

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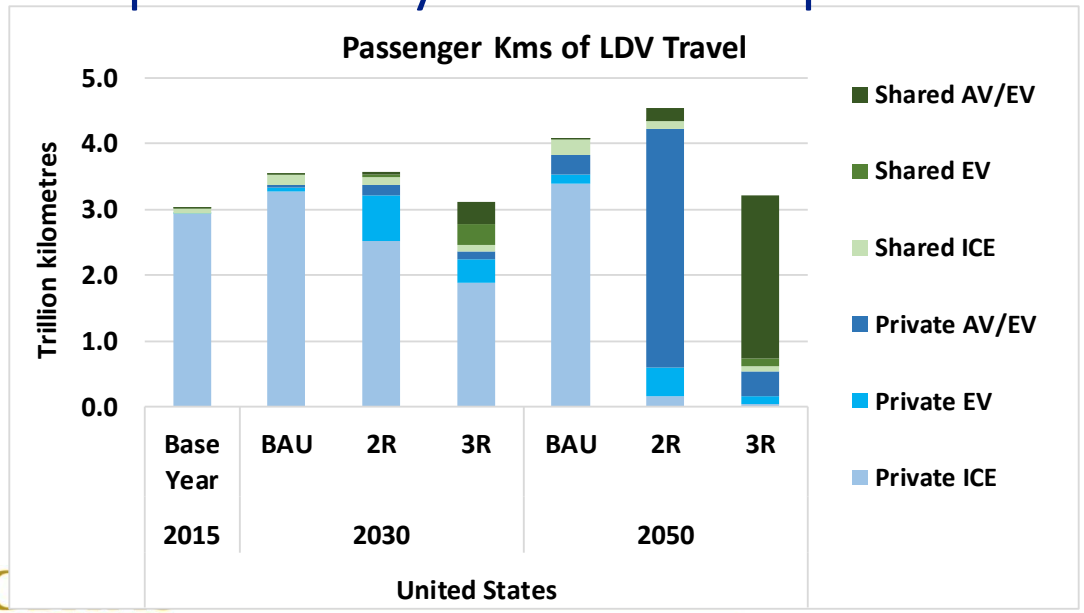
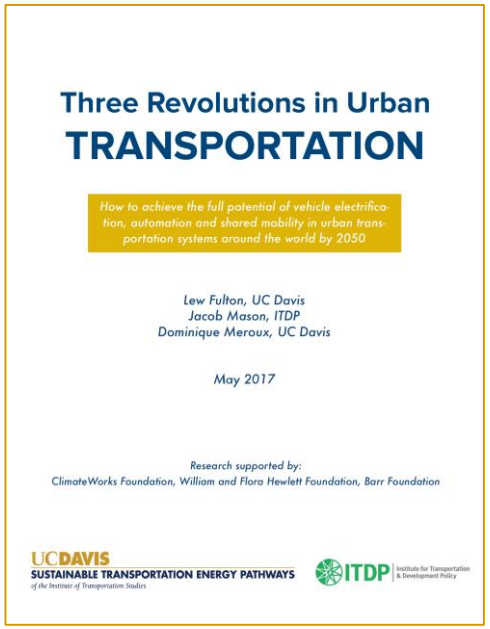
2017 STEPS RESEARCH INSIGHTS: **Three Revolutions in Urban Transportation (Fulton, Mason, Meroux)**

- 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.





