



Sustainable Transportation Energy Pathways (STEPS)

Costs and Travel Choices in a 3R World

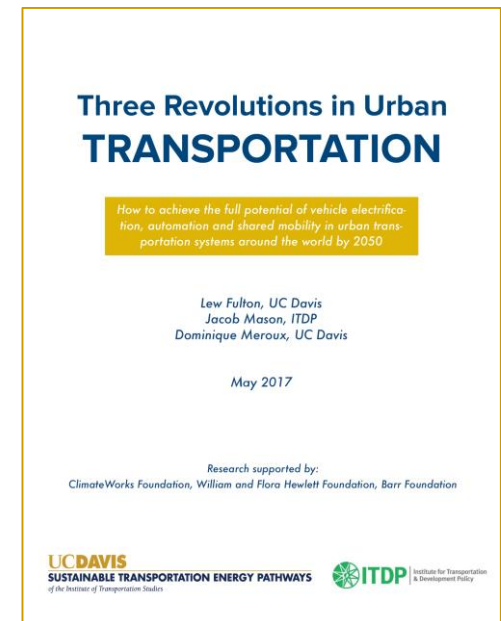
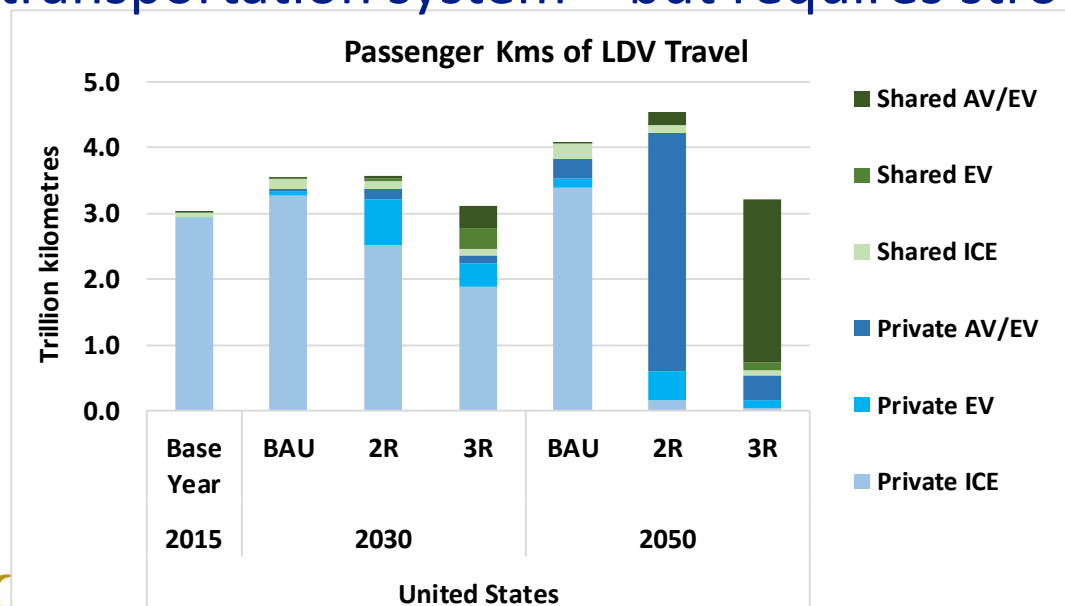
*IEA Modeling Disruptions in
Mobility Workshop*

14 June 2018, 2018

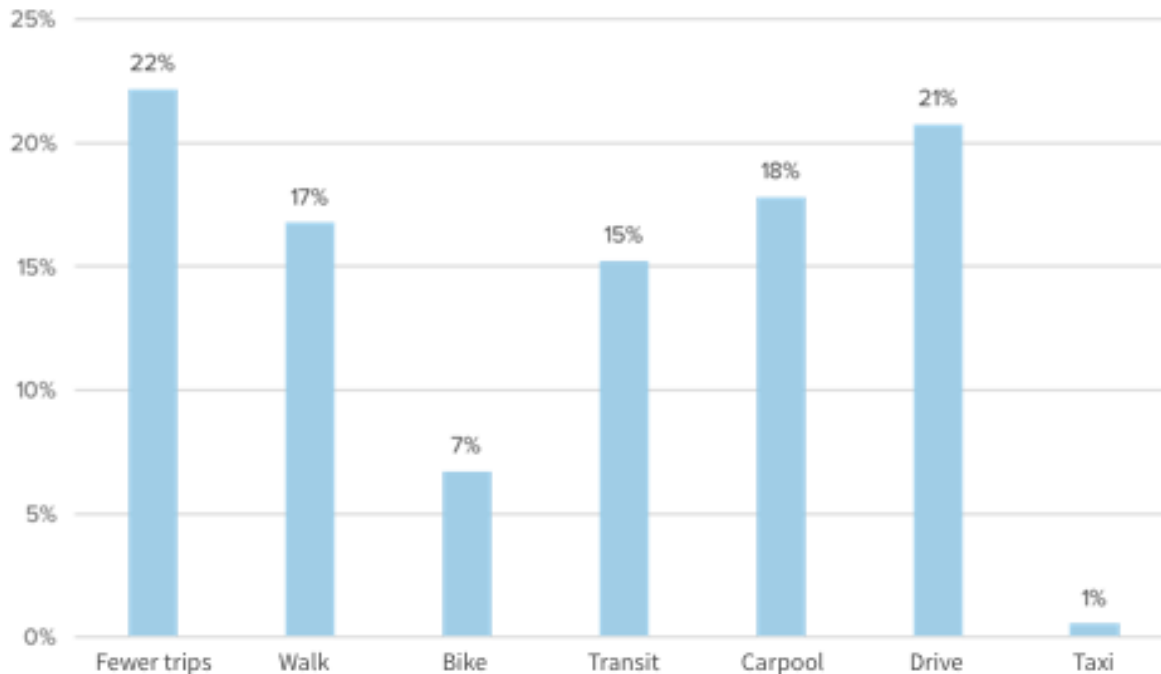
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2017 STEPS RESEARCH INSIGHTS: Three Revolutions in Urban Transportation (Fulton, Mason, Meroux)

- Automation without electrification and shared mobility saves little energy or CO2
- Automation and electrification can cut CO2 but may still increase traffic
- 3 Revolutions, including more shared trips, active travel, transit use can save the most CO2 and would be the least expensive transportation system – but requires strong policies to achieve.



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).

