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

Stati Generali della Green Economy 2017

The Future of mobility: less, electric, green and shared

Rimini Italy, 7 November 2017

Lew Fulton, Co-Director
Sustainable Transportation Energy Pathways Program (STEPS)
UC Davis

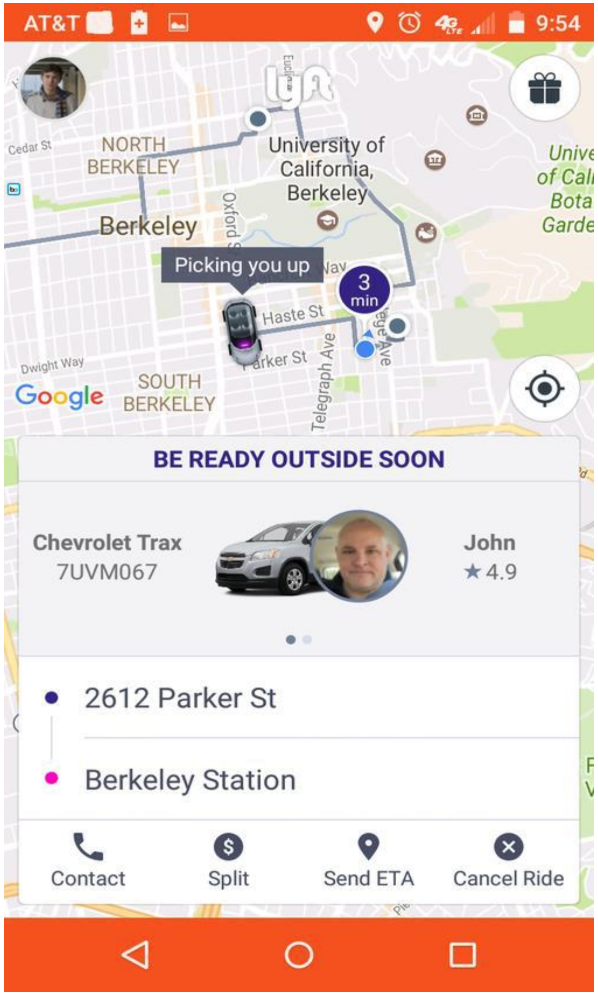
ITS UC DAVIS INSTITUTE OF TRANSPORTATION STUDIES

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



UCDAVIS
SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS

Research undertaken by UC Davis and ITDP, part 3 of a series

Global scenario study to 2050 focused on potential 3 Revs impacts on CO_2, 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

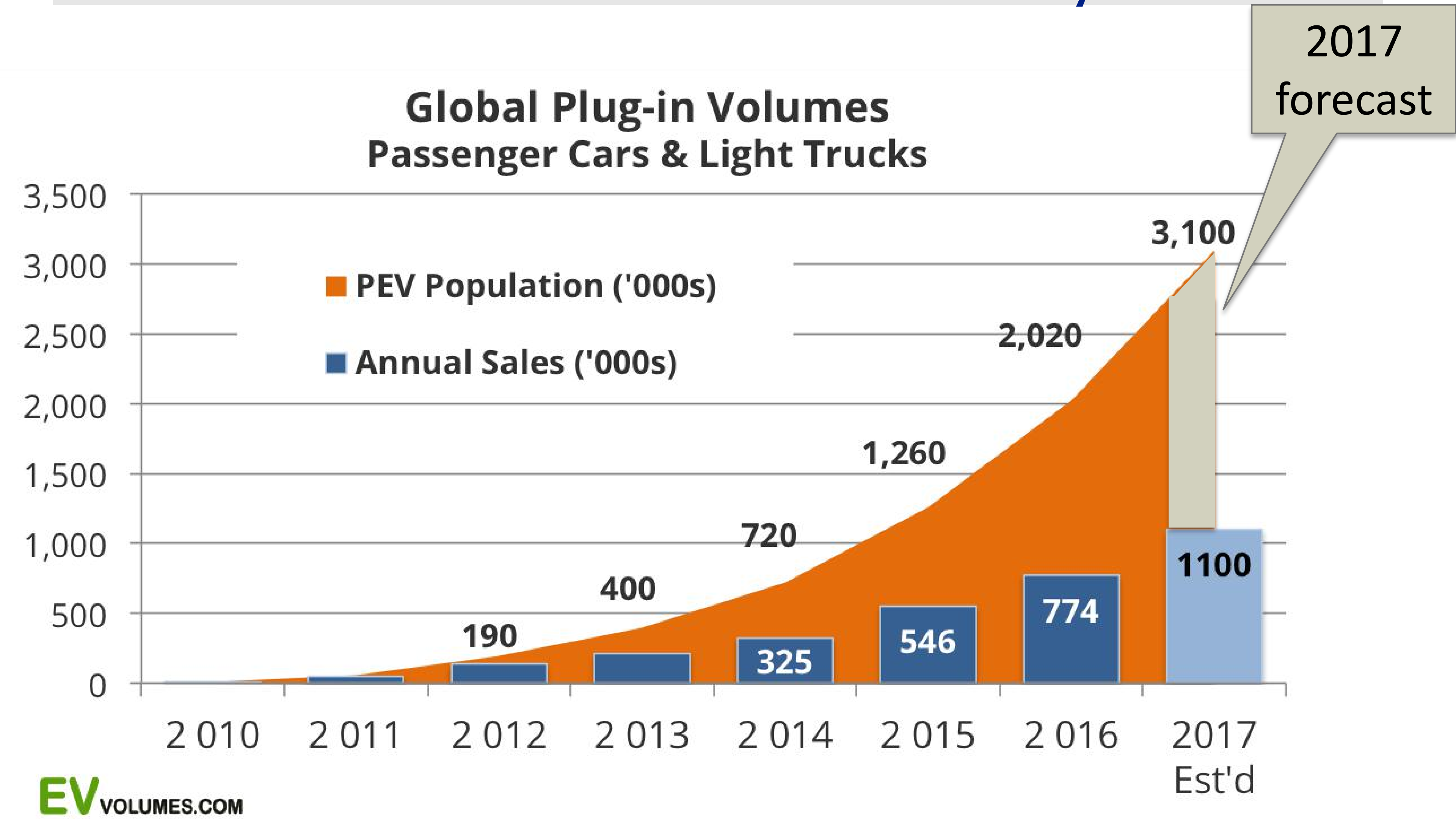
UC DAVIS
SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS
of the Institute of Transportation Studies

