Transportation and Carbon Emissions
New Challenges in Land Use and Transportation Planning

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March 5, 2010
Part I – Planning Context
6°C
Entire regions experience major declines in crop yields

5°C
Sea level rise threatens major world cities

4°C
Many ecosystems affected

3°C
Significant changes in water availability

2°C
Many species face extinction

1°C
Rising number of people at risk from hunger

Food

Water

Ecosystems

Extreme weather events

Risk of climate change & major irreversible impacts

Rising intensity of storms, forest fires, droughts, flooding and heat waves

Onset of irreversible melting of the Greenland ice sheet

Increasing risk of abrupt, large-scale shifts in the climate system
Transportation and Carbon Emissions

Transportation

\[ \text{CO}_2 \]

Vehicles
Fuels
VMT

Image of different types of vehicles and a road.
Effects of CAFÉ & Fuel GHG Goals Alone

Source: S. Winkelman based on EIA AEO 2008 (revised), HR6 and sources cited in Growing Cooler.
VMT Growth Prevents Reaching CO2 Target

Source: S. Winkelman based on EIA AEO 2008 (revised), HR6 and sources cited in Growing Cooler.
# VMT Reduction through Pricing & Transit Improvements

<table>
<thead>
<tr>
<th>Policy Variables</th>
<th>VMT Elasticities with Respect to Policy Variables (%)</th>
<th>Change in Annual Growth Rates of Policy Variables (% above/below Trend)</th>
<th>Effect on Annual VMT Growth Rate (% below Trend)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real Fuel price</td>
<td>-0.17</td>
<td>2.7*</td>
<td>-14.4%</td>
</tr>
<tr>
<td>Transit Revenue Miles</td>
<td>-0.06</td>
<td>2.5</td>
<td>-4.6%</td>
</tr>
<tr>
<td>Population Density</td>
<td>-0.30</td>
<td>?</td>
<td>?</td>
</tr>
</tbody>
</table>

*Average annual real price growth rate has been less than 2% from 1963 to 2008, and from 1980 to 2008*
Add Pricing, Transit, & 50mpg CAFÉ Standards:
2030 CO2 is 15% Above Target

Source: S. Winkelman based on EIA AEO 2008 (revised), HR6 and sources cited in Growing Cooler.
Possible VMT Reduction from Compact Development

- How much compact development might occur?
- To what degree does compact development reduce VMT?
Estimates of Possible VMT Reduction

- Aggregate travel studies
- Disaggregate travel studies
- Regional simulation studies
- Project simulation studies
US Land Scenario Planning Studies

26% VMT reduction by 2050 in 62 study locations
U.S. Land Use-Transportation Scenario Planning Projects

Source: Bartholomew 2005
VMT versus Density

Source: Ewing, Bartholomew, et al. 2008
Figure 3-23
Best-Fit Model of Percent VMT Reduction Relative to Trend (with Robust Standard Errors)

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference in density (% above trend)</td>
<td>–0.074</td>
<td>–1.48</td>
<td>0.15</td>
</tr>
<tr>
<td>Development centralized</td>
<td>–1.50</td>
<td>–2.13</td>
<td>0.037</td>
</tr>
<tr>
<td>Land uses mixed</td>
<td>–4.64</td>
<td>–2.15</td>
<td>0.036</td>
</tr>
<tr>
<td>Population growth increment (% over base)</td>
<td>–0.068</td>
<td>–2.02</td>
<td>0.056</td>
</tr>
<tr>
<td>Transportation coordinated</td>
<td>–2.12</td>
<td>–1.01</td>
<td>0.33</td>
</tr>
</tbody>
</table>
Site Design & Location Studies *in US and Canada*
33% Savings Due to Regional Accessibility
Alternative Site Plan Comparison

Atlantic Steel Jacoby Design

Atlantic Steel Redesign

2% Savings Due to Site Design
Successful Community/Lower VMT than Predicted

Atlantic Station
Estimates of Possible VMT Reduction

- Aggregate travel studies: 35%
- Disaggregate travel studies: 40%
- Regional simulation studies: 26%
- Project simulation studies: 35%
Potential 2050 VMT Reduction due to Compact Development

