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

STEPS Symposium

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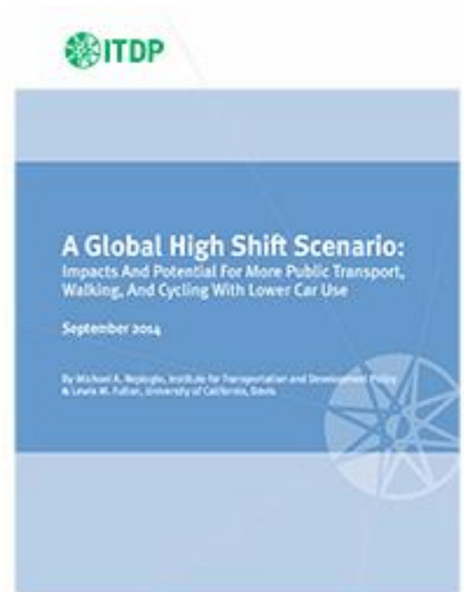
Project Background

- This research project grows out of two previous "High Shift" studies done by ITDP and UC Davis
- This one focuses on 3 major impending transportation "revolutions" not included in the two previous studies: electrification, shared mobility and automation/connected vehicles
- Scenario study to 2050 focused on potential scenario impacts on CO2, energy use, costs
- Study supported by STEPS Funds and by Climate Works, Hewlett Foundation, Barr Foundation
- Project time Frame: September 2016-April 2017
- Project advisory board established

3 Revolutions builds on 2 previous ITDP/UC Davis studies

Global High Shift Scenario

- High future urban mode shares of transit and active transport around the world; cut car use in half
- Much lower CO_2, significantly cheaper transportation system costs



Global HS Cycling Scenario

- Added very high cycling and e-biking mode shares to previous study
- Cut CO_2 use an additional 10% and lowered costs

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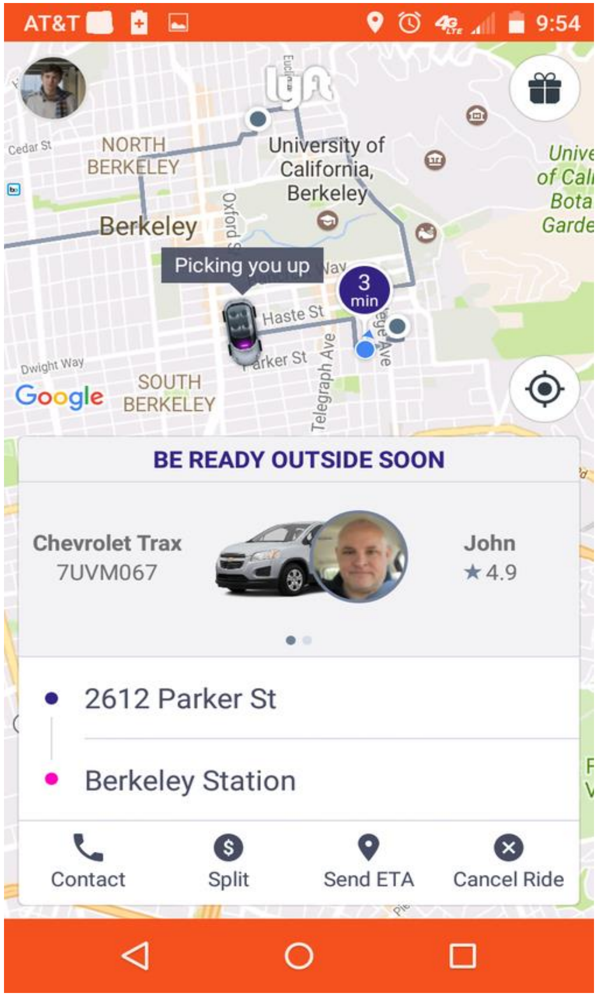
Passenger Transport Revolutions

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



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Ride sharing is exploding around the world…

…but is it really ride sharing?

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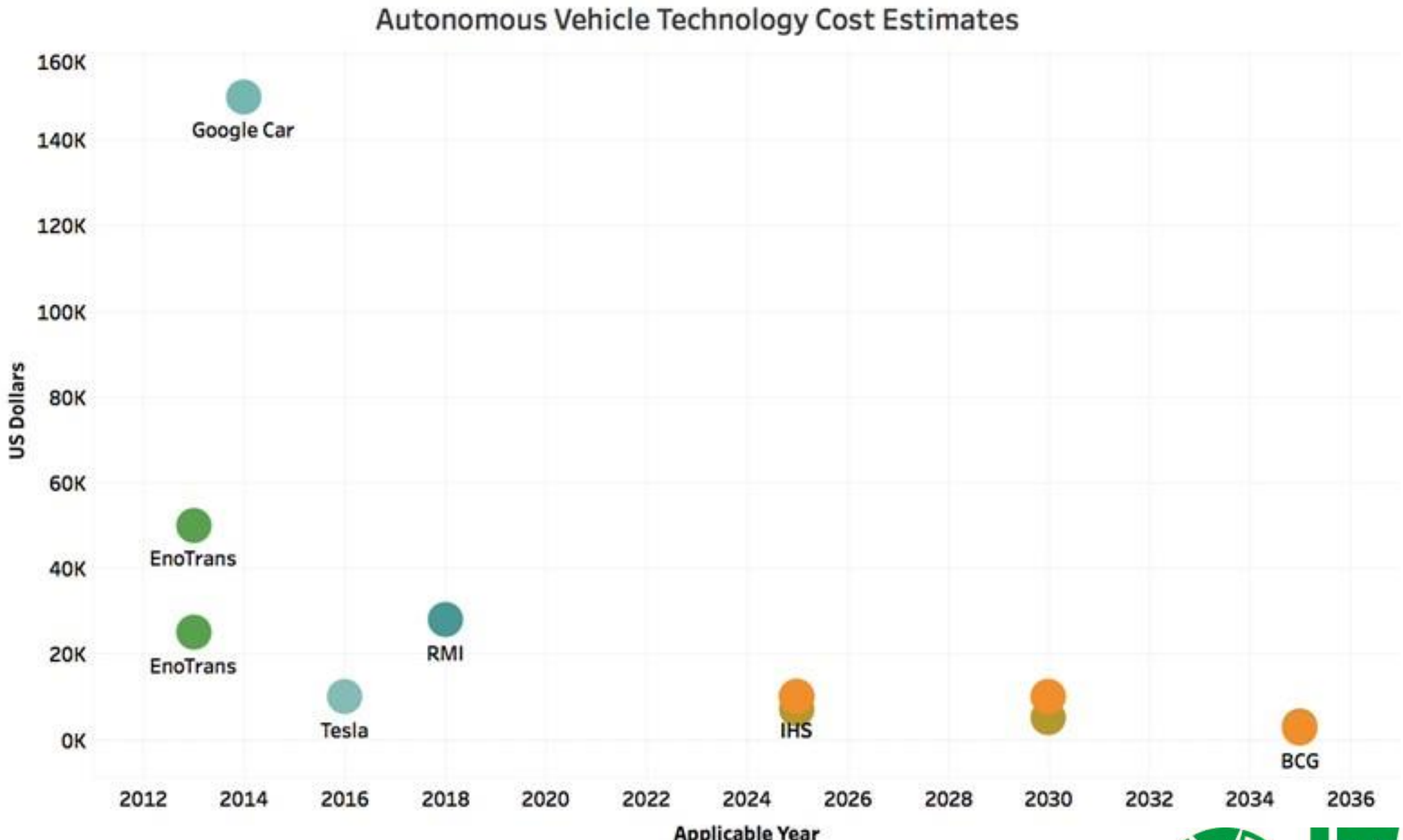
Electrification + Automation: likely, but not definitely, together