ITDP | Institute for Transportation & Development Policy

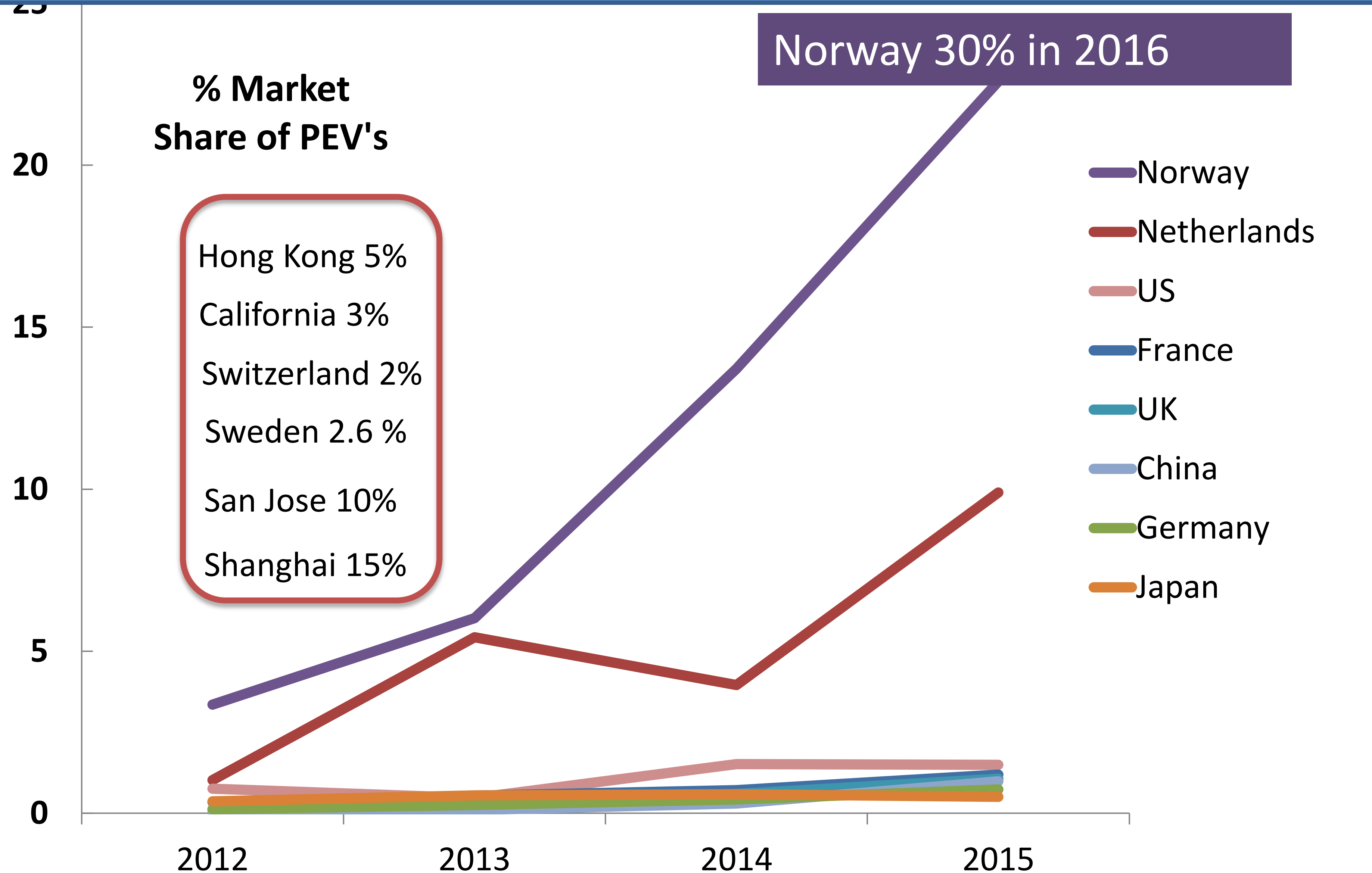
Have EVs arrived?

Image Source: Jato Dynamics

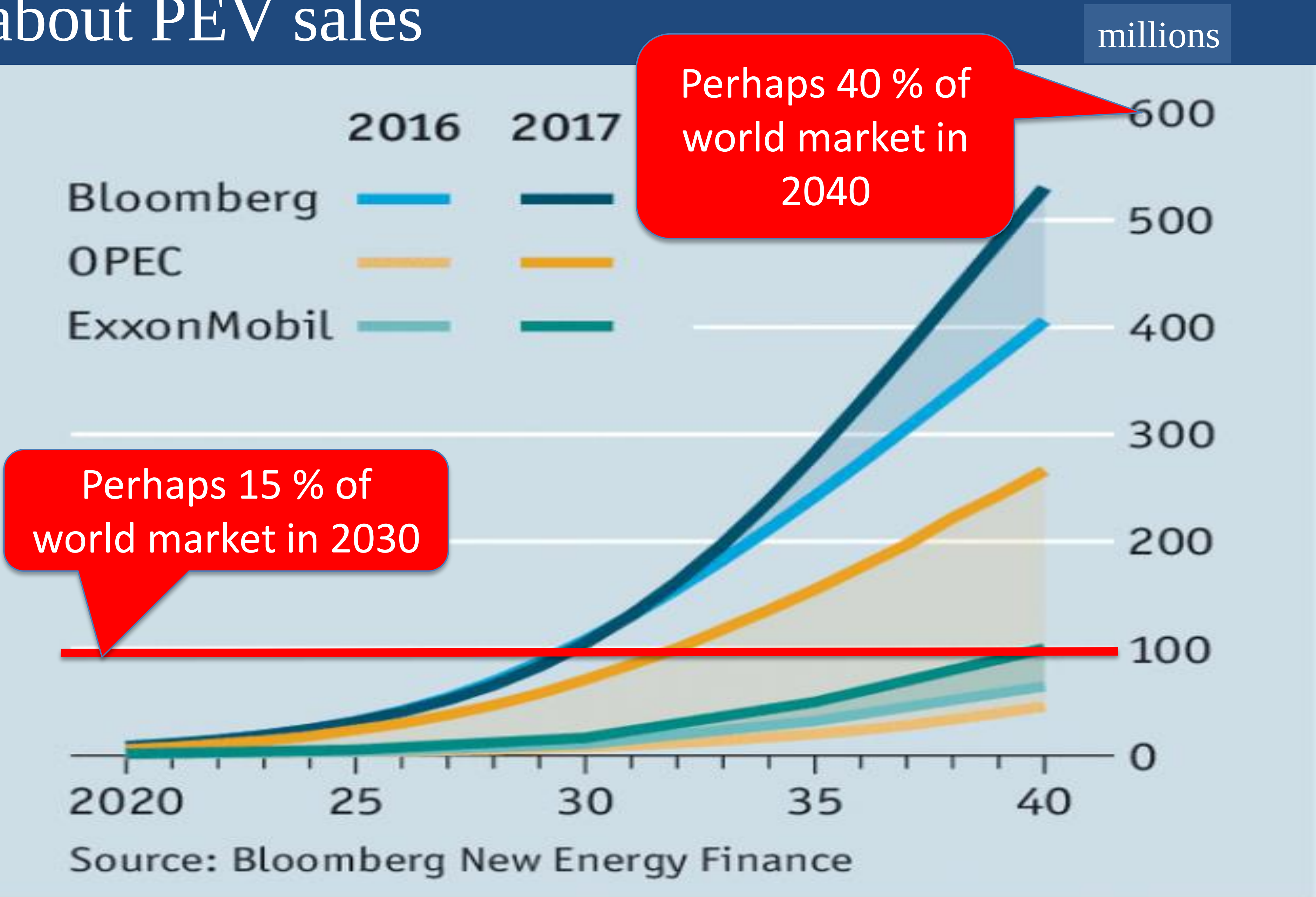
During 2017, The number of PEVs worldwide will likely go over 3 million, with over 1 million in sales this year



Norway & Netherlands achieved high PEV market shares in 2016, most other national markets around 1-2%



Many PEV sales forecasts getting optimistic about PEV sales



A plausible PEV rollout scenario based on technology change, incentives & history of previous technology rollouts

