Our review of 40 empirical studies of eco-driving, driving behavior

- Average impact of eco-driving interventions = 9% increase in fuel economy
  - Estimate better reflects plasticity, but only for a subset of behaviors (k)
  - Three most commonly measured (variously operationalized):
    1. Accelerating
    2. Cruising
    3. Decelerating

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 HOW MUCH CAN ECO-DRIVING SAVE?

The path to better savings estimates

• Define and measure eco-driving behavior!
  • 32/40 studies measured fuel economy
  • Only 24/40 studies measured behavior
• Define and measure eco-driving behaviors consistently across studies
• More research on network level impacts in different contexts
  • Alam & McNabola, 2012, *Transport Policy*

\[ I = \sum (t_{\text{potential}} \times p_{\text{population}}^k) \]
Most research targets **driving** behaviors

Most common strategy: In-vehicle feedback
- 27/40 studies reviewed
  - Average 5.6% improvement in fuel economy

Other strategies include:
- Training
  - In-vivo coaching
  - Verbal instruction
HOW IS ECO-DRIVING PROMOTED?

- Feedback is more effective when it:
  - aligns with driver’s goals, e.g., to get around faster, save money, etc.
  - is adaptive, becoming more challenging as the driver progresses

- Other influential features include:
  - specificity of targeted behaviors
  - mode of interface, e.g., haptic or visual

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HOW IS ECO-DRIVING PROMOTED?

The path to more effective eco-driving feedback

- Meta-analysis of literature
- Systematic comparative research
  - Findings from the few comparative studies are singular
  - Map well-defined behaviors onto well-defined feedback types
    - Most studies are devoid of behavioral theory (re: design and measurement)
    - Address for whom and in what contexts feedback works for which behaviors
- Assessment of commercially available in-vehicle feedback
5. WHAT IS A POLICYMAKER TO DO?

- Standardized test procedures, e.g., CAFE, serve useful purposes
- Be careful of promises of energy and emissions outcomes
  - What behaviors?
    - Is $k > 1$?
  - Enacted by whom, where, and when?
    - Who is the population ($n$); how many of them will take up the behavior ($p$)?
    - Not just technical potential
  - What are the distributions of outcomes?
    - Across behaviors (functions, typologies, contexts), promotions, 
      ...and individual driver-owner-buyers
  - What are the aggregate impacts over time?
- Do something