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.



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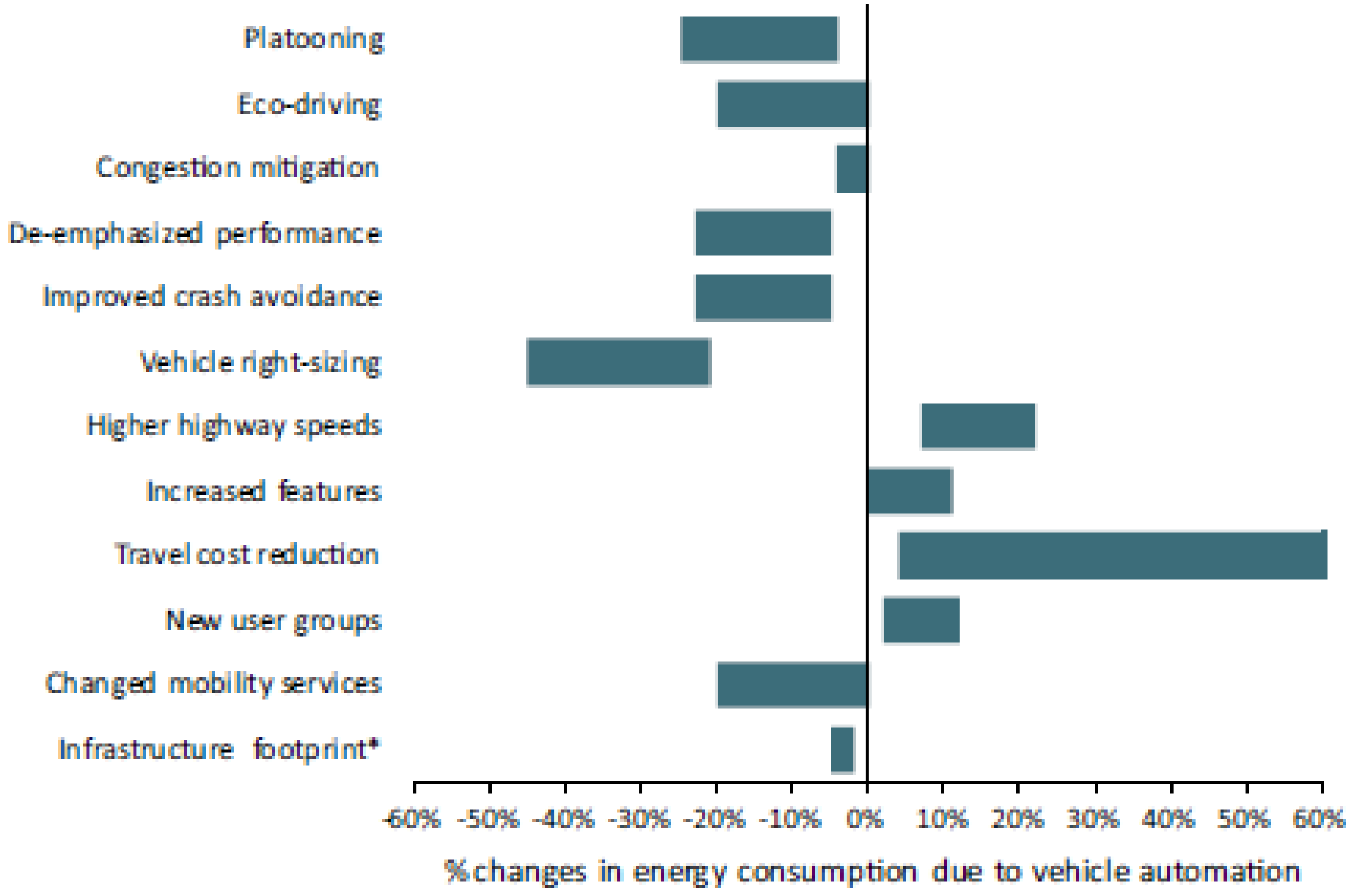
Vehicle Automation Impact on Energy Use: Wide Range of Possible Impacts



Wadud, McKenzie, Leiby 2015

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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**
  - Longer trips?
  - Empty running (zero passengers) of vehicles
- **Electrification goes with automation – does it really?**
  - Can get the job done with upgraded electrical system (such as hybrids)
- **Ride sharing: cost savings v. convenience and risk**
  - and perceived risks, esp. with no driver?
  - at conflict with public transit use?
  - Will lower costs/increased incomes 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

	Use of Automation	Use of Electrification	Use of Shared Vehicles	Urban Planning/ Pricing/TDM Policies	Aligned w 2˚C (or Lo Scenario
BAU, limited intervention	Low	Low	Low	Low	No
2R with high electrification, automation	High	High	Low	Low	Maybe
3R with high shared mobility, public transport, walking and cycling	High	High	High	High	Yes