60-90% Compact
x
67% New Development
x
30% VMT Reduction
=
12-18% Reduction in Metropolitan VMT
Part II – New Planning Challenges
New Planning Challenges

1. Political and Statutory Context

2. New Paradigm for Planners
   - Climate
   - Energy
   - Health
State Level Actions

GHG Emissions Targets (19 States)

Climate Action Plans (38 States)

Regional Initiatives (32 states)
Demographic Drivers

Year

Number of People Turning 65

US Statistics
Market Considerations

- Average number turning 65 each year:
  - between 1996 and 2006: 300,000
  - between 2015 and 2025: 1,700,000
- Families without children in 2025: 72%
- Single person households in 2025: 28%
- 61% would prefer to live in smart growth communities
- Decline in housing value farther from regional center
- Annual gasoline real price increase 20% since 1998, 40% since 2007
Health Considerations

- **Auto oriented land use patterns**
- **Decreased walking and biking for short trips**
- **Lack of supporting infrastructure**

*Obesity Trends* Among U.S. Adults 2005

(*BMI = 30, or ~ 30 lbs overweight for 5’ 4” person)*

U.S. Centers for Disease Control
Balancing the Trade-Offs

Development Economics
Consumer Choice
Traffic LOS

Sustainability
Climate Change
Multi-Modalism
Energy Use
Addressing Climate & Energy in Planning & Impact Assessment

1. Account for benefits of compact development and integrated multi-modal transportation

2. Quantify and mitigate VMT and trips per capita

3. Quantify and mitigate impacts to mobility and system stability
LEED-ND Sustainable Development Criteria

- **Prerequisite: Smart Location**
  - Infill location, or VMT < regional average

- **Prerequisite: Compact Development**
  - > 7 DU/acre, FAR > 0.50

- **Credits for Smart Location and Linkage**
  - Brownfield, redevelopment, dense street grid, bike access

- **Credits for Neighborhood Pattern and Design**
  - Density, diversity, design, distance to transit, demand management
7 “D” factors that influence trip generation:

- **Density** dwellings, jobs per acre
- **Diversity** mix of housing, jobs, retail
- **Design** connectivity, walkability
- **Destinations** regional accessibility
- **Distance to Transit** bus, rail proximity
- **Development Scale**: population, jobs
- **Demographics** household size, income
Density

- Shortens traffic distances
- Walking/biking become possible for at least some trips
- Makes public transportation practicable
- Major influence on the amount of green-space conversion
Diversity

- Shortens traffic distances
- Makes shared parking practicable (reduces need to pave green space)
Design

Cul-de-sacs lengthen travel distances and force trips onto highways

Grid pattern creates much shorter trips with less need to use the highway
Design

Strip development

6 vehicle trips
5 parking spaces
10 turning movements

Exact same area, but average trip length is halved

Downtown

2 vehicle trips
1 parking space
2 turning movements
Destinations

Which development location creates the most traffic?
Distance to Transit

- \( \frac{1}{4} - \frac{1}{2} \) mile buffer is rule of thumb for walk access

Pleasant Hill BART Station (2003 surveys)

- 0 - 1/2 mile: 45%
- 1/2 - 3 miles: 14%
- >3 miles: 8%
Smart Growth Development Types

TOD

IND

MXD

TND

Atlantic Station
### 4D Elasticity Ranges

<table>
<thead>
<tr>
<th></th>
<th>Vehicle Trips Per Capita</th>
<th>VMT per Capita</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Density</strong></td>
<td>4% to 12%</td>
<td>1% to 17%</td>
</tr>
<tr>
<td><strong>Diversity</strong></td>
<td>1% to 11%</td>
<td>1% to 13%</td>
</tr>
<tr>
<td><strong>Design</strong></td>
<td>2% to 5%</td>
<td>2% to 13%</td>
</tr>
<tr>
<td><strong>Destinations</strong></td>
<td>5% to 29%</td>
<td>20% to 51%</td>
</tr>
</tbody>
</table>