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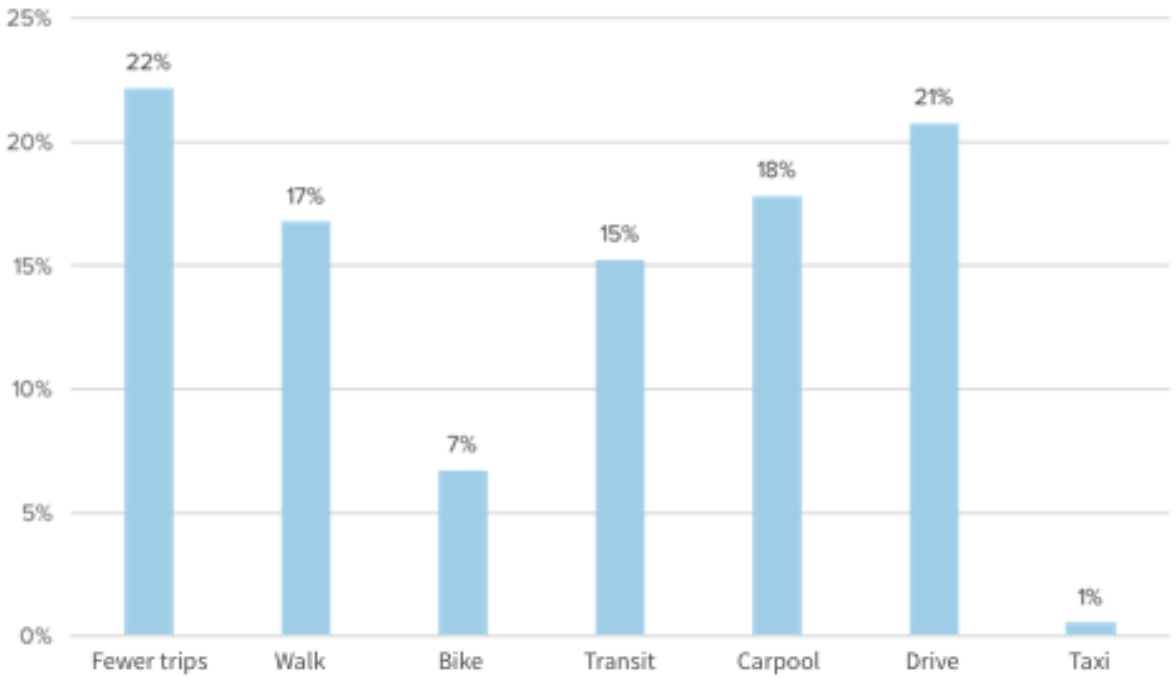
SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS