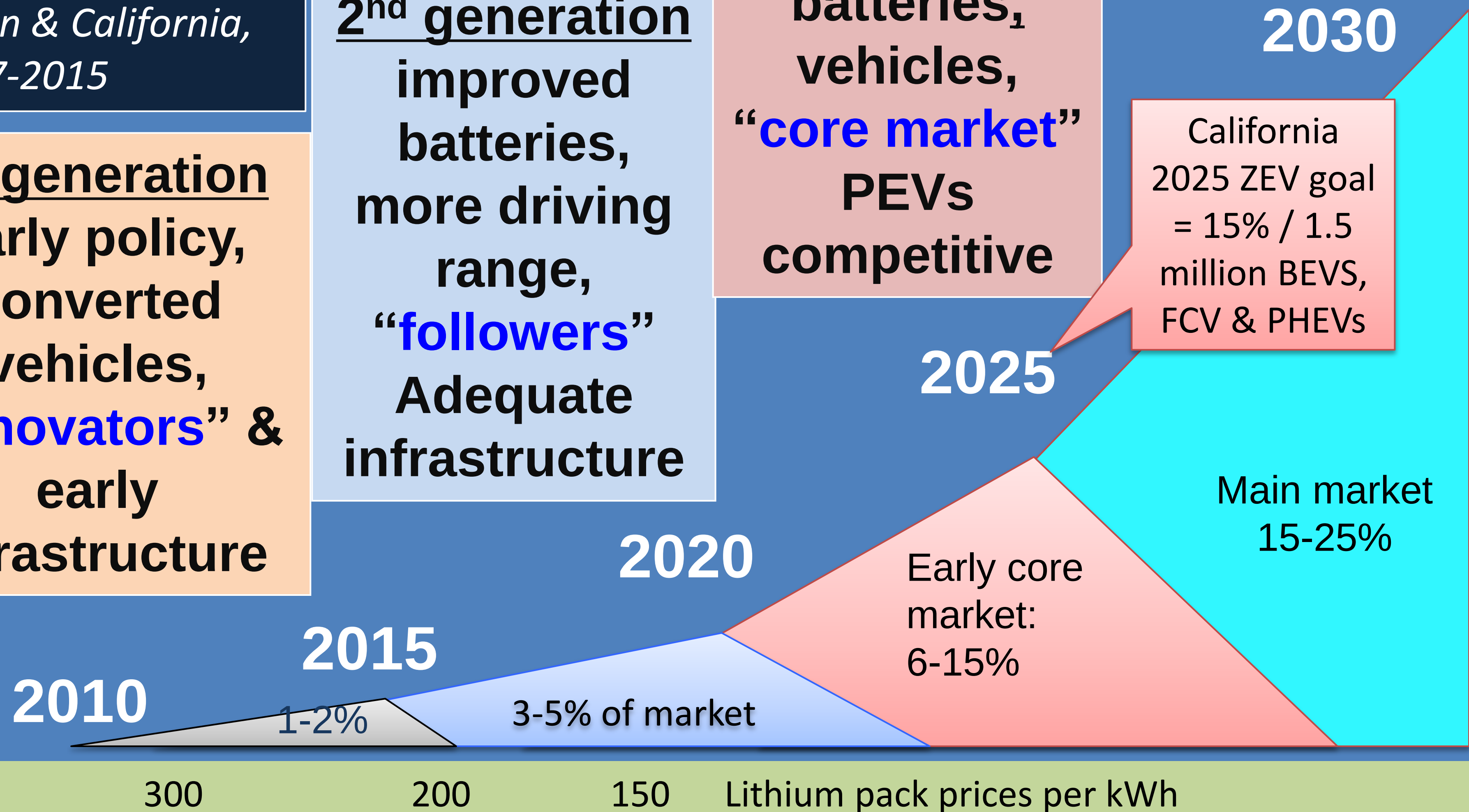
This sales curve would be similar to the rollout of HEVs in Japan & California, 1997-2015

1st generation early policy, converted vehicles, "innovators" & early infrastructure

2nd generation improved batteries, more driving range, "followers" Adequate infrastructure

3rd generation: batteries, vehicles, "core market" PEVs competitive

4th generation: PEVs begin to dominate



Car of the future?

Or this?

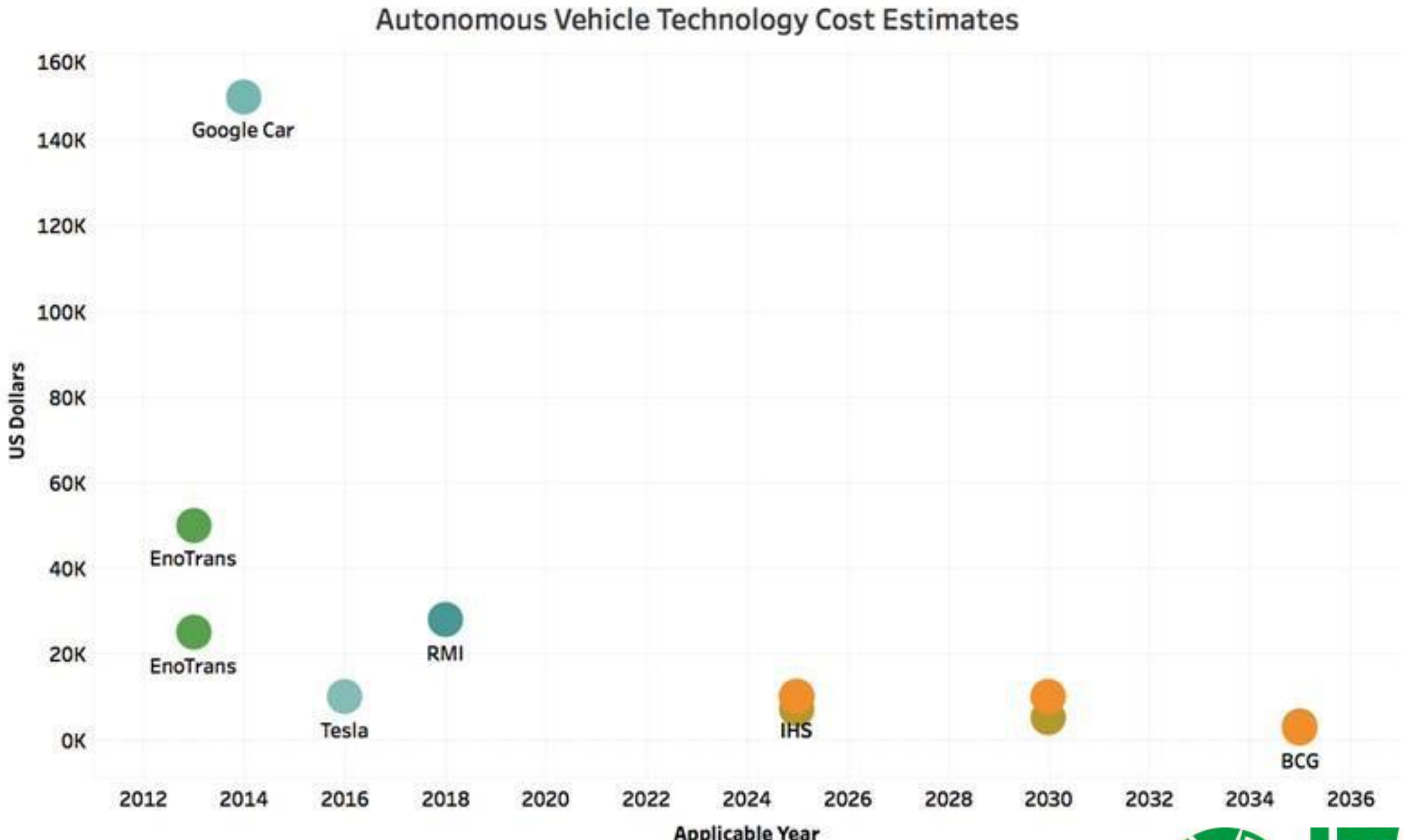
Electrification + Automation: likely, but not definitely, together

All autonomous vehicles in development feature some form of electrification

Parent Company	Make	Model	Powertrain	Production Goal	Notes
Nissan	Nissan	Leaf	Electric	2020	
GM	Chevrolet	Bolt	Electric		Testing 40 vehicles in SF and Scottsdale
FCA	Chrysler	Pacifica	Hybrid		Testing 100 vehicles with Google
Ford	Ford	Fusion	Hybrid	2021	
Volvo	Volvo	XC90	Hybrid		
Uber	Ford	Fusion Energi	PHEV		
Uber	Volvo	XC90	Hybrid		
Daimler	Mercedes-Benz	F015 Luxury in Motion	Hydrogen Fuel Cell Plug-In Hybrid		Research Vehicle

AV costs dropping quickly

Cost of LIDAR used on the Google car was $75 – 85,000, and by early 2016, Velodyne began selling LIDAR for $500 per unit to Ford.