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):



The wide range of costs related to mobility choices

Out-of-pocket Costs

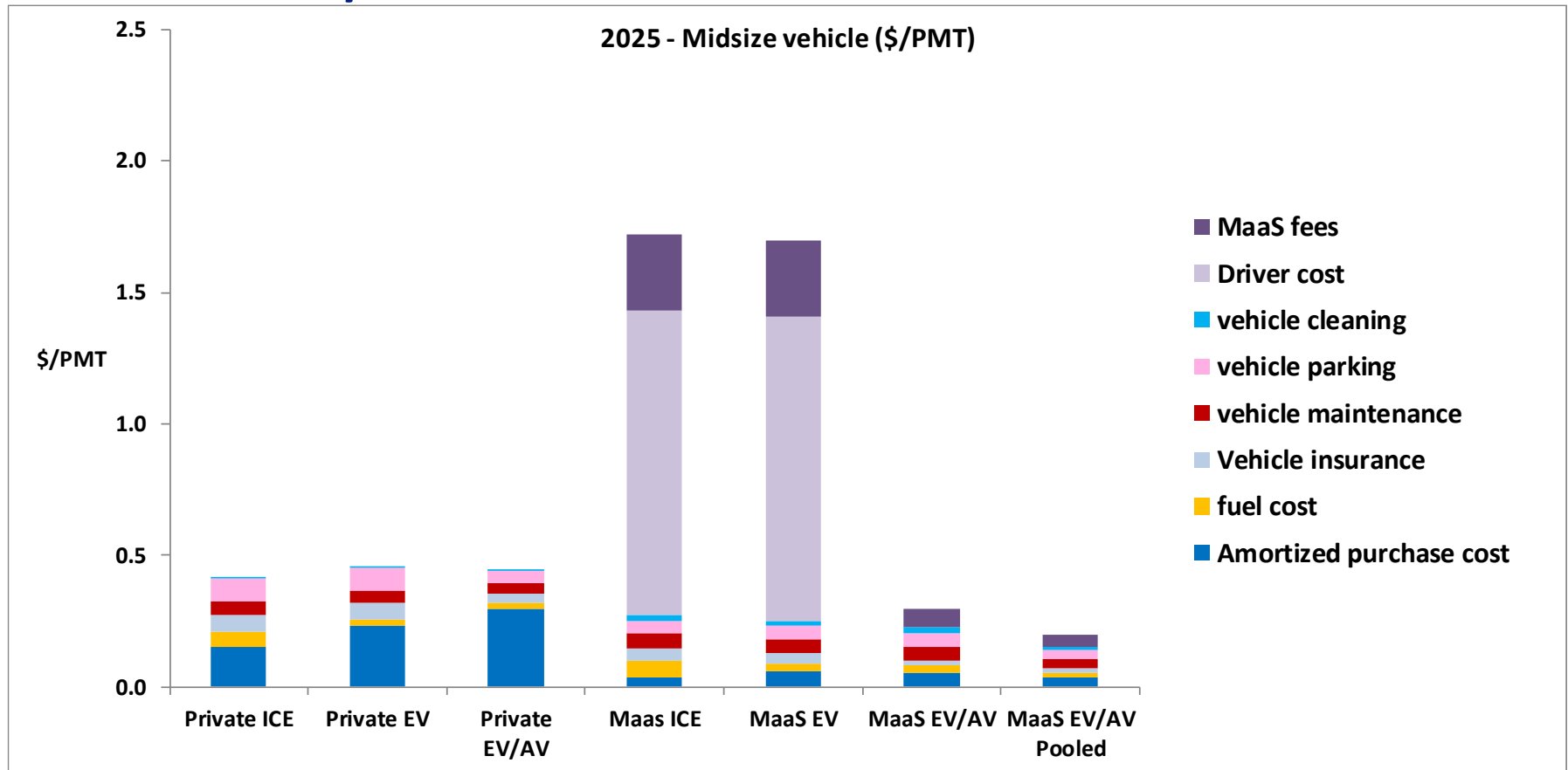
- Vehicle purchase
- Vehicle maintenance
- Fuel
- Insurance
- Cleaning
- Parking
- Driver
- MaaS fees
- Tolls
- Registration-related fees

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)
- Perceived Environmental Cost

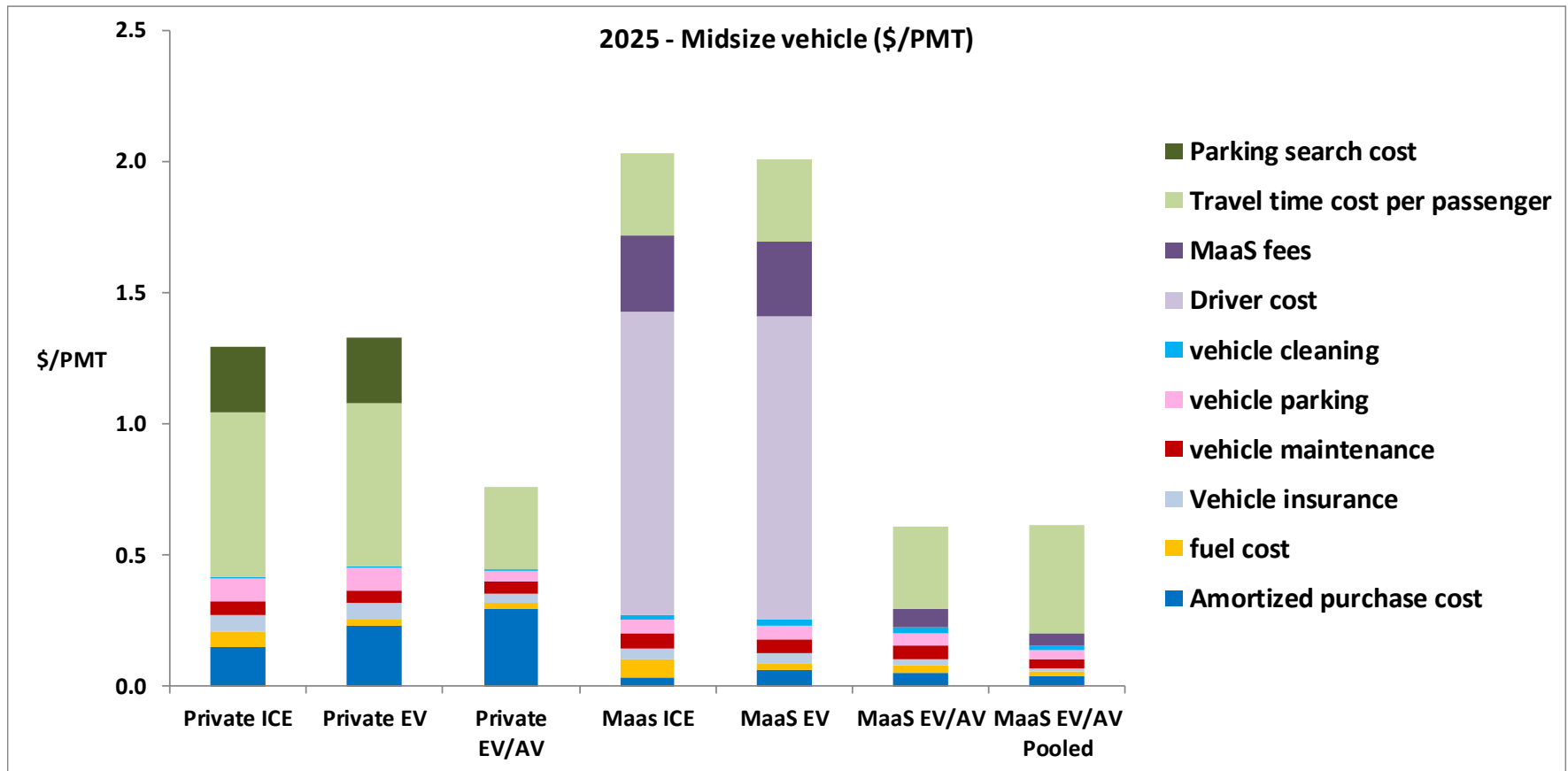
Out-of-pocket costs: Comparison of modes