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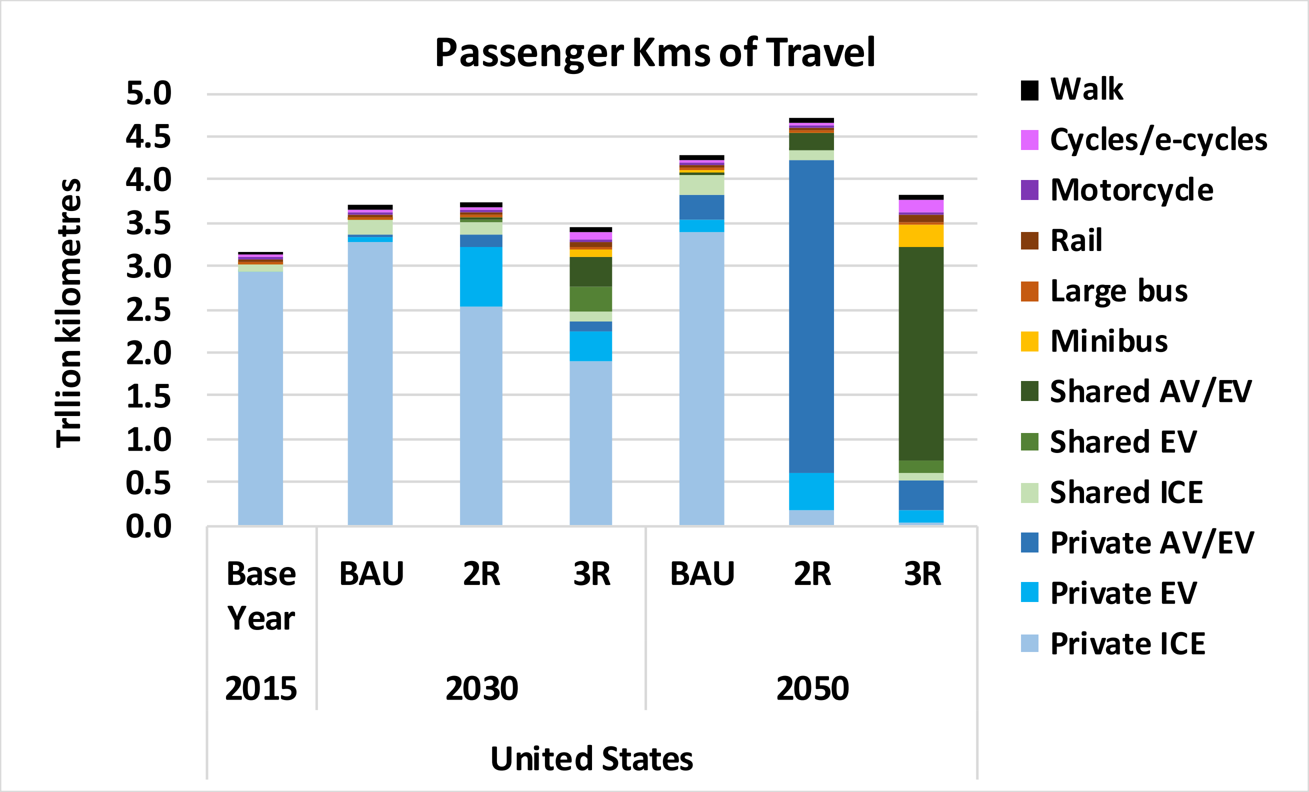
Passenger kilometers of travel by scenario/mode USA

- Automated vehicle travel not significant by 2030 in any scenario, but dominates in 2050. Results in much higher travel in 2R
- US remains car dominated to 2050 - increase in travel mode mix in 3R, but mostly due to TNCs. Also significant minibus travel. Non-car travel reaches 18% in 3R



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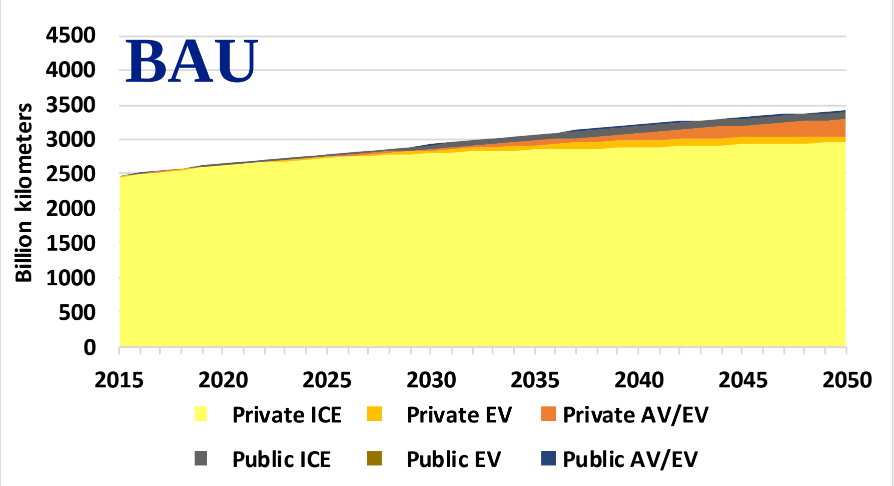
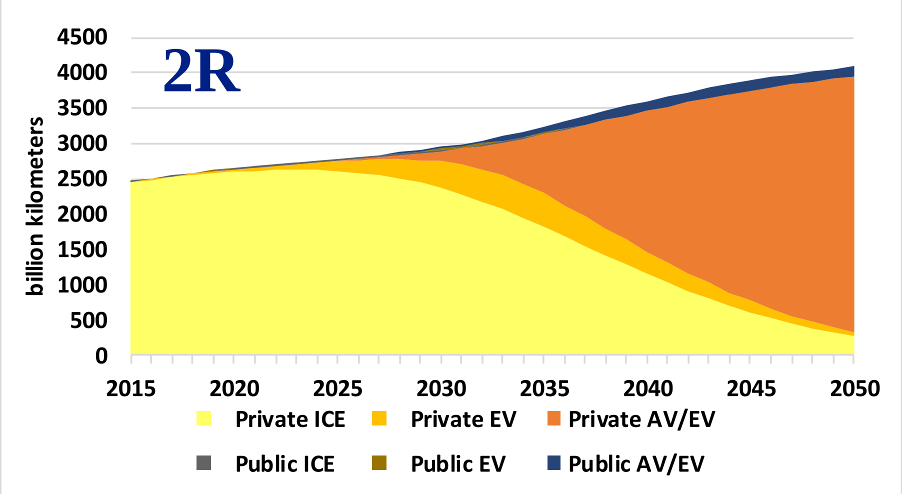
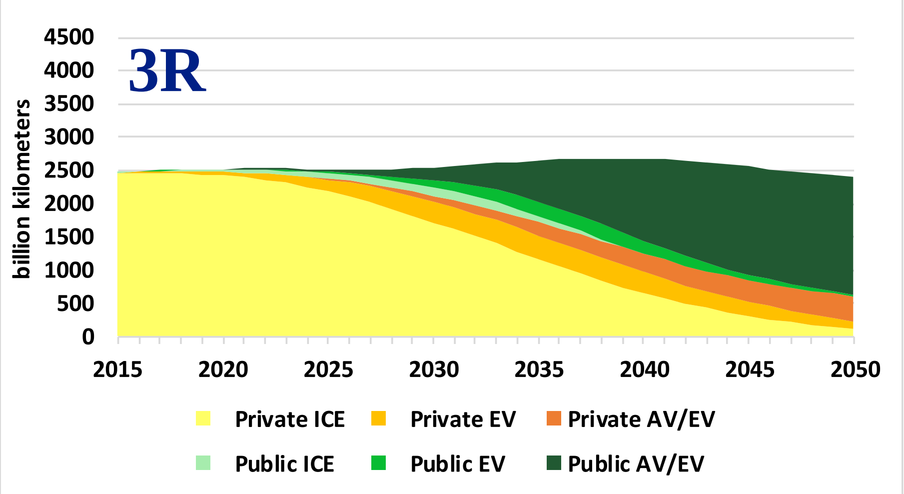
US LDV travel (VKm) by scenario