UCDAVIS
SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS

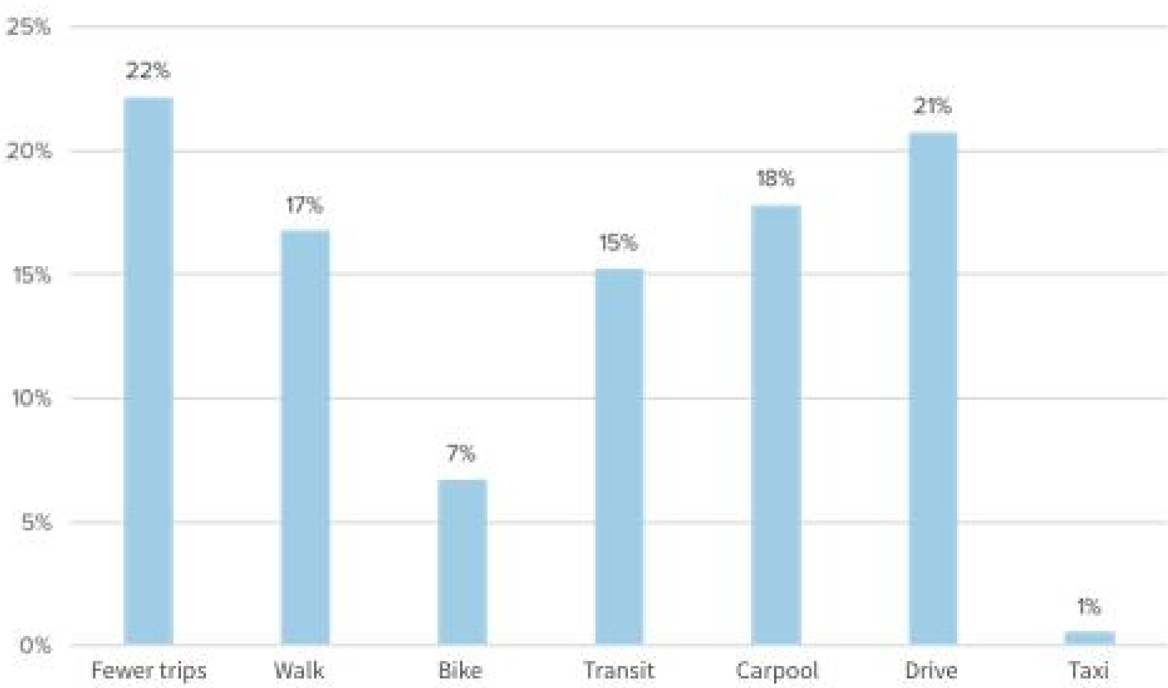
ITDP
Institute for Transportation & Development Policy

Ride sharing is exploding around the world…

…but is it really ride sharing?

UCDAVIS
SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS

Ride-hailing in the U.S. currently substitutes for more sustainable modes than for driving



Source: Clewlow, Regina R. and G S. Mishra (2017) Disruptive Transportation: The Adoption, Utilization, and Impacts of Ride-Hailing in the United States.

- 49% to 61% of ride-hailing trips in major U.S. metro areas would have not been made at all, or by walking, biking, or transit.
- Ride-hailing attracts Americans away from bus services (a 6% reduction) and light rail services (a 3% reduction).
- Ride-hailing serves as a complementary mode for commuter rail services (a 3% net increase in use).
- Directionally, we conclude that ride-hailing is currently likely to contribute to growth in vehicle miles traveled (VMT).

This can go in very different directions…

"Heaven" Scenario

- Ride sharing, multimodal (transit/NMT) ecosystem
- More compact, livable cities
- "Right-sizing" of vehicles
- Reduction in traffic/travel times
- Fuel efficiency improvements/ electrification/lower CO2

"Hell" Scenario

- More single-occupant (and zero occupant) vehicles
- More sprawl/car-dependence
- Bigger vehicles
- Longer trips/ time spent traveling/ increased traffic congestion
- Higher energy use/CO2

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?

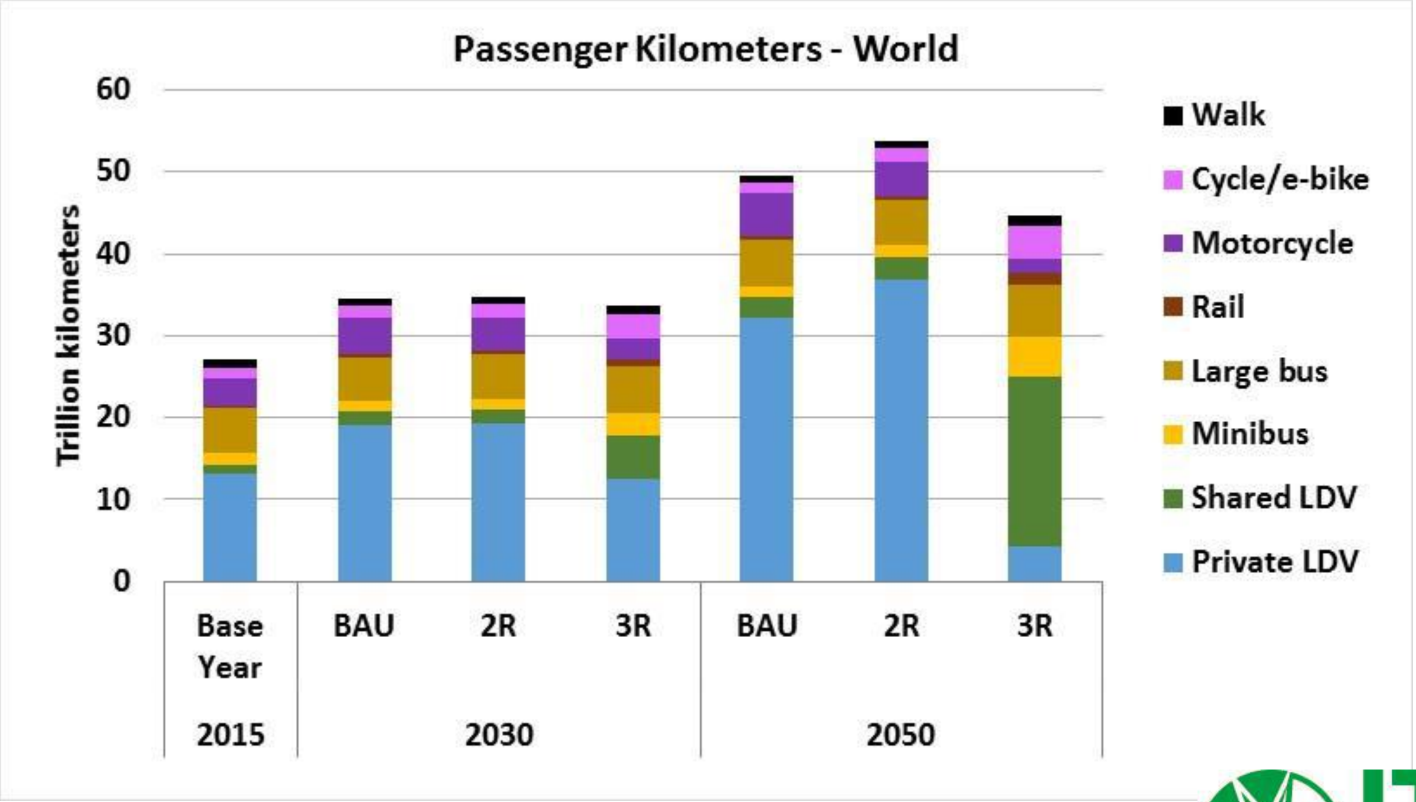
Part 2: our scenarios…we want to explore these interactions and different possible futures