- Driven TNC vehicles are premium service, automation makes these competitive***



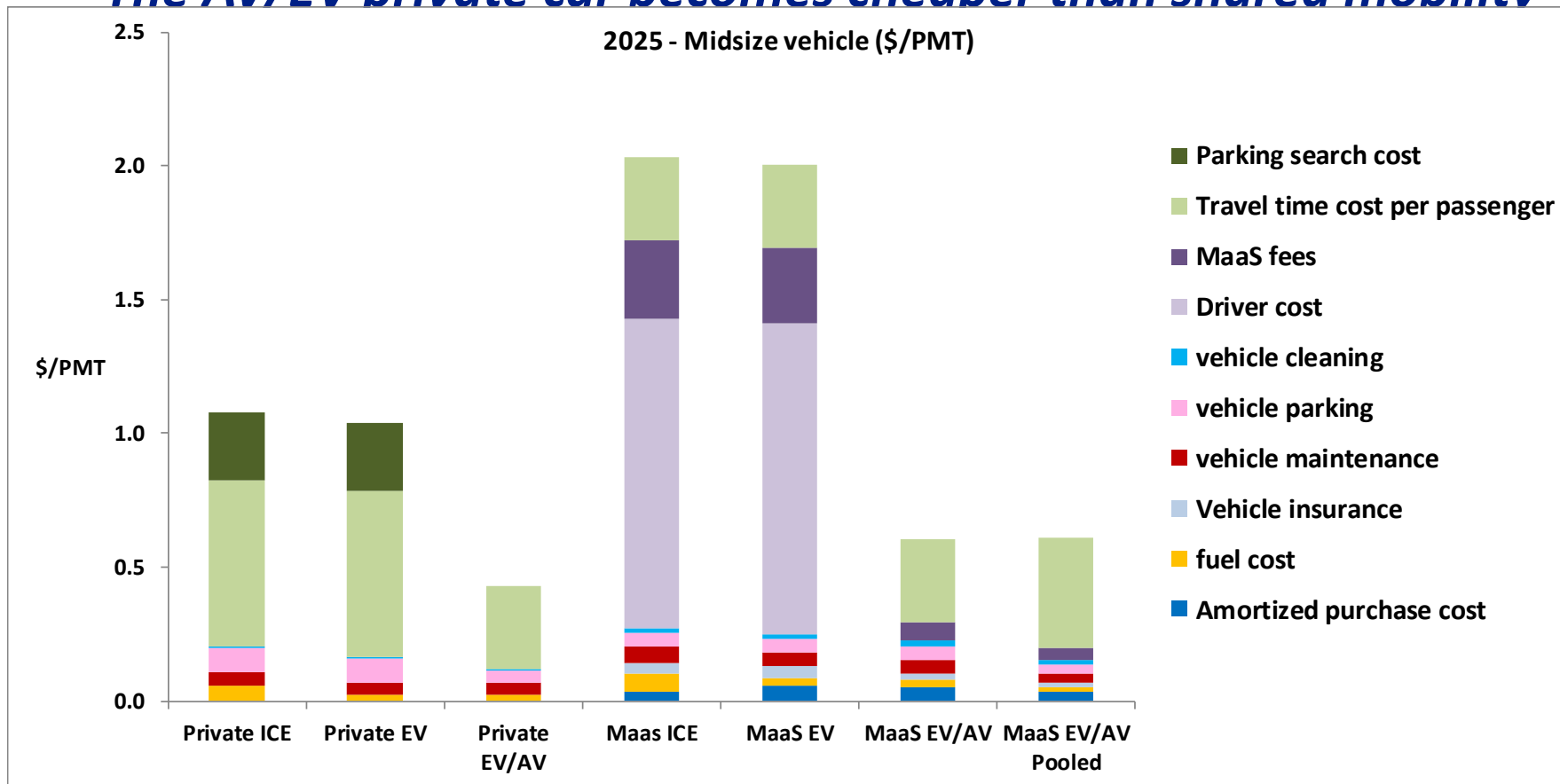
Added a value of time for driving, travelling, parking

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



Included only variable costs (daily decision)

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



Costs of Mobility...