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

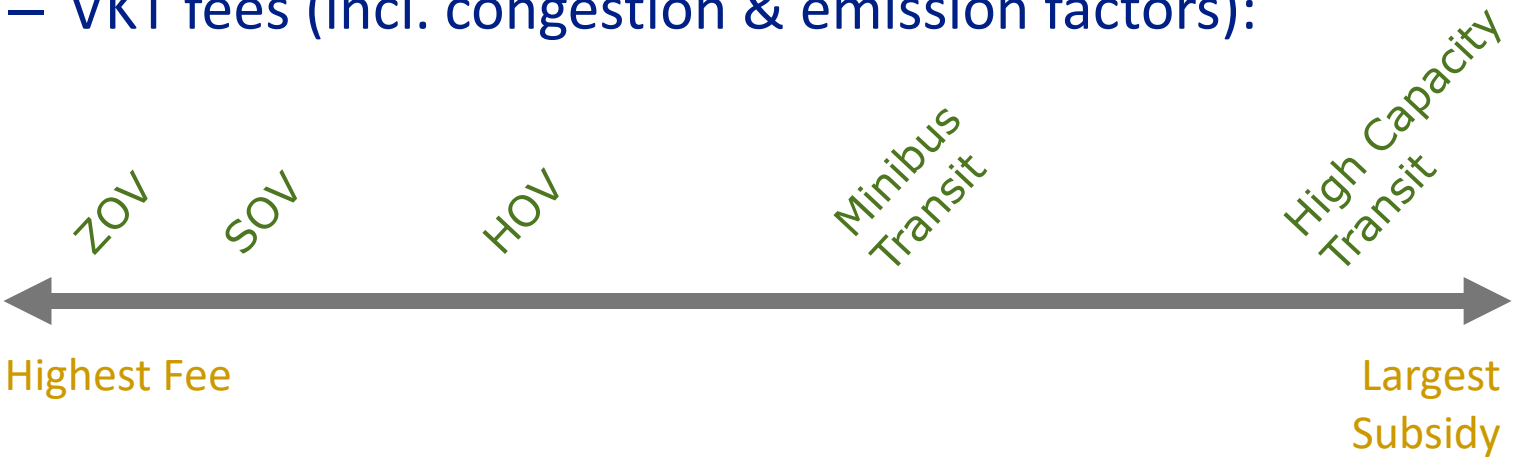


Source: Clewlow, Regina R. and G S. Mishra (2017) Disruptive Transportation: The Adoption, Utilization, and Impacts of Ride-Hailing in the United States.

- 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).

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

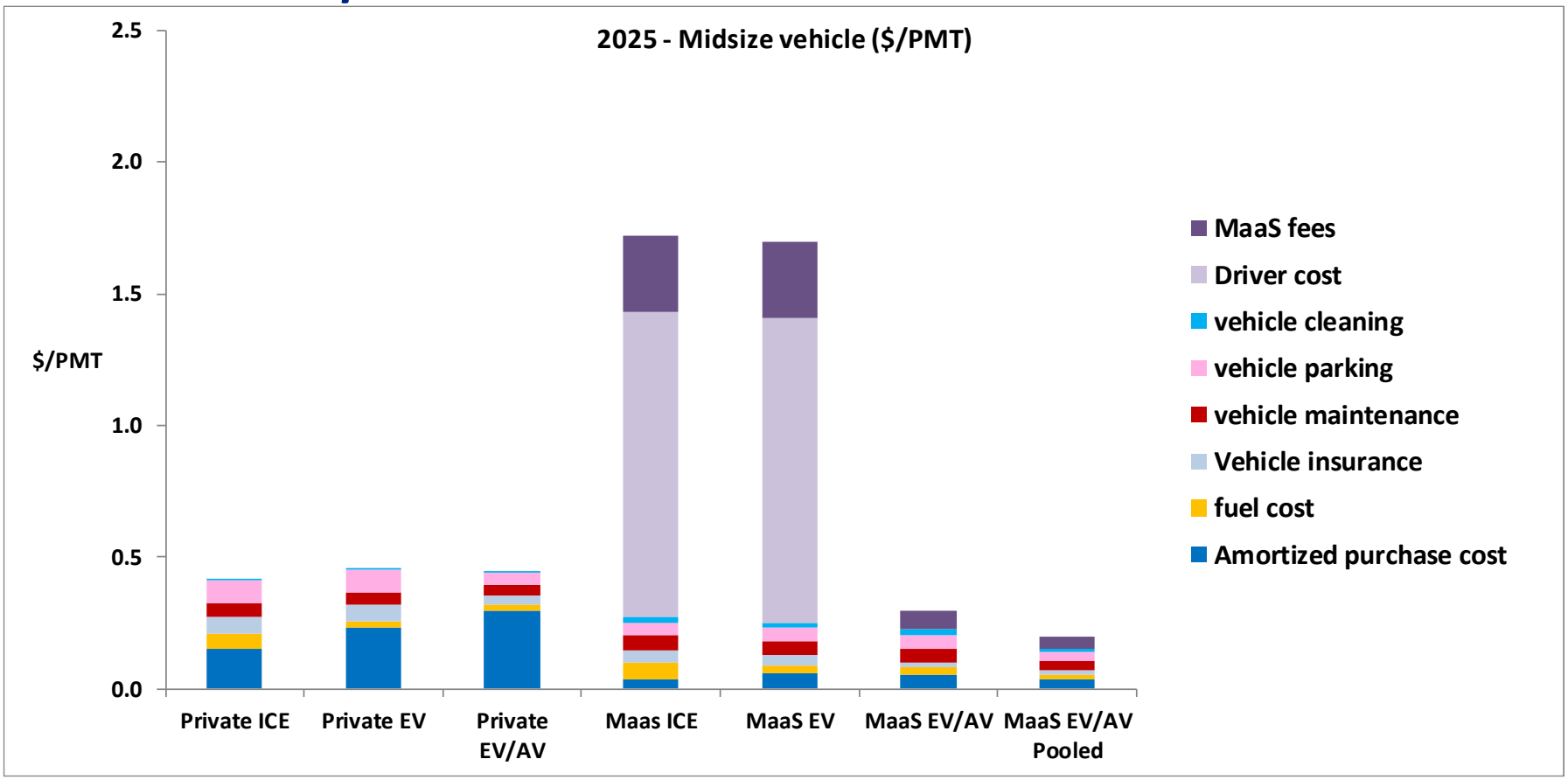
- Vehicle purchase
- Vehicle maintenance
- Fuel
- Insurance
- Cleaning
- Parking
- Driver
- MaaS fees
- Tolls
- Registration-related fees