*Sources: National Syntheses, Twin Cities, Sacramento, Holtzclaw*
Emerging Findings on Smart Growth Trip Generation

National studies of Mixed Use, TOD and Infill development

<table>
<thead>
<tr>
<th></th>
<th>MXD</th>
<th>TOD</th>
<th>Infill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trip Discount</td>
<td>30%</td>
<td>44%</td>
<td>36%</td>
</tr>
</tbody>
</table>

Examples: San Diego, Seattle, Portland, Sacramento, Houston, Atlanta, Boston
Sources: EPA MXD, SANDAG SG TG, TCRP H-27A, Caltrans, Trip Generation Rates for Urban Infill
Practical Challenges: Conventional Technical Methods & Models

- Regional travel demand models are not sensitive to “D” characteristics
- Traffic Impact Analysis (TIA) methods are almost solely focused on motorist delay
Shortcomings of Conventional Travel Models in Assessing Smart Growth

- Primary use is to forecast long-distance auto travel on freeways and major roads
- Secondary use is to forecast system-level transit use
- Short-distance travel, local roads, non-motorized travel modes are not addressed in model validation
Typical Model “Blind Spots”

- Abstract consideration of distances between land uses within a given TAZ or among neighboring TAZ’s
- Limited or no consideration intra-zonal or neighbor-zone transit connections
Typical Model “Blind Spots”

- Sidewalk completeness, route directness, block size generally not considered
Typical Model “Blind Spots”

- Little consideration is given to spatial relationship between land uses within a given TAZ (density)

- Interactions between different non-residential land uses (e.g. offices and restaurants) not well represented
Caltrans Study Recommendation
Use 4D’s to compensate for any lack of sensitivity in travel model response to built-environment variables.

Source: Assessment of Local Models and Tools for Analyzing Smart-Growth Strategies, 2007
Other Supply-Side Factors

- Transit multiplier effects
- Effects of congestion on MPG and CO2 / VMT
- Induced investment, induced travel
Institute of Transportation Engineers (ITE) Trip Generation Rates

- Traditional TIAs use ITE average trip generation rates for traffic analysis
- Appropriate for average development types
- ITE suggests that projects with unique “D” characteristics should include adjustments to the average rates
ITE Recommended Adjustments

Trip Generation 5th Edition

“Modification of Average Rate or Equation

The use of an average trip rate or equation is applicable if the site is likely to be average in nature. If there is evidence, such as through a market analysis, that the site may be better or different than average, the average trip rate or equation result should be adjusted accordingly.

It may also be necessary to adjust the trip generation rates provided in this report to reflect the use of alternative modes of transportation. In making these adjustments, it is suggested that the practitioner estimate the portion of the trips most likely to be affected by alternative modes and adjust this portion of the trips.”
ITE Trip Generation Rates

Average Rate
9.57

Range of Rates
4.31 - 21.85

Field-measured rates vary widely

Standard Deviation
3.69

Range of normal experience is 5.88 – 13.26
ITE Recommended Adjustments

- *Trip Generation* 5th Edition recommended adjusting rate
- 6th Edition added pedestrian amenities and TDM programs as additional reasons for adjustments
- 7th Edition added a whole new chapter on adjustments for mixed-use developments
Basis for Adjustments

- Adjustment factors (elasticities) were developed for the SACOG Blueprint Project
- Initial data from SACOG’s 2000 Household Travel Survey (3,200 households)
- Growing data sets from Salt Lake City, Denver, San Diego
- Accepted at the highest levels
  - US-EPA’s Award for Smart Growth Achievement
  - FHWA’s Transportation Planning Excellence Award
  - AMPO’s National Award for Outstanding Achievement
  - AIA’s Presidential Citation
  - Numerous state awards
ITE Mixed-Use Adjustment

**Rationale:** When complementary land uses are in the same site, some trips will be internalized

**Method:** Estimate the potential for local trips for each land use, and take the smaller number for each interaction

**Example:**

**Limitation:** Only considers mix of uses

300 potential local trips  Use 50  50 potential local trips
4D Adjustment Method

**Rationale:** Surveys show that certain neighborhood characteristics have a significant effect on travel behavior (Density, Diversity, Design, Destinations).