- 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







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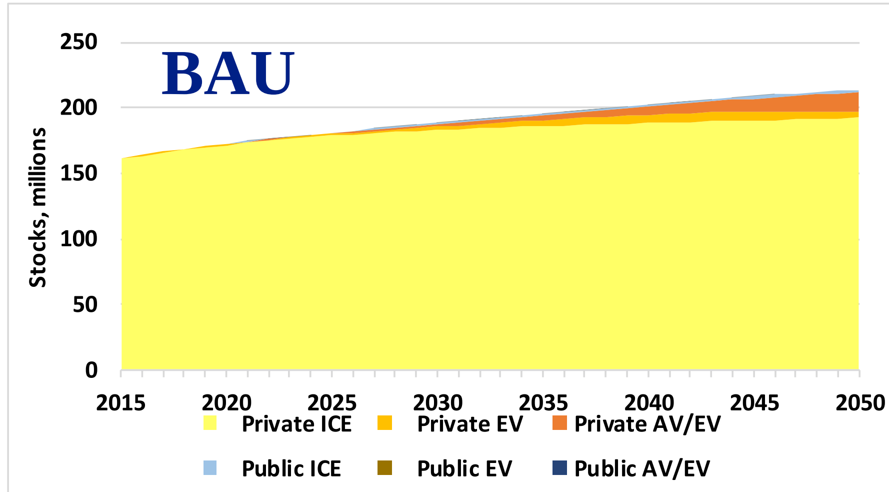
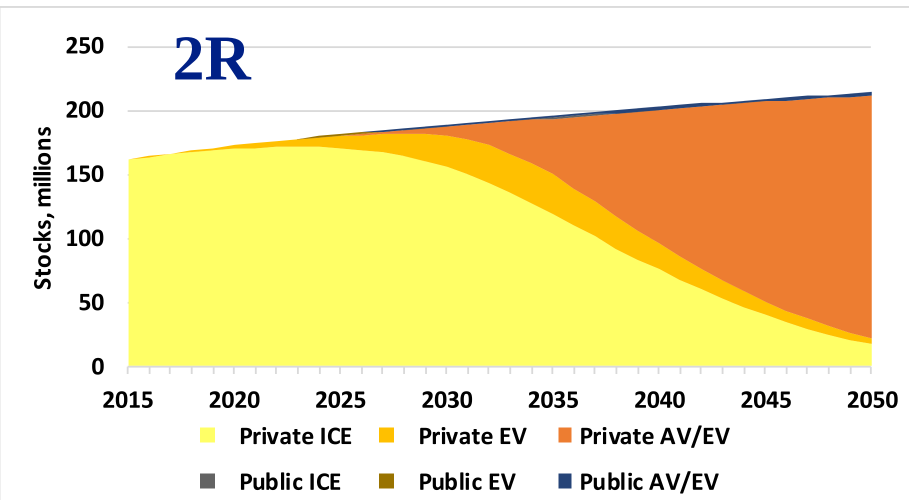
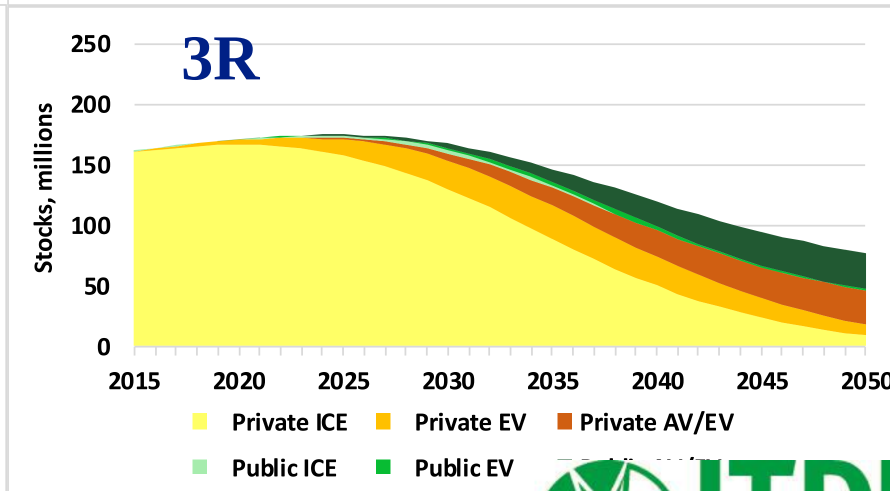
US LDV stock evolution by scenario