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**

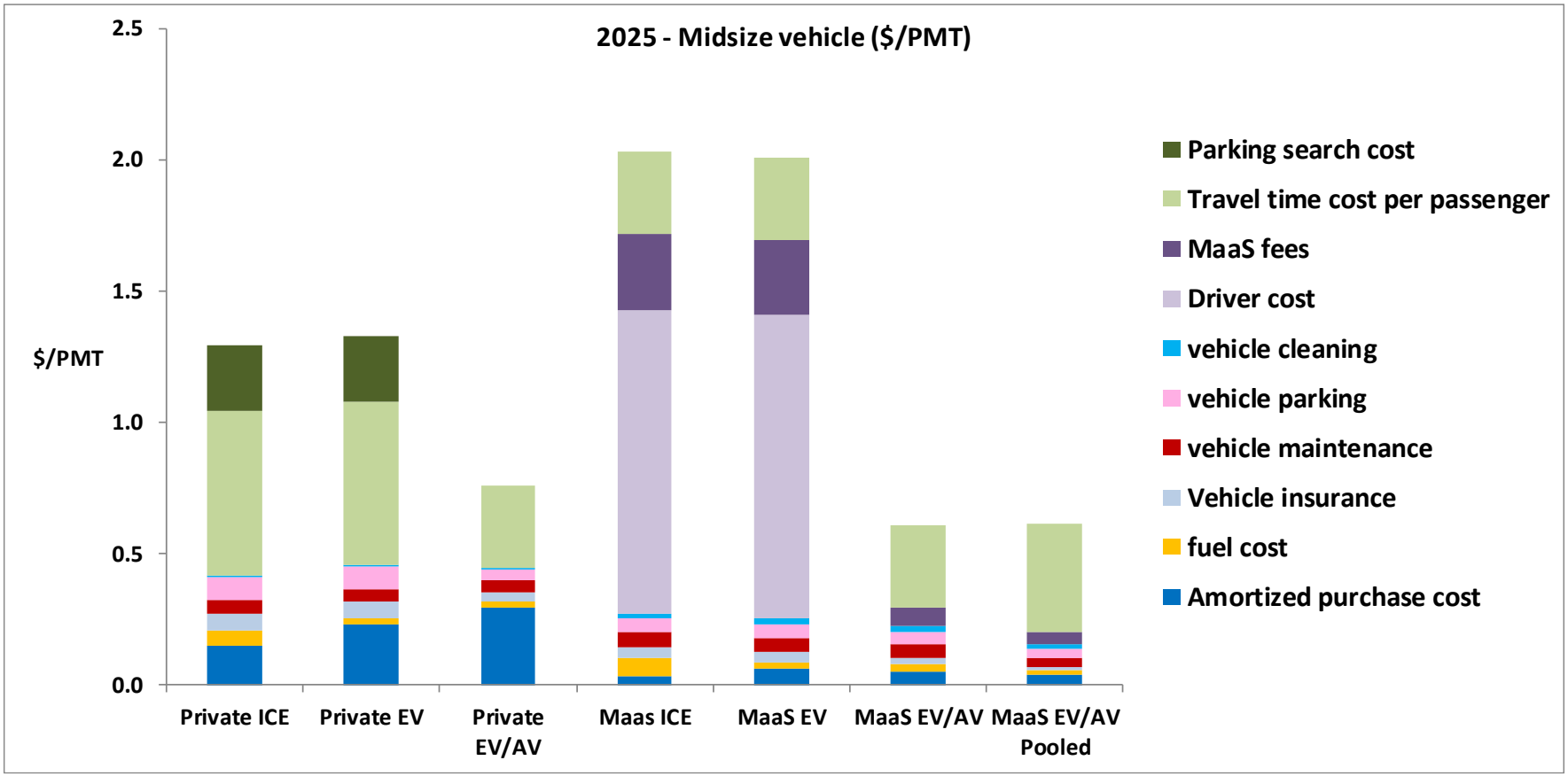
Out-of-pocket costs: Comparison of modes