- Still trying to get a handle on monetary costs of different modes
 - Wide range of fixed and variable costs
 - ICE vs electric and automated vehicles
 - Differences by trip type and location
- But at the same time, we have reason to believe that non-monetary costs are as important or potentially more important.
 - Even harder to quantify
 - But let's try

Considering these costs by when, and how often, paid

	Separate from trip	Once per trip	Lumpy	Roughly per-mile
Monetary	<ul style="list-style-type: none"> • Insurance • Registration and other annual or monthly fees 	<ul style="list-style-type: none"> • Parking cost • TNC "first mile" fee 	<ul style="list-style-type: none"> • Tolls • Vehicle cleaning 	<ul style="list-style-type: none"> • Depreciation • Maintenance • Fuel cost • TNC per-mile fees • Per-mile road user fees (taxes)
Non-monetary	<ul style="list-style-type: none"> • Maintenance and inspections events (time, loss of vehicle use) • Car ownership pride and other hedonic ownership benefits • Per-vehicle environmental impacts (vehicle production, disposal) 	<ul style="list-style-type: none"> • Time spent parking and searching for parking • Walking to/from vehicle to "door" • Loading/unloading vehicle 	<ul style="list-style-type: none"> • Refueling/cleaning time • Recharging search, recharging time, anxiety • Keeping items in vehicle 	<ul style="list-style-type: none"> • Travel time • Driving stress/enjoyment • Ride sharing (pooling) stress/enjoyment • Other in-ride hedonic factors • In-ride productivity • Per-mile environmental impacts (CO2, air pollutants)

Important when in own vehicle (**positive/negative**)

	Separate from trip	Once per trip	Lumpy	Roughly per-mile
Monetary	<ul style="list-style-type: none"> • Insurance • Registration and other annual or monthly fees 	<ul style="list-style-type: none"> • Parking cost • TNC "first mile" fee 	<ul style="list-style-type: none"> • Tolls • Vehicle cleaning 	<ul style="list-style-type: none"> • Depreciation • Maintenance • Fuel cost • TNC per-mile fees • Per-mile road user fees (taxes)
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Important when Ride-hailing (**positive/negative**)

	Separate from trip	Once per trip	Lumpy	Roughly per-mile
Monetary	<ul style="list-style-type: none"> • Insurance • Registration and other annual or monthly fees 	<ul style="list-style-type: none"> • Parking cost • TNC "first mile" fee 	<ul style="list-style-type: none"> • Tolls • Vehicle cleaning 	<ul style="list-style-type: none"> • Depreciation • Maintenance • Fuel cost • TNC per-mile fees • Per-mile road user fees (taxes)
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Cost types where we have poor or no data

	Separate from trip	Once per trip	Lumpy	Roughly per-mile
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Fixed, lumpy and per-mile costs – for those costs we have

- *Many costs are fixed or lumpy*
- *TNC fees and travel time dominate per-mile costs*

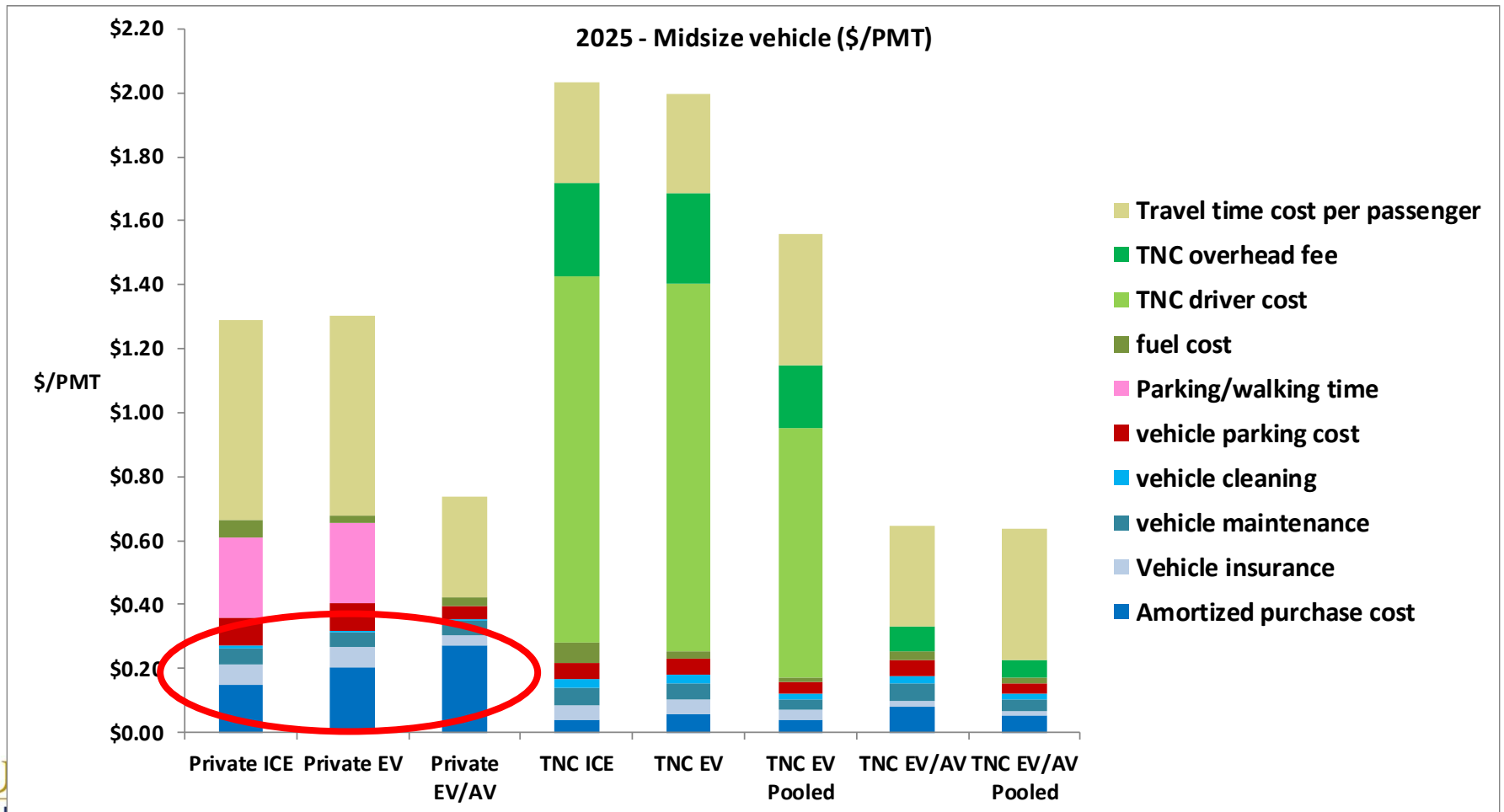
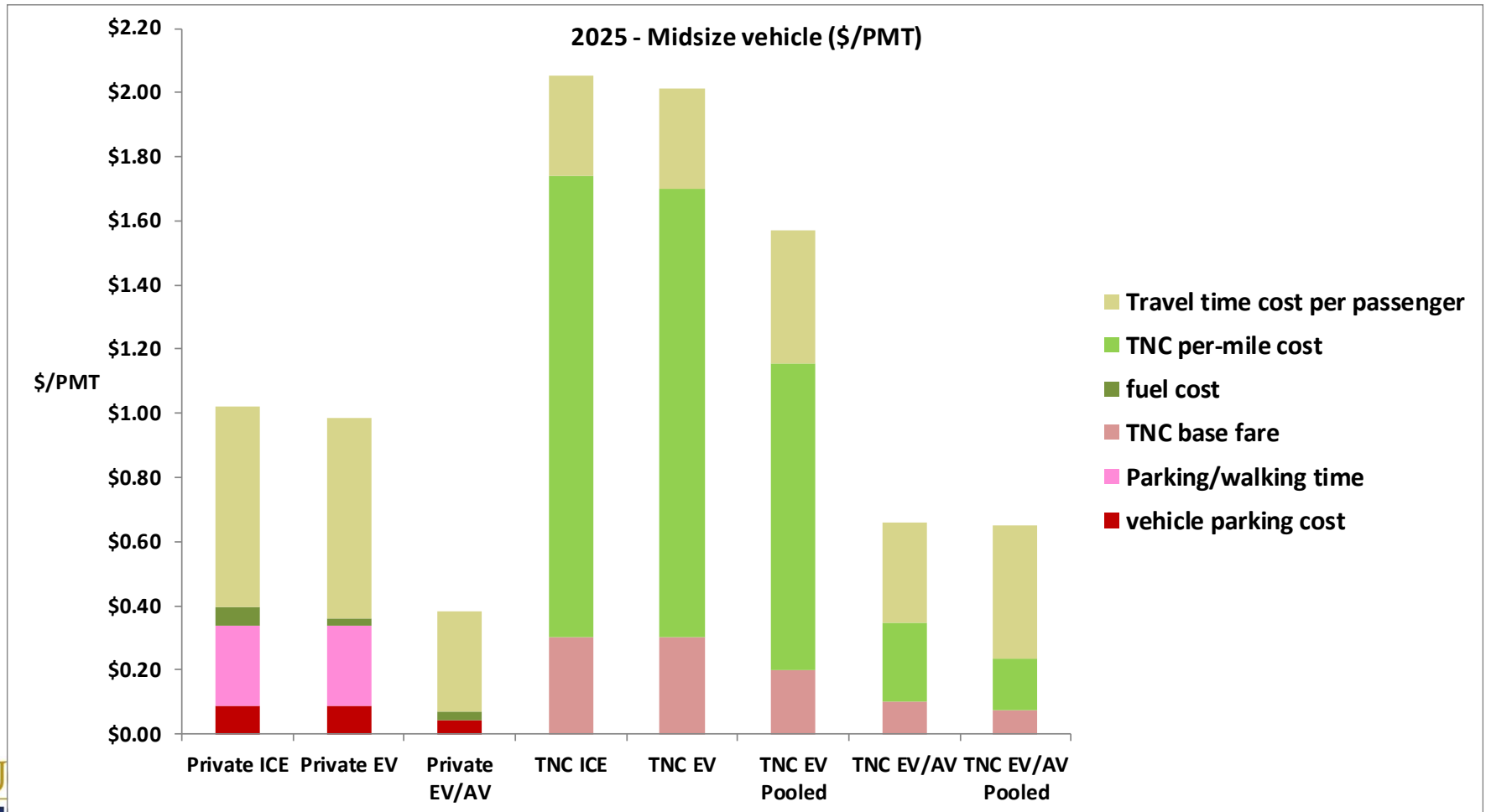