- 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







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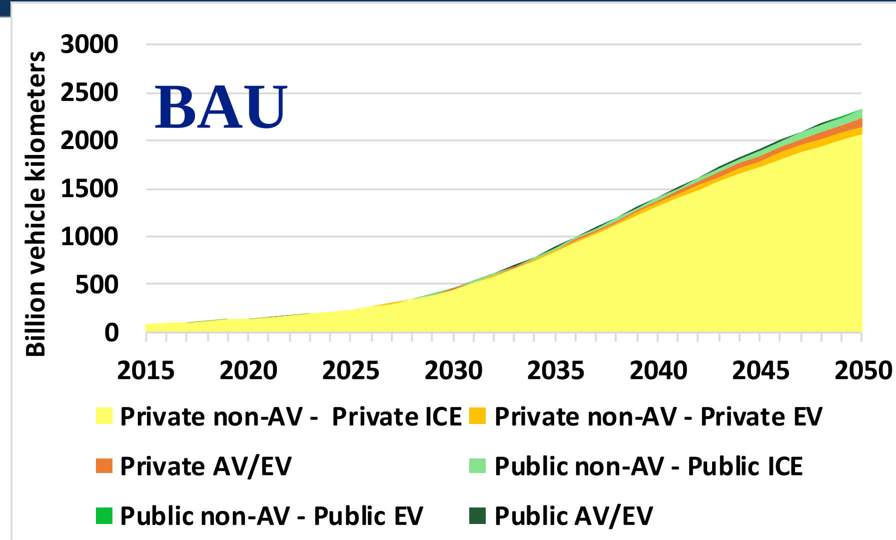
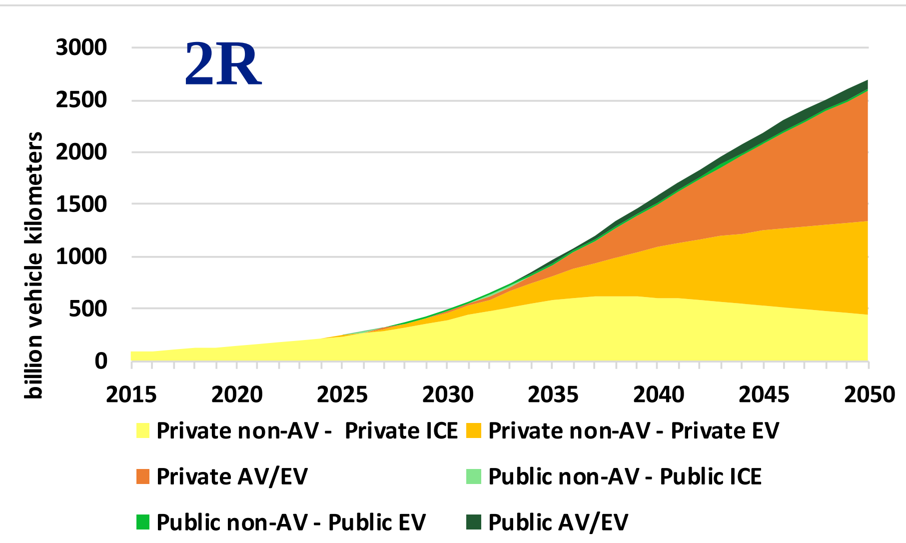
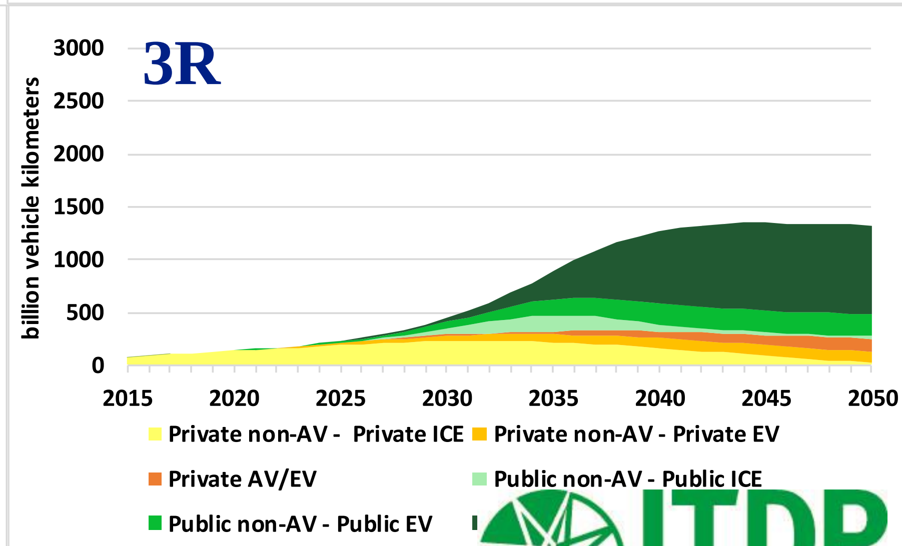
India LDV travel (VKm) by scenario

- 2R vehicle travel rises by a factor of nearly 10 in BAU and 2R
- 3R vehicle travel rises much more slowly then levels off as shared mobility kicks in over time