Rough guide to the three scenarios

	Auto-mation	Electrifi-cation	Shared Vehicles	Urban Planning/ Pricing/TDM Policies	Aligned with 1.5 Degree Scenario
Business as usual, Limited Intervention	Low	Low	Low	Low	No
1R Automation only	HIGH	Low	Low	Low	No
2R With high Electrification	HIGH	HIGH	Low	Low	Maybe
3R With high shared mobility, transit, walking/cycling	HIGH	HIGH	HIGH	HIGH	YES

Passenger kilometers of travel by scenario/mode World

- Automated vehicle travel not significant by 2030 in any country/scenario, but dominates in 2050 in most of the world. Results in much higher travel in 2R
- In 3R private LDVs reach very low levels; nearly 50% of travel in 2050 is in transit/non-LDV modes.

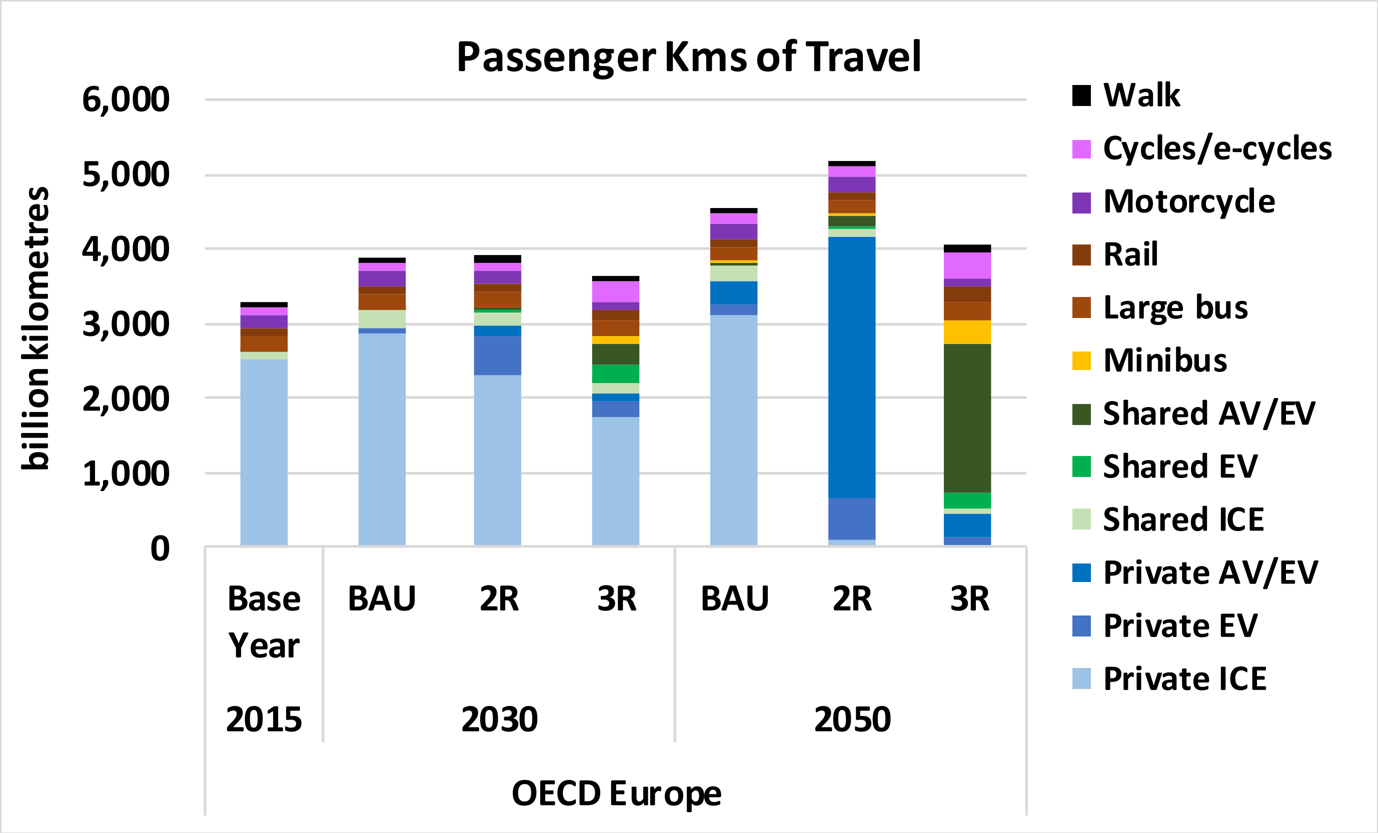


UC DAVIS
SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS

ITDP
Institute for Transportation & Development Policy

Passenger kilometers of travel by scenario/mode OECD Europe

- Automated vehicle travel not significant by 2030 in any scenario, but dominates in 2050. Results in much higher travel in 2R
- Europe remains fairly car dominated to 2050 - modal mix changes in 3R, but mostly due to TNCs. Significant minibus travel. Non-car travel reaches 35% in 3R

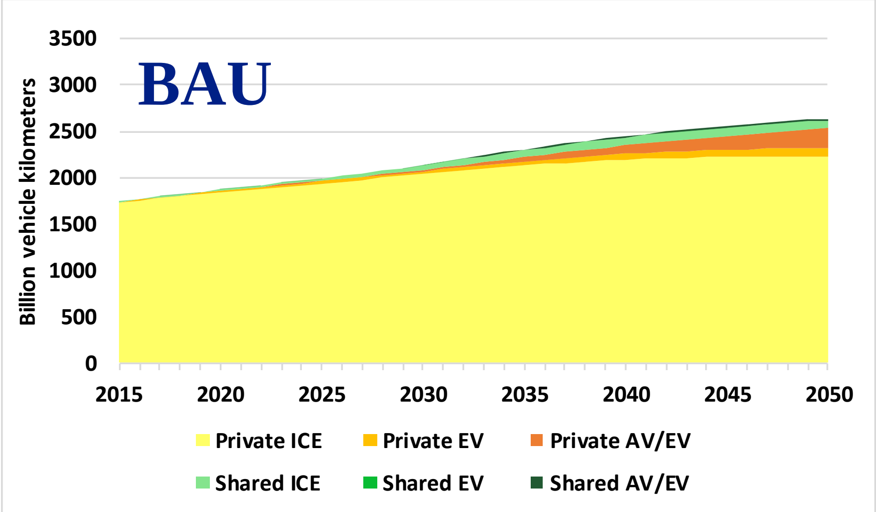


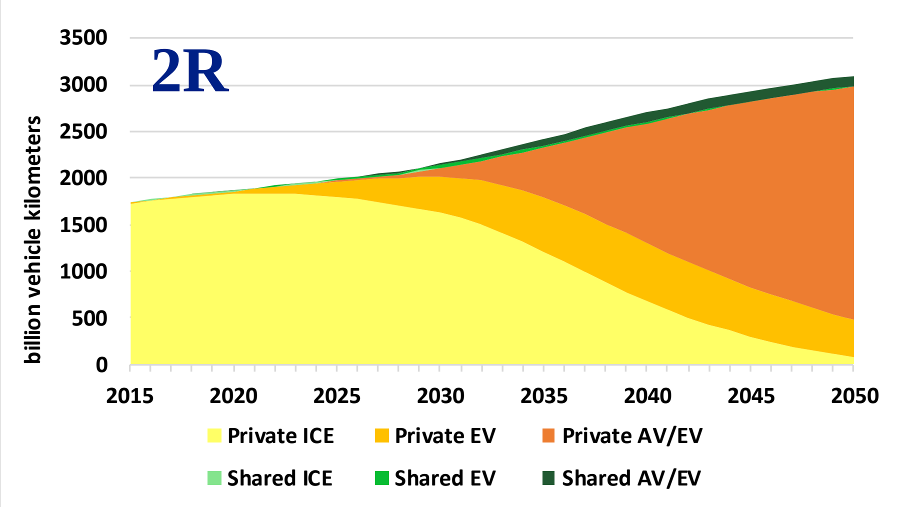
UC DAVIS SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS