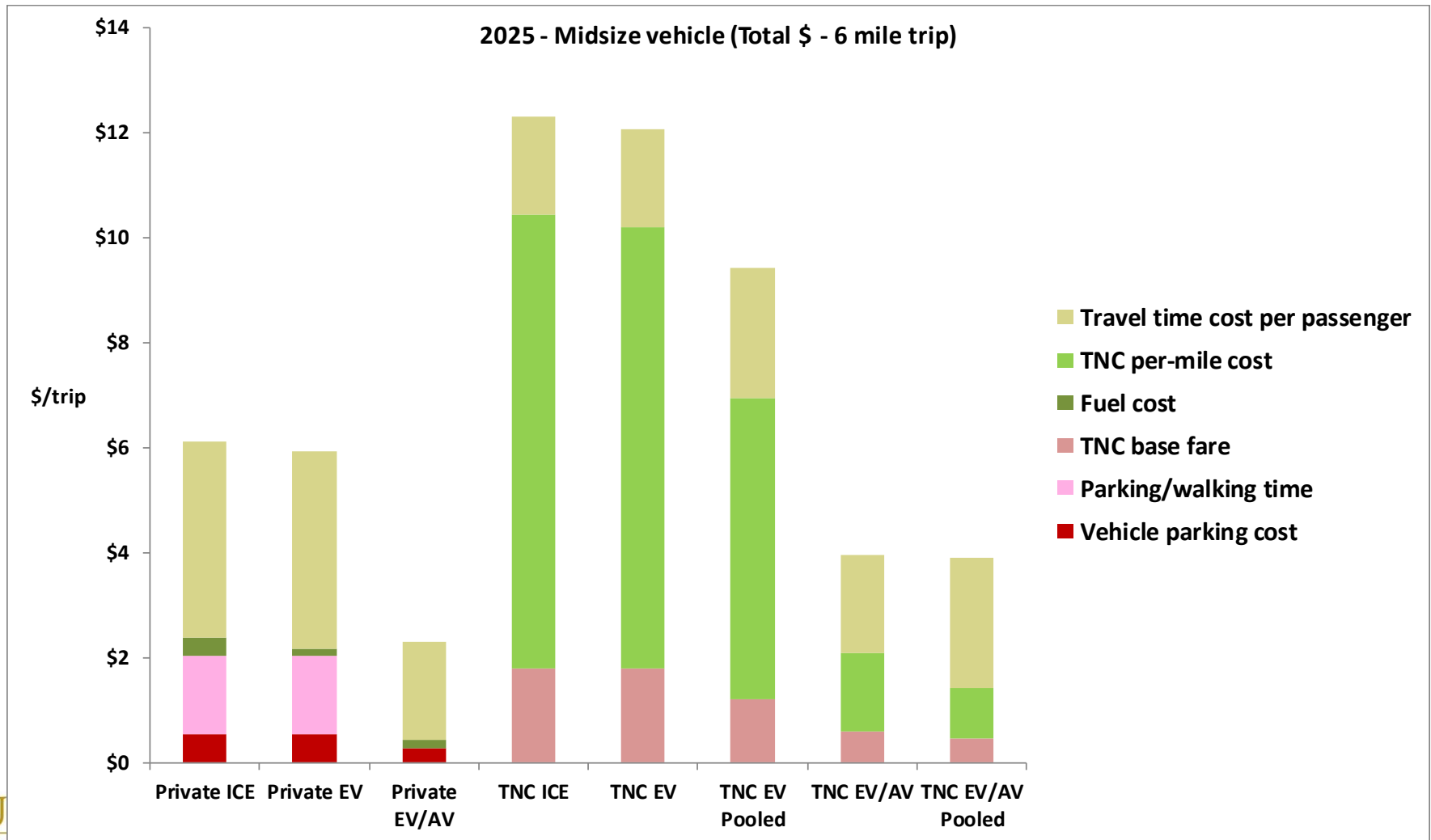
Figure with only the trip fixed and per-mile costs shown