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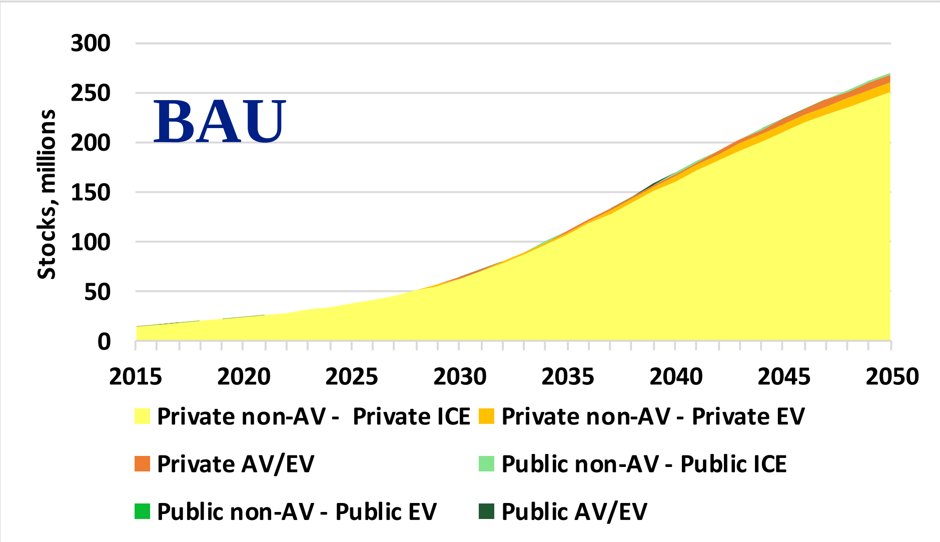
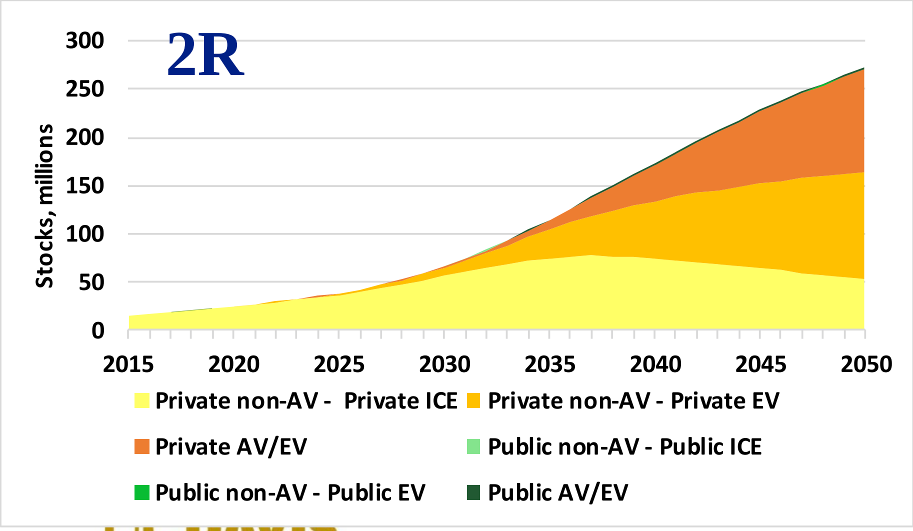
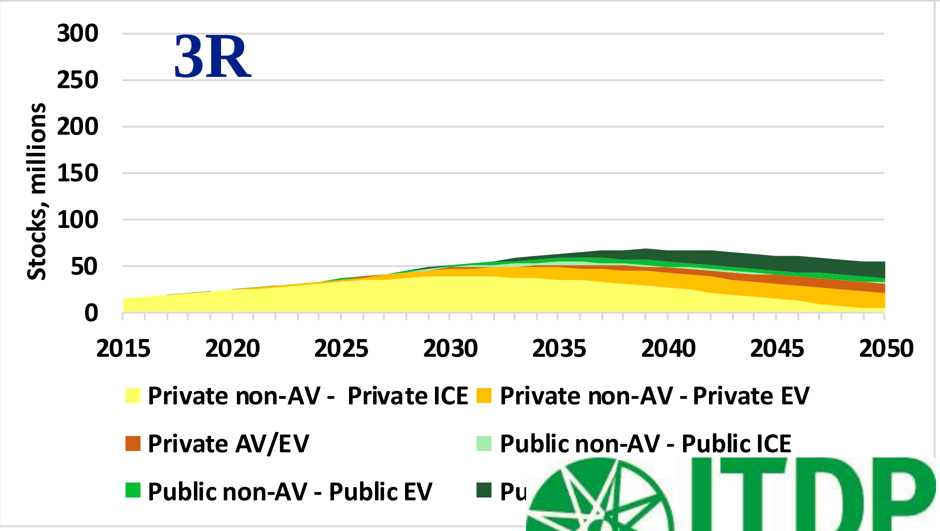
India LDV stock evolution by scenario

- 2R stocks a mix of electric and autonomous vehicles by 2050
- 3R stocks never grow to anywhere near BAU/2R levels







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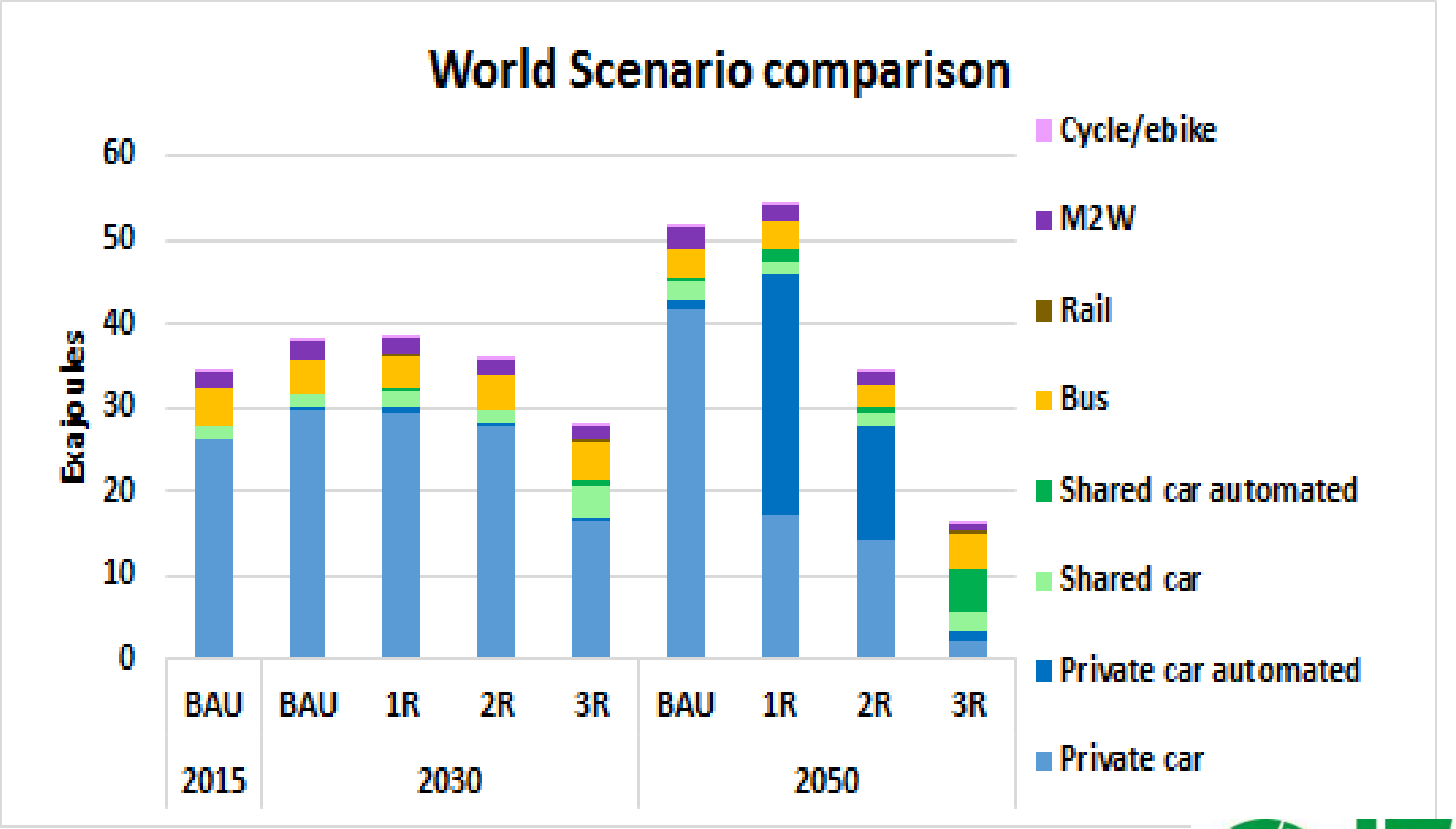
Energy use by scenario, mode