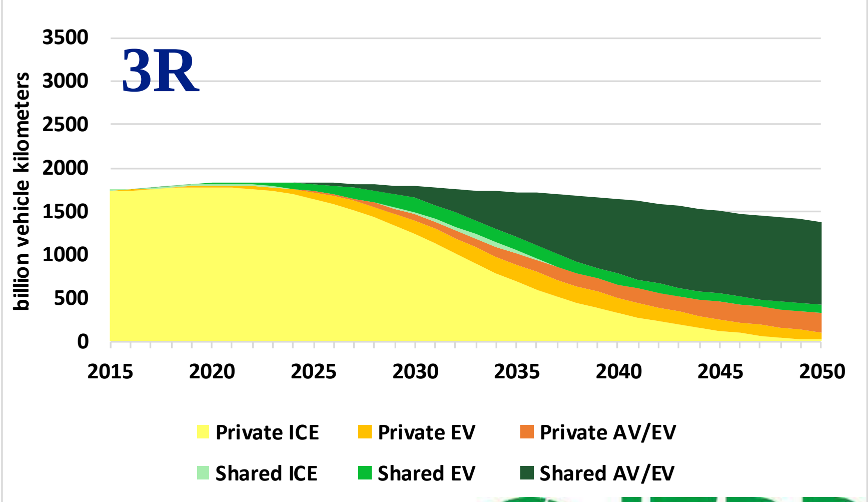
ITDP Institute for Transportation & Development Policy

OECD-Europe LDV travel (VKm) by scenario

- 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





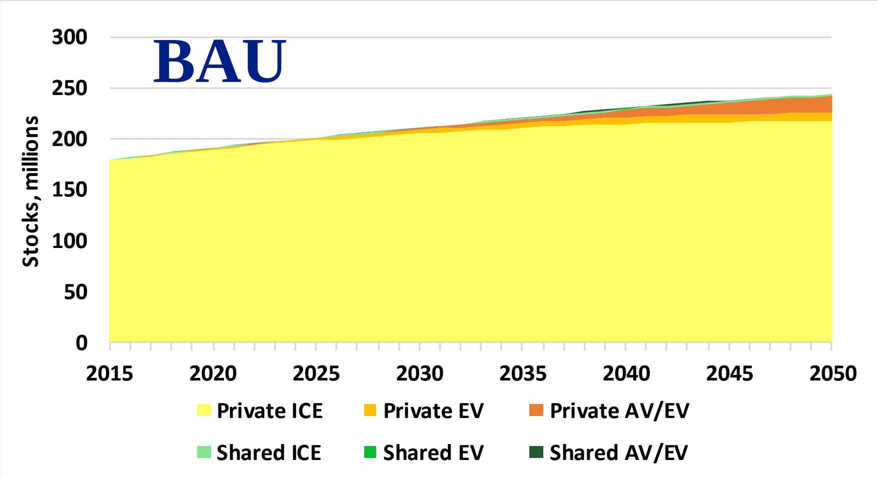


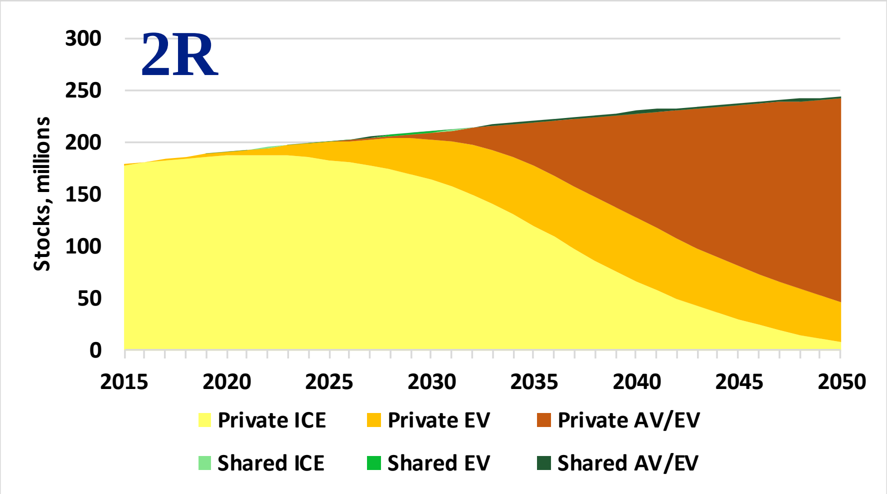
UC DAVIS
SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS

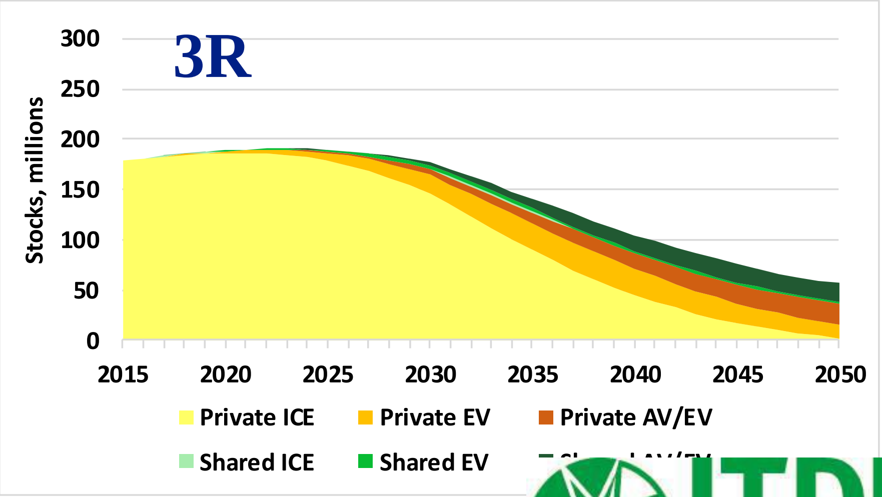
ITDP
Institute for Transportation & Development Policy