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



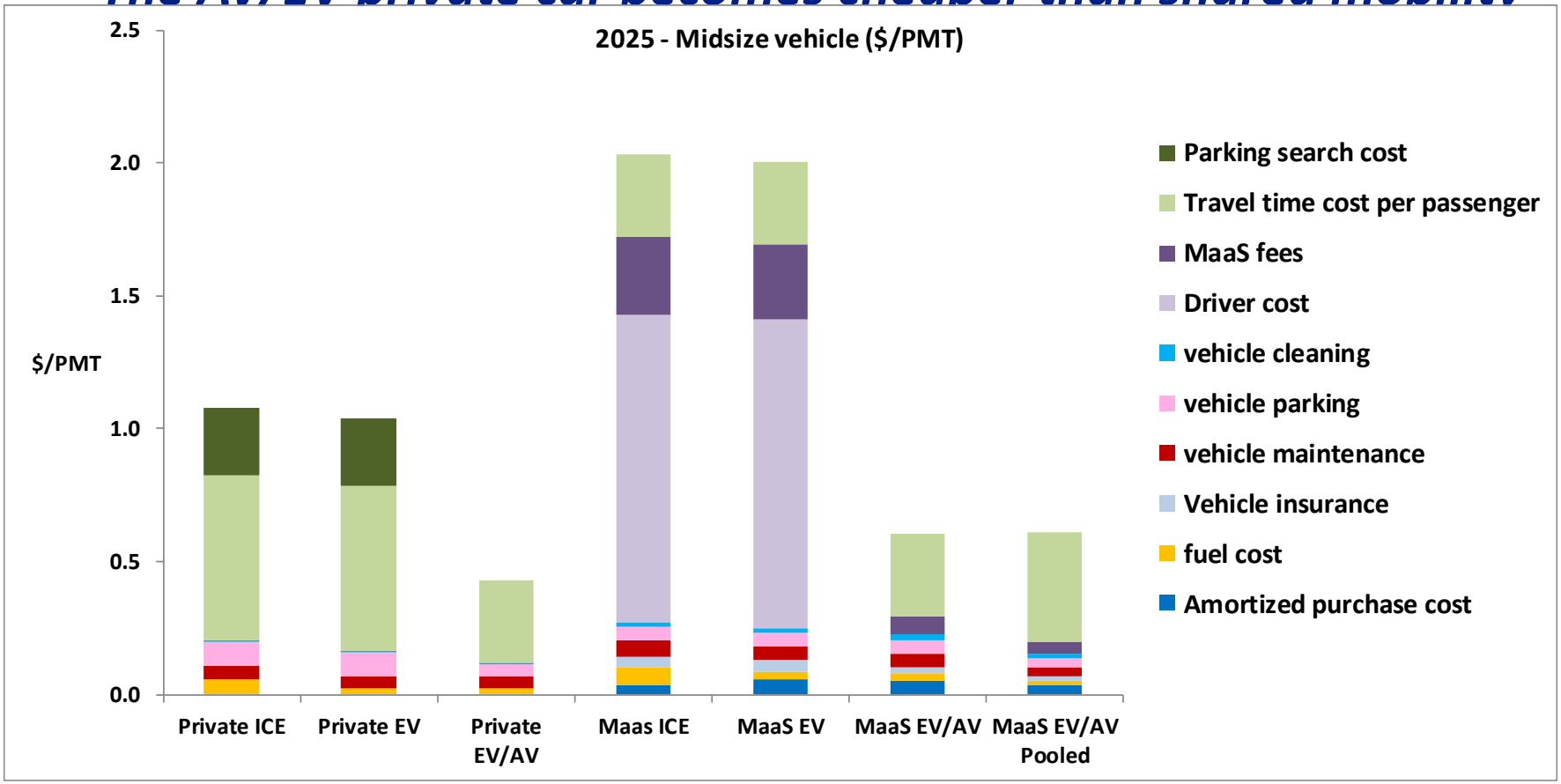
Added a value of time for driving, travelling, parking