- Far lower energy use in 3R due to low LDV mode shares



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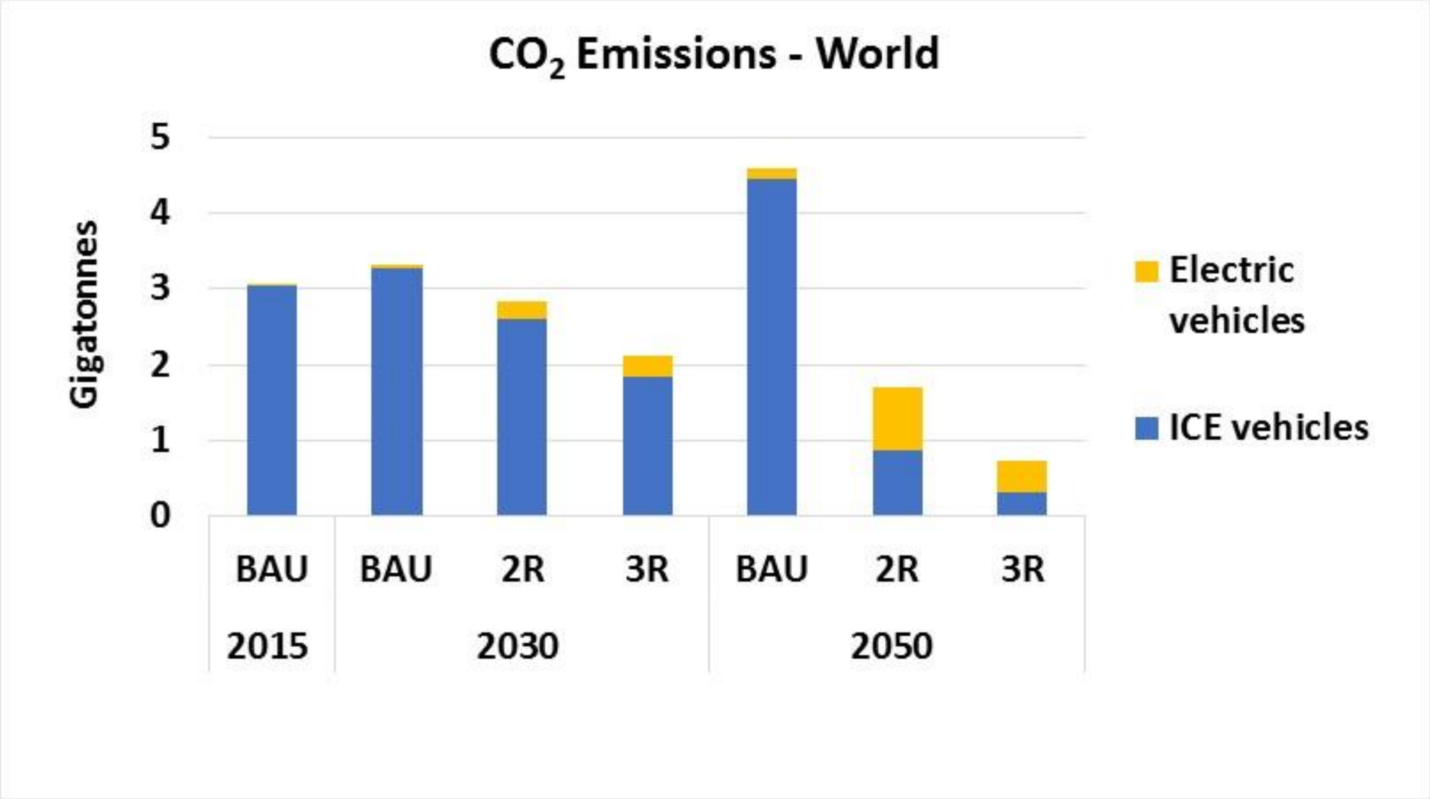
Urban passenger transport CO2 by scenario, vehicle type, world

