The Three Transportation Revolutions and What They Mean for Energy and Climate

Daniel Sperling
Professor and Director
Institute of Transportation Studies
University of California, Davis
and
Board Member
California Air Resources Board

iSEE Congress 2016
Energy 2030: Paths to a Sustainable Future

University of Illinois at Urbana-Champaign
13 September 2016
Transportation is largest source of GHGs in US (as of 2016)

California has new law requiring 40% reduction in GHGs by 2030

But almost zero (system) innovation in US passenger transportation for past 50+ years

Transportation is now on the cusp of massive change

.... which could be very positive, or not.
Transportation’s Roots are in Civil Engineering Which Aimed to Serve Automobility (in 20th Century)
Outcome: Transport Monoculture in US

✓ Solo driving increased
✓ Carpooling shrank
✓ Public transport = 3% of PMT (~5% of trips)

<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Drove alone</td>
</tr>
<tr>
<td>Car pooled</td>
</tr>
<tr>
<td>Public transport</td>
</tr>
<tr>
<td>Other</td>
</tr>
</tbody>
</table>

OTHER= Worked at home, Walked only, Bicycle, Motorcycle, Taxicab
Outcome: Soaring Global Demand for Vehicles

Sperling and Gordon (2009), based on DOE, JAMA, other
Gone Too Far

Car-Centric Brasilia

I-105 and I-110 with HOV Flyovers in LA
Car-Centric Monoculture is Extraordinarily Expensive and Carbon-Intensive

- **Road Infrastructure Cost**
  - Over $100 billion/yr (US)
  - Plus other infrastructure costs to support sprawl

- **Personal Cost**
  - $9000/year to own and operate a car (US)
  - Total = $1+ trillion/yr (US)

- **Oil**
  - 70% of oil consumption (USA)
  - $300-$500 billion/yr

- **Climate Change**
  - 1/3 of GHGs (US)

- **Air Pollution**
  - Half of urban air pollution
Billions spent, but fewer people are using public transportation in Southern California
Path to Sustainability is Challenging and Uncertain

... overcoming path dependence and technology lock-in, and acknowledging technological, political, economic, behavioral uncertainties

“Forecasts” for GHG Reduction in California based on several energy systems models

Source: Yeh et al (UC Davis), May 2015
Principal Sustainability Strategies (GHG Reduction) for Transportation

- Less vehicle use (VMT/capita)
- Low-carbon fuels (gCO₂-eq/MJ)
- Efficient, low-carbon vehicles (gCO₂-eq/km)
How to Reduce Vehicle Use? Many reasons to do so!

Travel has peaked in rich countries

Source: IEA, 2012 (ETP 2012)
Vehicle Travel (VMT) Flat in US?

- Total VMT
- VMT per capita

 FHWA, September 2015
How to Shift from High-Carbon Fossil Fuels?

- Oil Sands
- Arctic Oil
- Shale Oil/Gas

Source: Richard Doctor, Argonne, 2003
Vehicle Efficiency
First Big Step to “Sustainability”
How to Create Transport Systems That Are Cheaper, Better, and More Sustainable?

- Less expensive
- Less resource intensive
- Less carbon intensive
- More accessible

➢ Three Transportation Revolutions
Passenger Transport “Revolutions”

1. Streetcars (~1890)
2. Automobiles (~1910)
3. Airplanes (~1930)
4. Limited-access highways (1930s…1956)

2010+
1. Vehicle electrification
   - low carbon vehicles and fuels
2. Real-time, shared mobility
   - less vehicle use
3. Vehicle automation (2025?)
   - Uncertain impacts
Revolution 1: Vehicle Electrification

38 models available, including....

- Nissan Leaf
  - Battery electric

- Tesla Model S
  - Battery electric

- Chevy Volt
  - Plug-in hybrid

- Toyota Mirai
  - Hydrogen fuel cell
Fuel Cell cars lined up for fueling in Sacramento, Aug 26, 2016
Walking the Talk...
bike, fuel cell car, electric car
Battery Costs are Dropping Sharply
(from $1300/kwh in 2006 to $400 in 2015)

Light Duty Vehicles Almost Definitely Will be Electrified

- 2005: 25 mpg
- 2020: 50 mpg
- 2035: 75 mpg
- 2050: PEVs and FCVs

4%/yr improvement
California and 8 Other States Require ~15% of Vehicle Sales to be “ZEVs” by 2025

Source: energy.gov
My next car... and 375,000 others?!

Tesla Model 3
Revolution #2: Sharing Rides and Vehicles

... engaging policy, industry, and consumers!

“Silicon Valley” transformed how we communicate, do research, buy books, listen to music, and find a date ....

Now it is starting to transform transportation...
flexible, reliable, dynamic, adaptive, cheap, sustainable
Car companies becoming mobility companies?!
New Mobility Services Could Capture Half of Passenger Travel

- Unable to drive
  - Elderly and young; physical disabilities
- Prefer not to drive
  - Drinking alcohol
  - Deteriorating driving skills (esp nighttime)
- Emergencies
  - Car breakdown or car unavailable
- Save money
  - Carpool to work, school, events
  - Access to conventional transit (first/last mile)
- Use travel time productively
Revolution 3. Vehicle Automation

Going Driverless

Will this be transportation heaven or hell?
Vehicle Automation Increases or Reduces Energy Use (and GHGs)?!

Wadud et al, 2015
From Partial to Full Automation

Phase/Level 4:
Fully automated ...
but when?

Adapted from Robin Chase and Morgan Stanley company research, 2015
Are 3 Revolutions in Public Interest?

- Vehicle Electrification… unequivocally yes
- Mobility Sharing … mostly yes (beyond glorified taxis)
- Vehicle Automation … could be

➢ Goal (public interest): Merge all three!
Consumer Challenge

Researchers, Policymakers, and Industry Need to Understand and Motivate Consumers and Travelers.... From Early Adopters to Followers

- Rational inattention (Sallee, 2013)
- Loss aversion (Greene et al, 2009)
Leadership Challenge

1. Vehicle Revolution
   - Gov’t led … need clever/effective regulations, consumer incentives, energy infrastructure (with big help from researchers)

2. New Mobility Services Revolution
   - Consumer led …. policy leaders (and researchers) need to steer revolution to the social good

3. Automation Revolution
   - Consumer led …. policy/researchers can steer revolution to social good
University Researchers and Gov’t Leaders Need to Cross the Chasm

... to create sustainable 21st century transportation
“We can not solve our problems with the same thinking [and institutions and research] we used when we created them.”

- Albert Einstein

Thank You