- Private automated vehicle trips starting to look good, especially for shorter trips (this one is 6 miles, 30 mph)**



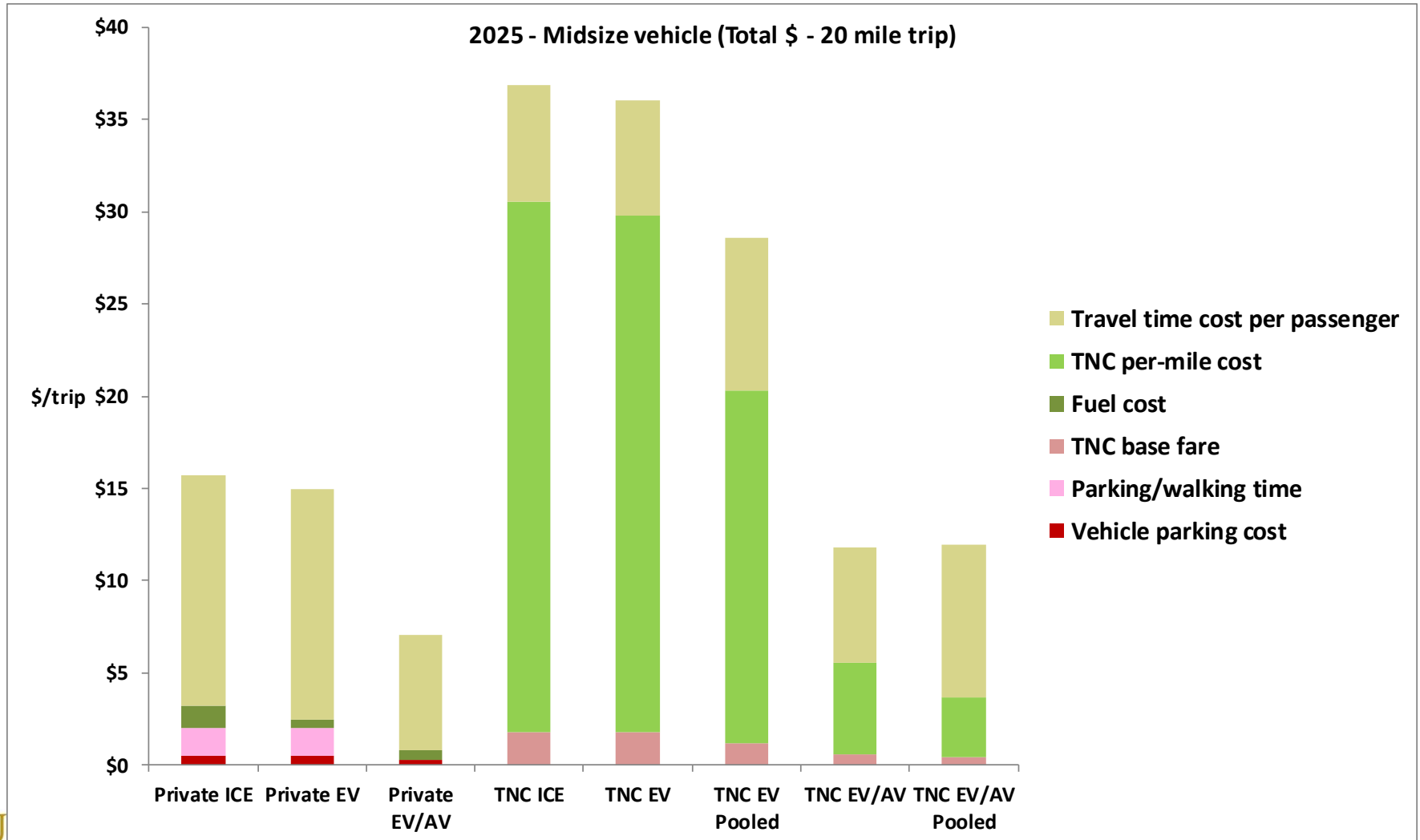
Same scenario, but shown as total costs for a six mile trip