OECD-Europe LDV stock evolution by scenario

- 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





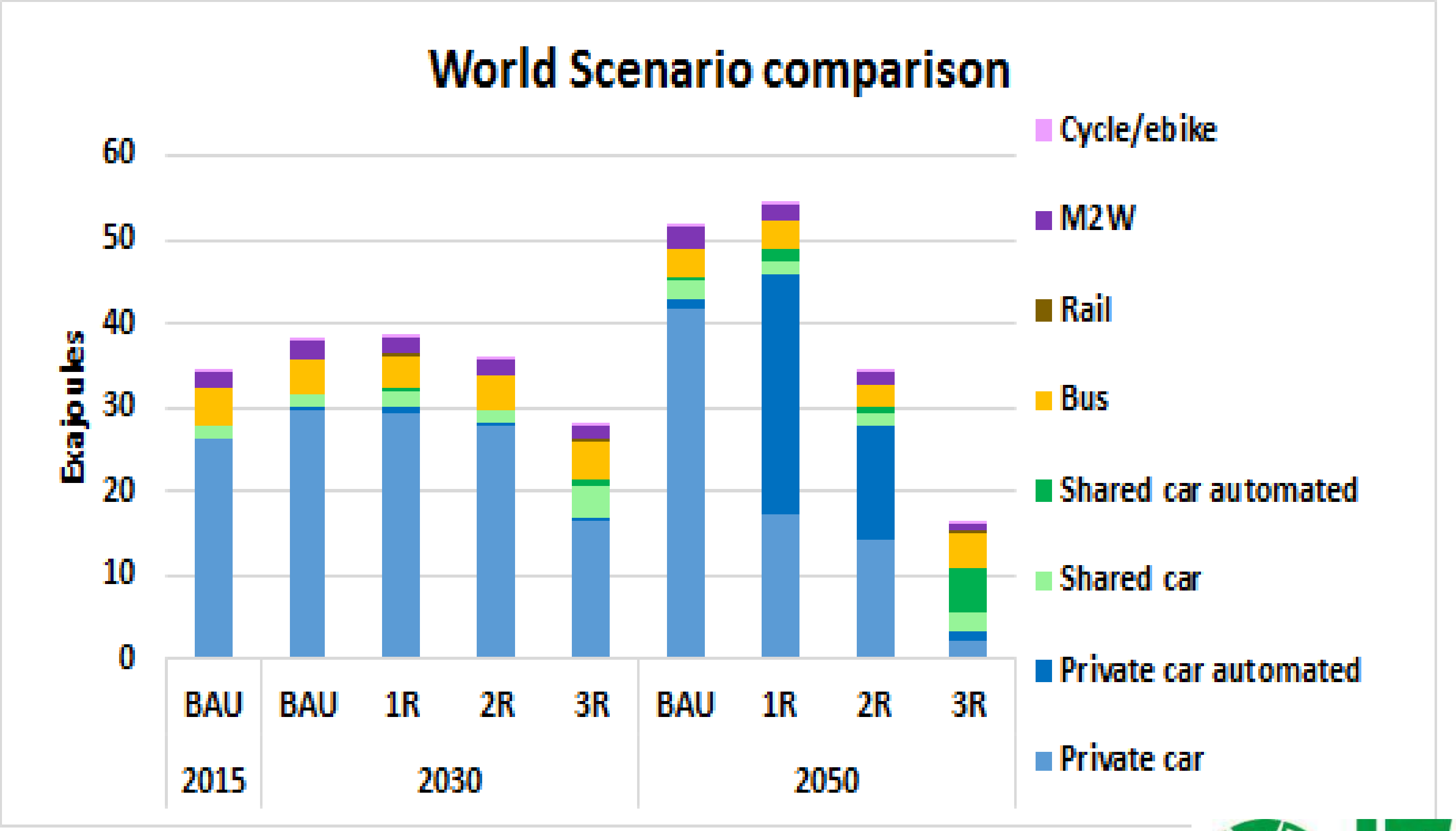


UCDAVIS
SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS

ITDP
Institute for Transportation & Development Policy

Energy use by scenario, mode

- Far lower energy use in 2R due to EVs, and in 3R due to low LDV mode shares



UC DAVIS SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS

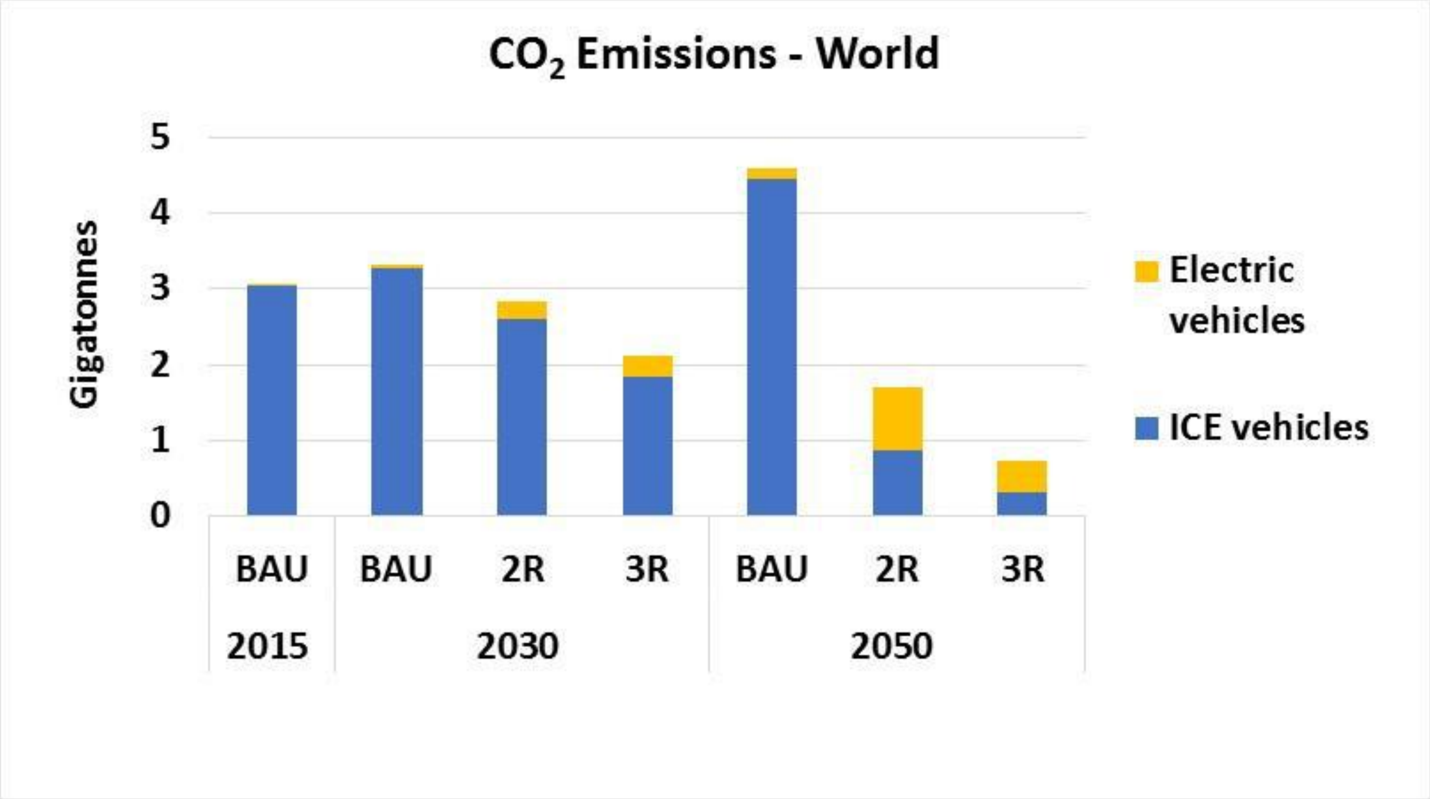
ITDP Institute for Transportation & Development Policy

Urban passenger transport CO2 by scenario, vehicle type, world

Global CO2 reduction in a 2DS electricity world, 2R/3R v. BAU, in 2050 and cumulative