**Method:** Determine how much above/below average the neighborhood is for each characteristic, and multiply this by the adjustment factor (elasticity).

**Example:**

<table>
<thead>
<tr>
<th>Average Residential Density</th>
<th>3 DU/Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Residential Density</td>
<td>5 DU/Acre</td>
</tr>
</tbody>
</table>

More dense than average: 67%

Elasticity of VT to Density: -0.12

Expected Reduction in VT: -8%

**Limitation:** Requires data on average characteristics.
Distance to Transit Adjustments

**Rationale:** Surveys show that TOD residents use cars much less than other people in the same city.

**Method:** Multiply the local average transit use by the ratio of additional use by TOD residents, and reduce auto use by that amount.

**Commute Share by Transit for Surveyed Cities**

- TODs: 26.5%
- Rest of City: 5.4%
- Ratio TOD/City: 4.91

* Average for This City: 3.5%
* Expected for TOD: 17.2%
* - Average for This City: 3.5%
* Additional Reduction for TOD: 13.7%

**Work/Non-Work Trip Purpose**

<table>
<thead>
<tr>
<th></th>
<th>Daily</th>
<th>Work AM</th>
<th>Work PM</th>
<th>Non-Work AM</th>
<th>Non-Work PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>21%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
<td>30%</td>
</tr>
<tr>
<td>Retail</td>
<td>20%</td>
<td>10%</td>
<td>10%</td>
<td>80%</td>
<td>90%</td>
</tr>
<tr>
<td>Office</td>
<td>18%</td>
<td>80%</td>
<td>80%</td>
<td>82%</td>
<td>20%</td>
</tr>
<tr>
<td>Hotel</td>
<td>25%</td>
<td>20%</td>
<td>20%</td>
<td>75%</td>
<td>80%</td>
</tr>
</tbody>
</table>

**Vehicular Mode Split by Trip Purpose**

<table>
<thead>
<tr>
<th></th>
<th>Daily</th>
<th>Work AM</th>
<th>Work PM</th>
<th>Non-Work AM</th>
<th>Non-Work PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>71.7%</td>
<td>71.7%</td>
<td>71.7%</td>
<td>87.1%</td>
<td>87.1%</td>
</tr>
<tr>
<td>Retail</td>
<td>77.8%</td>
<td>77.8%</td>
<td>77.8%</td>
<td>68.3%</td>
<td>68.3%</td>
</tr>
<tr>
<td>Office</td>
<td>77.8%</td>
<td>77.8%</td>
<td>77.8%</td>
<td>39.5%</td>
<td>39.5%</td>
</tr>
<tr>
<td>Hotel</td>
<td>57.7%</td>
<td>57.7%</td>
<td>57.7%</td>
<td>97.6%</td>
<td>97.6%</td>
</tr>
</tbody>
</table>
Conclusions for Transportation Planners

- Climate change and energy use are important issues for society, our clients and our profession.
- Standard models and ITE methods don’t capture the effects, but adjustments are permitted.
- New research and methods are available to improve standard methods.
- Planners and engineers should objectively apply best-practices to plan and evaluate sustainable development proposals.
Conclusions for Land Use Planners

• Probably will not meet CO2 reduction goals without TOD/Smart Growth.

• Market Demand for TOD/Smart Growth is Strong & Growing.

• Plans & Zoning Codes will need to be revamped to facilitate the demand.

• Public investments in infrastructure and public space design will need to be re-geared to support TOD/Smart Growth.
Part III – Q&A

Jeremy R. Klop
Fehr & Peers

Available from ULI
Changing the Paradigm

Land Use or Network Change → Four-Step Model → VMT/Capita, VMT by Speed → Project and Scenario Evaluation

VMT and LOS Deficiencies → New Project Design Features → Four-Step Model (+Ds) → Volumes & VMT by Speed

Traffic Operations Analysis → LOS

AQ Model → CO₂