- Costs range from \$2 to \$12 per trip; driverless modes below \$4



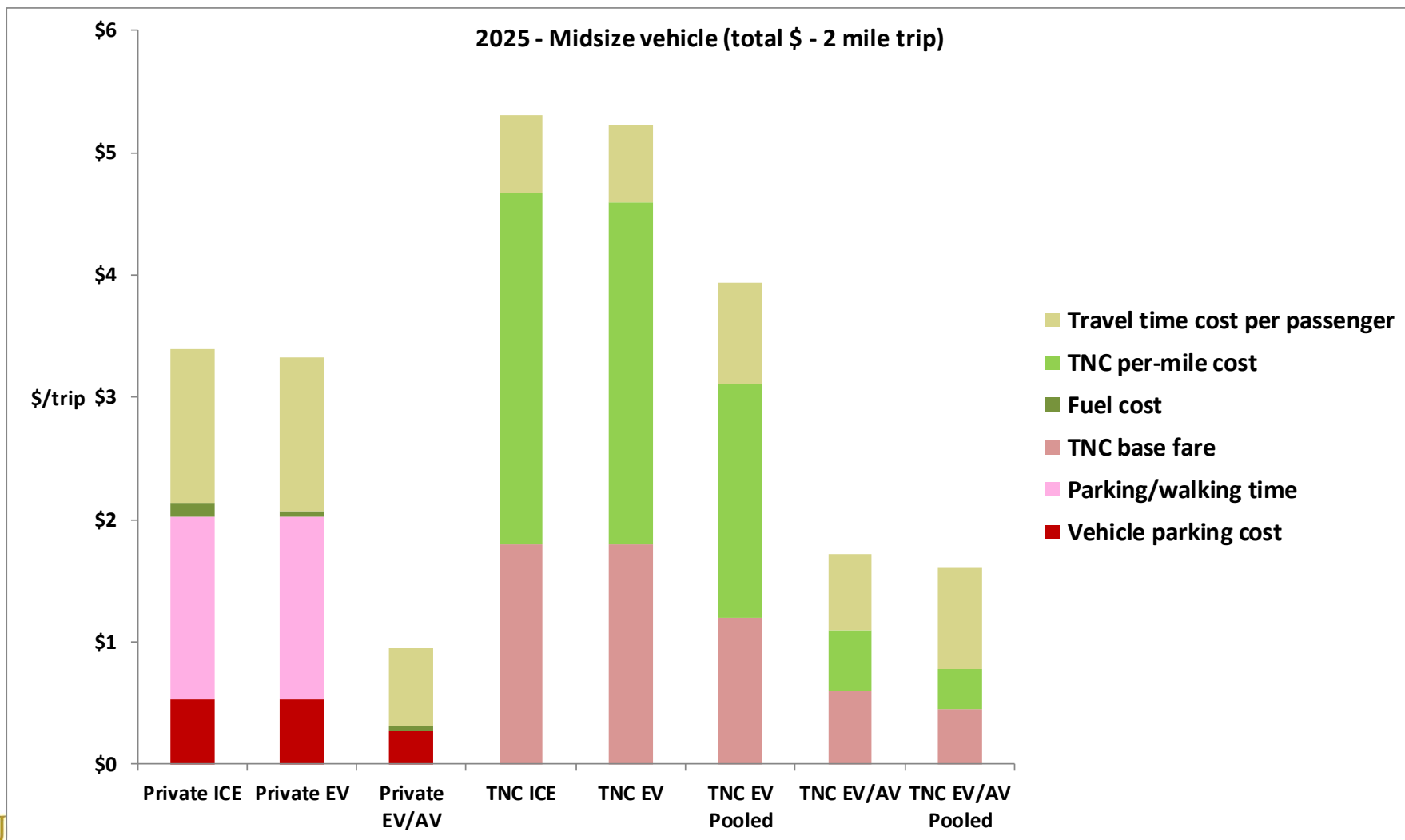
Data converted to per-trip costs for a 20 mile trip

- Fixed costs become less important for longer trips



And for a 2 mile trip

- Fixed costs start to dominate short trips



What about other non-monetary costs?

- We need to do much in-depth survey work, and maybe experiments to judge behavior in different situations
- Some aspects will be difficult to assess until situations change
 - Driverless vehicles:
 - Attitudes about travel, effective time cost penalties
 - Changes in total travel
 - EVs: recharging anxiety in an age of fast charging, abundant charging
 - Shared mobility: attitudes about pooling with no driver

A couple of thought experiments (don't try this at home)

- **Value of being able to store things in the vehicle**
 - If it takes 2 minutes (twice) to load/unload things like car seats and generally get all your stuff in and out of your car every trip, and it's an unwelcome hassle, this might be valued \$15k/hour. That's a \$1 hedonic cost per trip ($4/60 * \$15$) . For a 6 mile trip, that's **\$0.17 per mile**
- **Cost of an uncertain ride**
 - A “certain” ride means there is a car in a known location and you have the keys. There may be a cost to any uncertainty about available commercial rides, as well as time variance.
 - If one expects to ride hail with vehicle arrival in, say, 5 minutes there might be a hedonic cost if it arrives later than this. Each additional minute might cost $1/60 * \$15/\text{hr}$. This cost may also rise per minute, as frustration (or lateness) mounts. A vehicle that is 4 minutes late would incur a \$1 hedonic cost; if it happens (or is expected to happen) every 4th trip, this amounts to an average of about **\$0.04 per mile** for a 6 mile trip

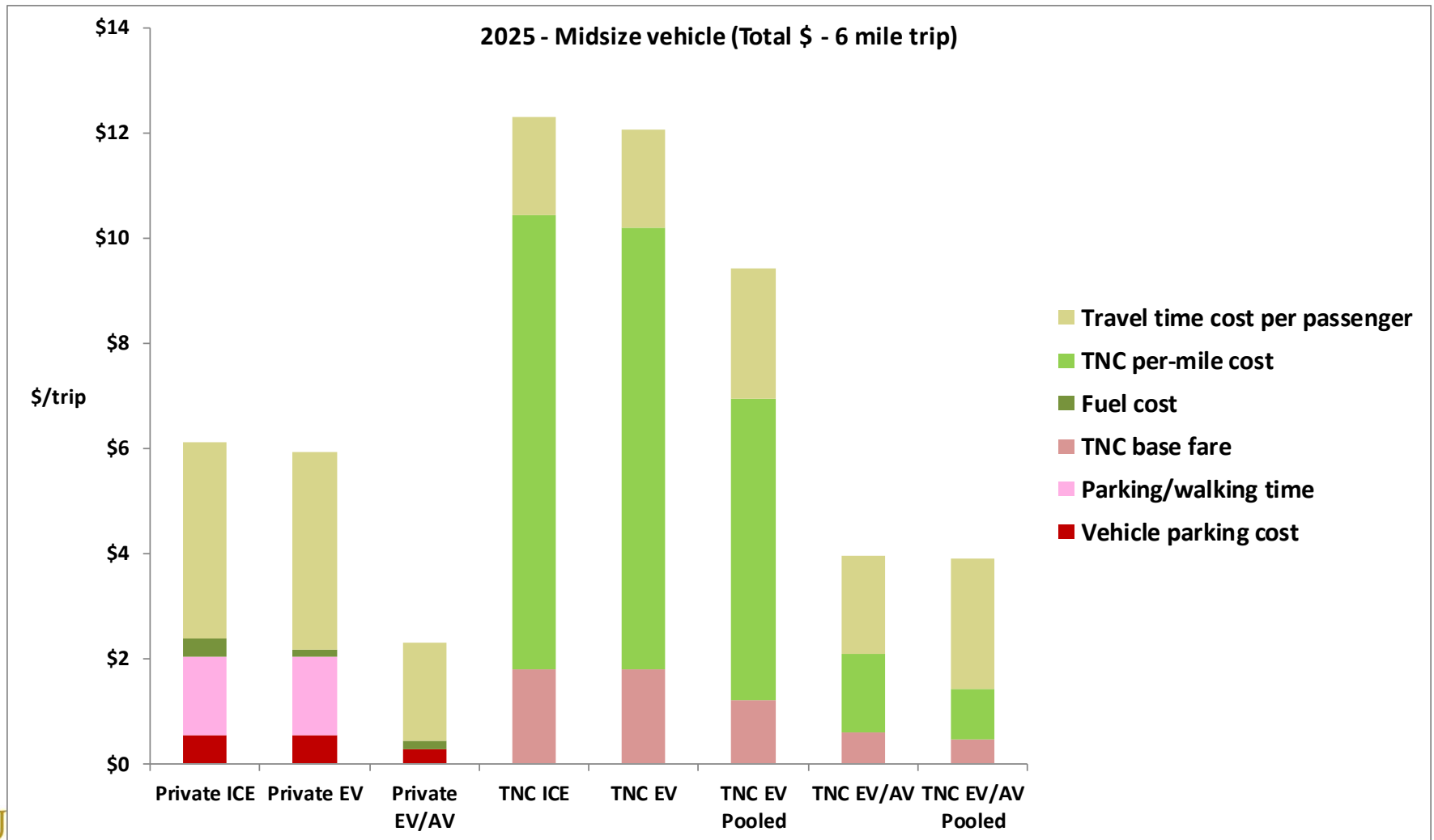
Simple \$15/hour time cost analysis across activities (Example of a 6 mile, 12 minute trip, 30 miles per hour)