	2050	2015-2050 cumulative
2R v BAU	82%	37%
3R v BAU	93%	53%

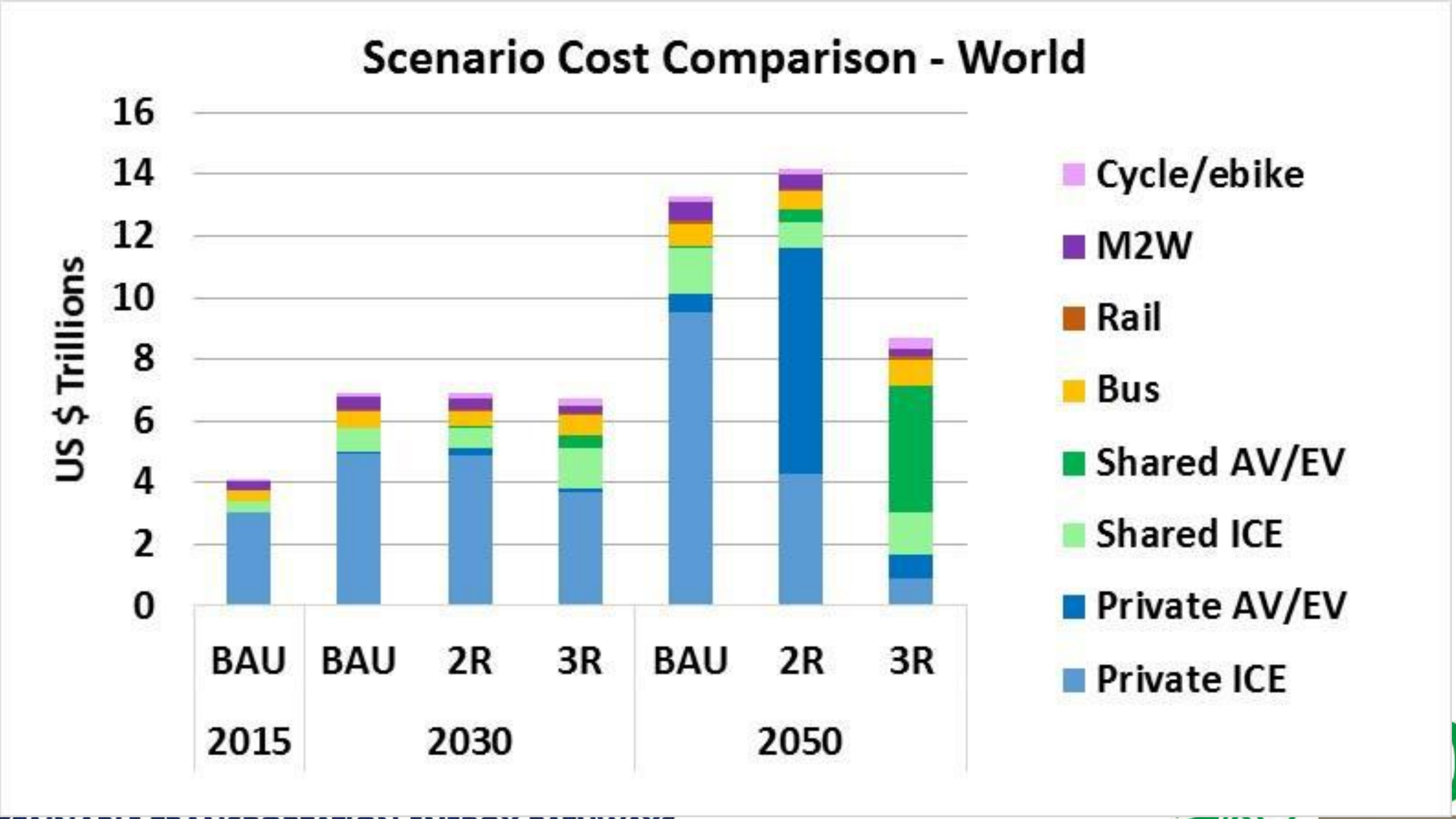
4DS electricity shown; in 2DS, CO2 from electricity drops to near zero in 2050



ITDP Institute for Transportation & Development Policy

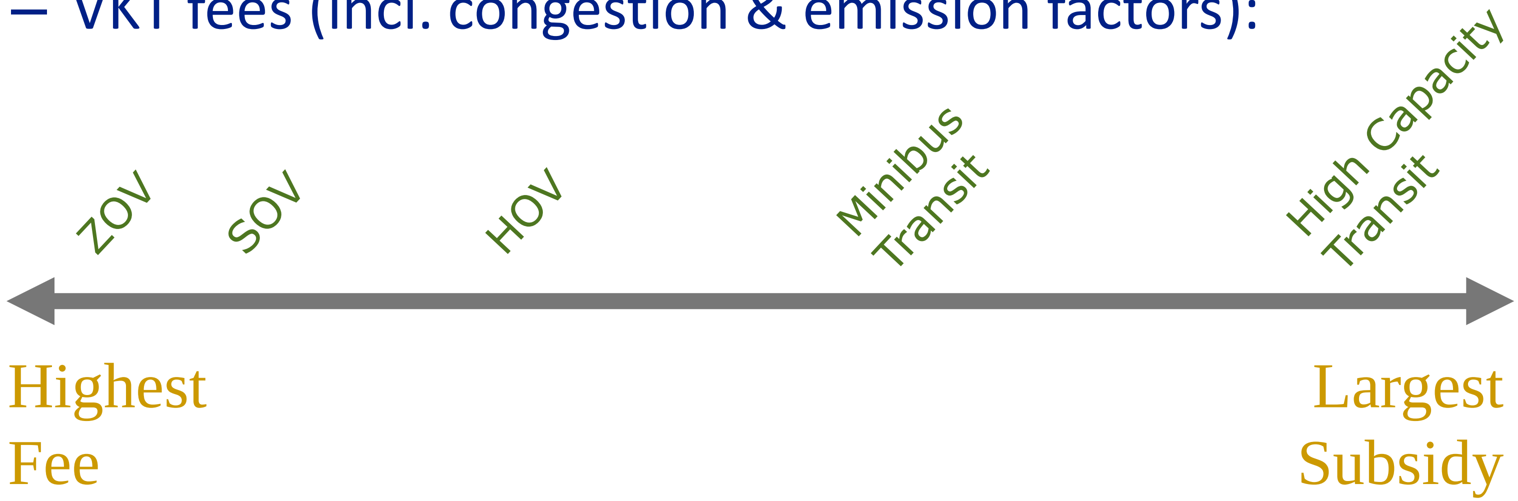
Costs start to deviate across scenario after 2030, 3R 40% cheaper in 2050

- The combination of far fewer vehicles, lower travel/fuel levels, lower infrastructure requirements (roads/parking) makes 3R far cheaper.
- 2R more expensive than BAU due to higher cost of AV/EVs and greater travel



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):



UC DAVIS
SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS

ITDP
Institute for Transportation & Development Policy

C40 CITIES

ICLEI Local Governments for Sustainability

ITDP Institute for Transportation & Development Policy

Partnership on Sustainable Low Carbon Transport

Rocky Mountain Institute

SHARED-USE MOBILITY CENTER

WORLD RESOURCES INSTITUTE | ROSS CENTER

10 Principles

https://www.sharedmobilityprinciples.org/

1. **We plan our cities and their mobility together.**
2. **We prioritize people over vehicles.**
3. **We support the shared and efficient use of vehicles, lanes, curbs, and land.**
4. **We engage with stakeholders.**
5. **We promote equity.**
6. **We lead the transition towards a zero-emission future and renewable energy.**
7. **We support fair user fees across all modes.**
8. **We aim for public benefits via open data.**
9. **We work towards integration and seamless connectivity.**
10. **We support that autonomous vehicles (AVs) in dense urban areas should be operated only in shared fleets.**

Three additional “Lew” Principles

1. **We must pay close attention to the relative cost of vehicles/modes ($$, time, safety convenience, etc)**
2. **We must enable pricing as a true policy option, and have a social contract on how we spend those revenues**
3. **We must somehow convince consumers that they (and society) will be better off if they don’t actually own driverless cars, and maybe don’t own any car**