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

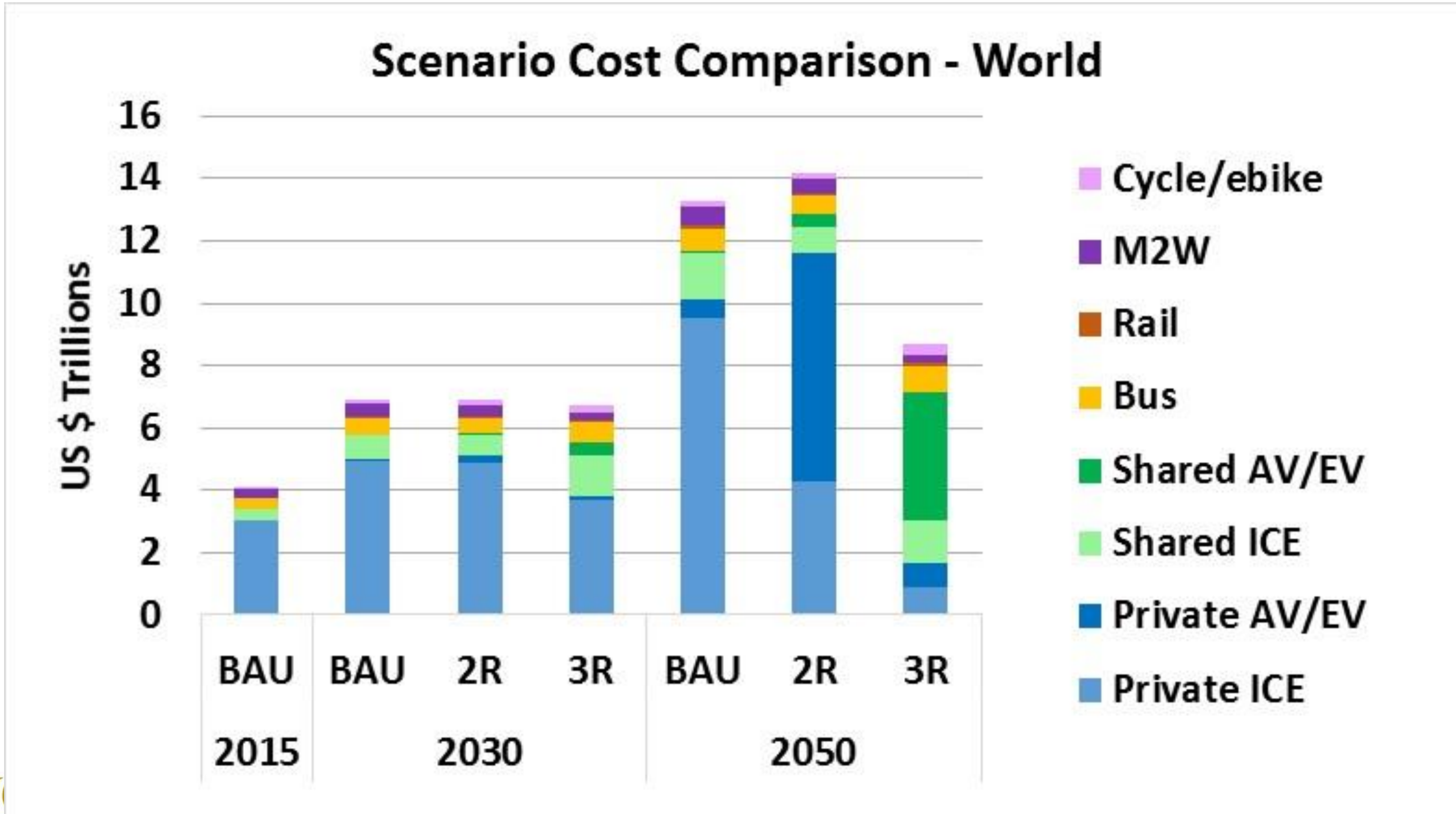
	2050	2015-2050 cumulative
2R v BAU	**82%**	**37%**
3R v BAU	**93%**	**53%**

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



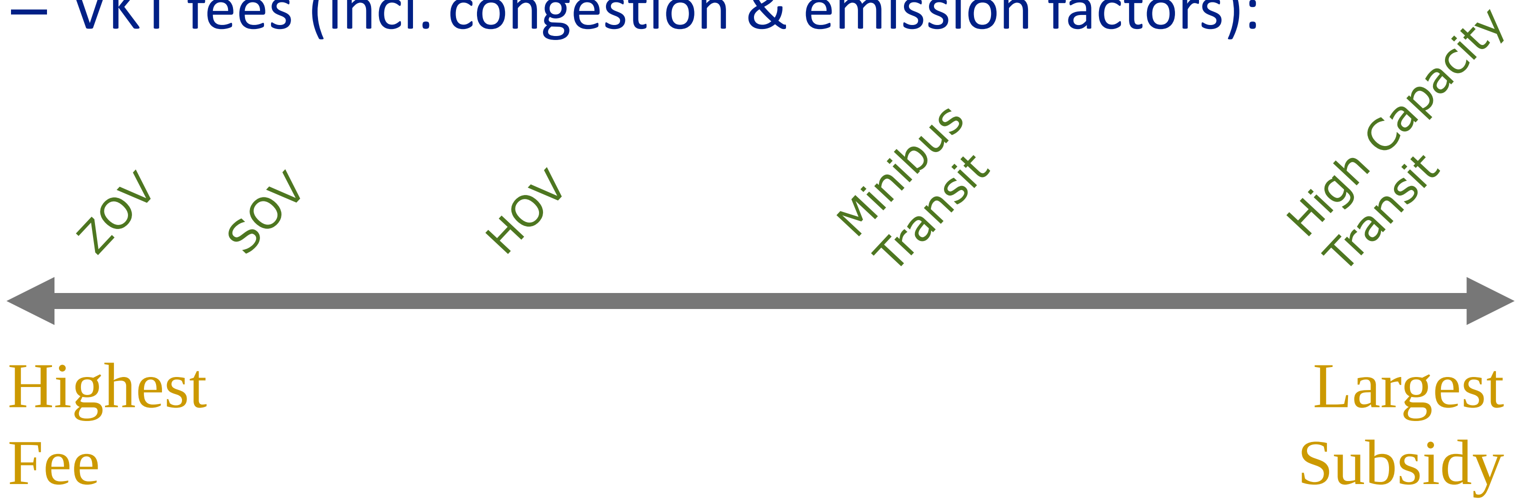
Costs start to deviate across scenario after 2030, 3R 40% cheaper in 2050

- 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):



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