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

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

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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

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Passenger Transport Revolutions

1. Streetcars (~1890)
2. ICE Automobiles (~1910)
3. Airplanes (~1930)
4. Limited-access highways (1930s….1960s)

2010+
1. Vehicle electrification
   – low carbon vehicles and fuels
2. Real-time, shared mobility
   – less vehicle use
3. Vehicle automation (2025?)
   – Safety benefits
   – Uncertain travel impacts
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?
## Rough guide to the 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>

*UCDAVIS SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS*
Urban passenger kilometers by scenario, USA

- US travel grows significantly except in 3R
- Travel remains fairly car dominated to 2050 – transit travel triples but remains below 20% of pkm.
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
Urban non-LDV passenger kms by scenario, USA

- US transit, walking and cycling is flat into the future in BAU and 2R
- Travel in these modes grows dramatically in 3R, doubling by 2030 and nearly doubling again by 2050.
Urban LDV travel (VKm) by scenario, USA

- 2R vehicle travel rises sharply after 2030 due to lower travel costs from automated vehicles.
- 3R vehicle travel flat despite declining vehicle stock, given higher travel per vehicle of public vehicles.
Urban LDV stock evolution by scenario, USA

- 2R stocks nearly completely autonomous by 2050
- 3R stocks strongly decline after 2030, due to lower passenger travel levels, intensive vehicle use and higher load factors.
Energy use by scenario, USA

- Far lower energy use in 2R due to EVs, and in 3R due to low LDV mode shares
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>Year</th>
<th>ICE Vehicles</th>
<th>Electric Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>BAU 0.8</td>
<td></td>
</tr>
<tr>
<td>2030</td>
<td>BAU 0.6</td>
<td>1R 0.01</td>
</tr>
<tr>
<td></td>
<td>2R 0.04</td>
<td>2R 0.03</td>
</tr>
<tr>
<td></td>
<td>3R 0.02</td>
<td>3R 0.01</td>
</tr>
<tr>
<td>2050</td>
<td>BAU 0.6</td>
<td>1R 0.01</td>
</tr>
<tr>
<td></td>
<td>2R 0.03</td>
<td>2R 0.01</td>
</tr>
<tr>
<td></td>
<td>3R 0.01</td>
<td>3R 0.005</td>
</tr>
</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.
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):

![Diagram showing ZOV, SOV, HOV, Minibus Transit, and High Capacity Transit with highest fee on the left and largest subsidy on the right.](image)
A few takeaways

• 2R without 3R could be a traffic nightmare, even with automation traffic benefits.
  – The rebound travel effects of automation should be carefully managed

• A 2R scenario could lead to deep CO2 reductions IF grid electricity is deeply decarbonized
  – A 3R scenarios provides more robust emissions reductions
  – Automation without electrification could increase CO2

• 3R: Sharing must be strongly incentivized, probably through pricing

• Even a super-rapid transition will take 3 decades to complete
  – Private “legacy” vehicles could be an issue; scrappage incentives could be interesting