- A few activities stand out as possibly “expensive”

Activity	Time (mins)	\$ / hour	\$ / event	Events / trip	\$ / trip	\$ / mile	Notes
Loading / unloading	4	15	0.50	0.50	1.00	0.08	2 minutes twice per trip
Uncertain ride	5	15	1.25	0.25	0.31	0.05	5 minutes wait time, 1/4 of trips
Maintenance events	30	15	7.50	0.01	0.08	0.01	20 minutes for dropoff, 10 for pickup
Parking / searching	5	15	1.25	1.00	1.25	0.21	5 mins for parking search and parking, once per trip
Walking to / from car	3	15	0.75	2.00	1.50	0.25	3 minutes twice per trip (short walks, one could be driveway)
Refueling / cleaning time	5	15	1.25	0.10	0.13	0.02	Assumes one refueling per 10 trips
Public recharging search time, anxiety	5	20	1.67	0.20	0.33	0.06	Search time at higher per-hour cost
Driving	12	15	3.00	1.00	3.00	0.50	General travel time cost
Driving stress	12	5	1.00	0.50	1.00	0.08	Additional time cost due to stressful driving

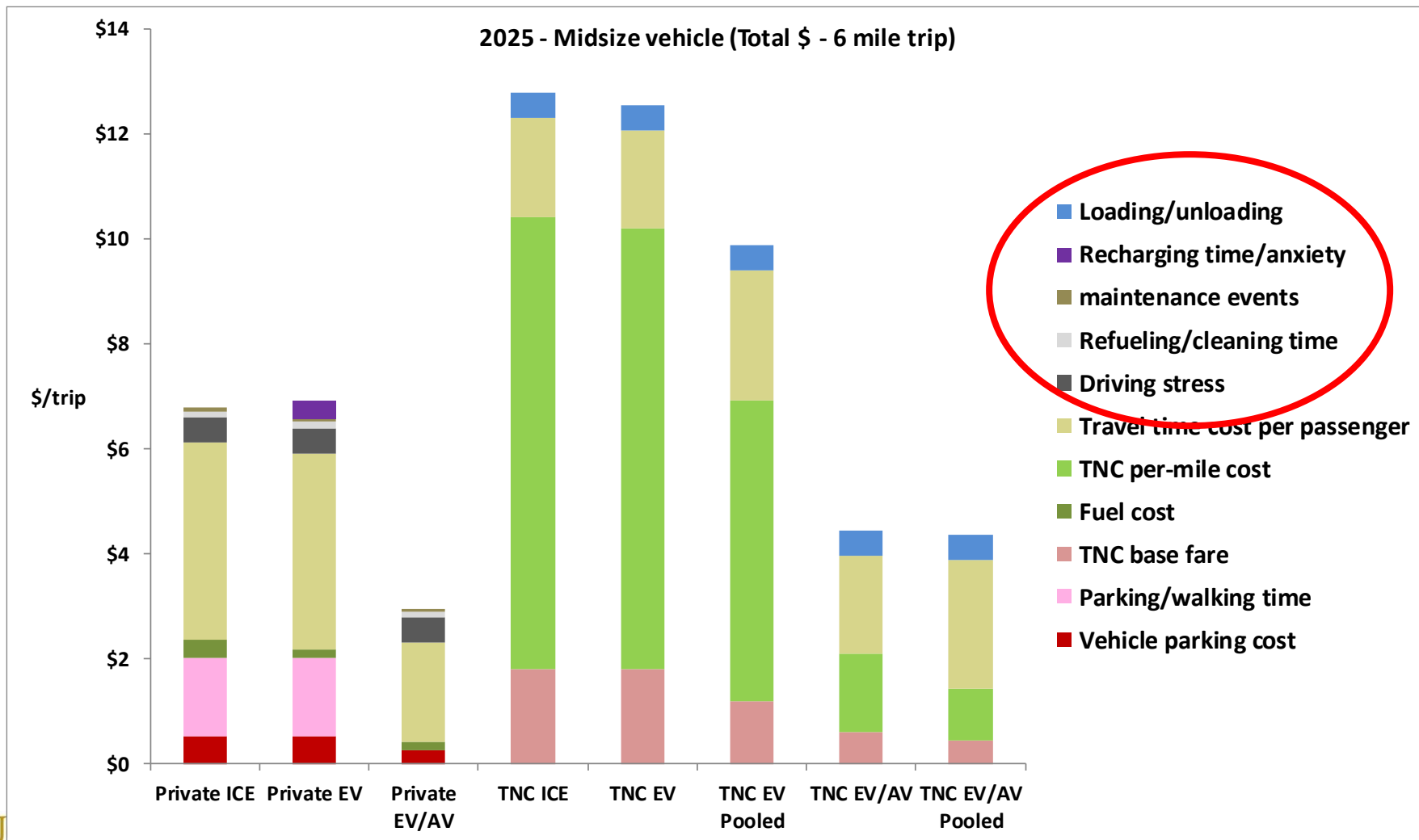
Back to our 6 mile trip

- Costs range from \$2 to \$12 per trip; driverless modes below \$4



6 mile trip, now with the additional categories

- The new categories, together, don't change things much



Conclusions

- Non-market cost factors are many, varied and difficult to measure
- My very simplistic first cut suggests that some may be relatively unimportant, *on average*
 - May still be critical in certain situations, or for certain people
- More research is needed, such as focus groups and surveys

Thank you

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