Three Revolutions in Urban Transportation: Future scenarios and the relative costs of mode choices and vehicle use cases in California

2018 Urbanism Next Conference
Portland, OR
March 5th, 2018

Lew Fulton, Co-Director
Sustainable Transportation Energy Pathways Program (STEPS)
UC Davis
MISSION: There is an urgent need for rigorous research and impartial policy analysis to understand the social and environmental second-order impacts of these transportation revolutions, and to guide industry investments and government decision-making to maximize public benefits.
Research undertaken by UC Davis and ITDP, part 3 of a series

Global scenario study to 2050 focused on potential 3 Revs impacts on CO2, energy use, costs

Study supported by UC Davis STEPS Consortium and by Climate Works, Hewlett Foundation, Barr Foundation

https://steps.ucdavis.edu/three-revolutions-landing-page/

Three Revolutions in Urban TRANSPORTATION

How to achieve the full potential of vehicle electrification, automation and shared mobility in urban transportation systems around the world by 2050

Lew Fulton, UC Davis
Jacob Mason, ITDP
Dominique Meroux, UC Davis

May 2017

Research supported by:
ClimateWorks Foundation, William and Flora Hewlett Foundation, Barr Foundation
Some questions and conflicts

• Automation: lower per-trip costs, lower “time cost” for being in vehicles
  – Just how much cheaper will it be?
  – Private automated vehicles = longer trips?
  – Empty running (zero passengers) of vehicles
  – Resulting relative costs of private vehicles, shared mobility, transit?

• Electrification goes with automation – does it really?
  – Can get the job done with upgraded electrical system (such as hybrids)
  – But electric running will be much cheaper – and durable?

• Ride hailing: cost savings v. convenience and risk
  – Complementary or at conflict with public transit use?
  – Will lower costs reduce the incentive to ride share?
Our report covers three scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Automation</th>
<th>Electrification</th>
<th>Shared Vehicles</th>
<th>Urban Planning/Pricing/TDM Policies</th>
<th>Aligned with 1.5 Degree Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business as usual, Limited Intervention</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>No</td>
</tr>
<tr>
<td>1R Automation only</td>
<td>HIGH</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>No</td>
</tr>
<tr>
<td>2R With high Electrification</td>
<td>HIGH</td>
<td>HIGH</td>
<td>Low</td>
<td>Low</td>
<td>Maybe</td>
</tr>
<tr>
<td>3R With high shared mobility, transit, walking/cycling</td>
<td>HIGH</td>
<td>HIGH</td>
<td>HIGH</td>
<td>HIGH</td>
<td>YES</td>
</tr>
</tbody>
</table>

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SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS

ITDP
Institute for Transportation & Development Policy
Urban LDV passenger kms by scenario, USA

- Electric vehicle travel reaches nearly 1/3 of PKMs by 2030
- Automated vehicle travel not significant by 2030 in any scenario, but dominates in 2R and 3R 2050. Results in much higher travel in 2R
Well-to-wheels CO2 by scenario/technology, USA

4DS electricity shown; in 2DS, CO2 from electricity drops to near zero in 2050

CO2 emissions by technology, USA

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2030</th>
<th>2050</th>
</tr>
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<tbody>
<tr>
<td>BAU</td>
<td>0.8</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>1R</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
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<tr>
<td>2R</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>3R</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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</tbody>
</table>

ICE Vehicles

Electric Vehicles
Total cost by scenario and mode, USA

- Total societal (out-of-pocket) 3R cost in 2050 is only 2/3 of BAU or 2R cost, thanks to deep cuts in car ownership, energy use, and road/parking requirements.
The wide range of costs related to mobility choices

**Out-of-pocket Costs**

- Vehicle purchase
- Vehicle maintenance
- Fuel
- Insurance
- Cleaning
- Parking
- Driver
- MaaS fees
- Tolls
- Registration-related fees

**Hedonic costs**

- Travel time (driving)
- Travel time (passenger)
- Parking search time
- Walking time
- Driving stress
- Shared trips (e.g. lack of privacy)
- EV range, charging anxiety
- Car ownership negatives (maintenance, registration, inspections etc.)
- Car ownership positives (car pride, guaranteed ride; can leave personal belongings in the car)
A more detailed cost comparison: California in 2025

- The following presentation assumes widespread availability of electric vehicles (EVs) and electric, connected automated vehicles (or AV/EVs).
- Comparison here is the cost per mile of:
  - Private ICEs, EVs, and AV/EVs
  - MaaS (Mobility as a Service, such as Uber) versions of EVs and AV/EVs
  - Pooled services included, in later slides
- Start with looking at vehicle costs per mile, then consider passengers.
- For some aspects need to assume specific trip lengths.
Out-of-pocket costs: Comparison of modes

- **Driven MaaS vehicles are premium service, automation makes these competitive**
- **Pooled mobility is a good deal**

![2025 - Midsize vehicle ($/PMT)](chart)

- MaaS fees
- Driver cost
- Vehicle cleaning
- Vehicle parking
- Vehicle maintenance
- Vehicle insurance
- Fuel cost
- Amortized purchase cost
Added a value of time for driving, travelling, parking

- **Time costs are equal to or in some cases far greater than the out-of-pocket costs**
- **Pooled mobility advantage disappears**

<table>
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<th>2025 - Midsize vehicle ($/PMT)</th>
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<tbody>
<tr>
<td>Parking search cost</td>
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<tr>
<td>Travel time cost per passenger</td>
</tr>
<tr>
<td>MaaS fees</td>
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<tr>
<td>Driver cost</td>
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<tr>
<td>Vehicle cleaning</td>
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<tr>
<td>Vehicle maintenance</td>
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<tr>
<td>Vehicle insurance</td>
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<tr>
<td>Fuel cost</td>
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<tr>
<td>Amortized purchase cost</td>
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Included only variable costs (daily decision)

- Ignore private car purchase, insurance cost
- *The AV/EV private car becomes cheaper than shared mobility options*

![Graph showing cost comparison between different transportation options including Private ICE, Private EV, Private EV/AV, Maas ICE, Maas EV, Maas EV/AV, and Maas EV/AV Pooled. The graph illustrates cost categories such as Parking search cost, Travel time cost per passenger, MaaS fees, Driver cost, vehicle cleaning, vehicle parking, vehicle maintenance, Vehicle insurance, fuel cost, and Amortized purchase cost.](image-url)
Supportive Policies – critical to success of the scenarios

• 3R Scenario (Automation + Electrification + **Sharing**):
  – Compact Urban Development policies
  – Efficient parking policies
  – Heavy investment in transit/walking/cycling
  – VKT fees (incl. congestion & emission factors):

<table>
<thead>
<tr>
<th>ZOV</th>
<th>SOV</th>
<th>HOV</th>
<th>Minibus Transit</th>
<th>High Capacity Transit</th>
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</thead>
<tbody>
<tr>
<td>Highest Fee</td>
<td></td>
<td></td>
<td></td>
<td>Largest Subsidy</td>
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