- ***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	• Insurance • Registration and other annual or monthly fees	• Parking cost • TNC "first mile" fee	• Tolls • Vehicle cleaning	• Depreciation • Maintenance • Fuel cost • TNC per-mile fees • Per-mile road user fees (taxes)
Non-monetary	• Maintenance and inspections events (time, loss of vehicle use) • Car ownership pride and other hedonic ownership benefits • Per-vehicle environmental impacts (vehicle production, disposal)	• Time spent parking and searching for parking • Walking to/from vehicle to "door" • Loading/ unloading vehicle	• Refueling/ cleaning time • Recharging search, recharging time, anxiety • Keeping items in vehicle	• Travel time • Driving stress/enjoyment • Ride sharing (pooling) stress/enjoyment • Other in-ride hedonic factors • In-ride productivity • Per-mile environmental impacts (CO_2, air pollutants)

Important when in own vehicle (positive/negative)

	Separate from trip	Once per trip	Lumpy	Roughly per-mile
Monetary	• Insurance • Registration and other annual or monthly fees	• Parking cost • TNC "first mile" fee	• Tolls • Vehicle cleaning	• 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	• Insurance • Registration and other annual or monthly fees	• Parking cost • **TNC "first mile" fee**	• Tolls • Vehicle cleaning	• Depreciation • Maintenance • Fuel cost • **TNC per-mile fees** • **Per-mile road user fees (taxes)**
Non-monetary	• Maintenance and inspections events (time, loss of vehicle use) • Car ownership pride and other hedonic ownership benefits • Per-vehicle environmental impacts (vehicle production, disposal)	• Time spent parking and searching for parking • Walking to/from vehicle to "door" • **Loading/ unloading vehicle**	• Refueling/ cleaning time • Recharging search, recharging time, anxiety • Keeping items in vehicle	• Travel time • Driving stress/enjoyment • **Ride sharing (pooling) stress/enjoyment** • **Other in-ride hedonic factors** • **In-ride productivity** • Per-mile environmental impacts (CO_2, air pollutants)

Cost types where we have **poor or no data**

	Separate from trip	Once per trip	Lumpy	Roughly per-mile
Monetary	• Insurance • Registration and other annual or monthly fees	• Parking cost • TNC "first mile" fee	• Tolls • Vehicle cleaning	• Depreciation • Maintenance • Fuel cost • TNC per-mile fees • Per-mile road user fees (taxes)
Non-monetary	• **Maintenance and inspections events (time, loss of vehicle use)** • **Car ownership pride and other hedonic ownership benefits** • **Per-vehicle environmental impacts (vehicle production, disposal)**	• **Time spent parking and searching for parking** • **Walking to/from vehicle to "door"** • **Loading/ unloading vehicle**	• **Refueling/ cleaning time** • **Recharging search, recharging time, anxiety** • **Keeping items in vehicle**	• Travel time • **Driving stress/enjoyment** • **Ride sharing (pooling) stress/enjoyment** • **Other in-ride hedonic factors** • **In-ride productivity** • **Per-mile environmental impacts (CO_2, air pollutants)**

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***

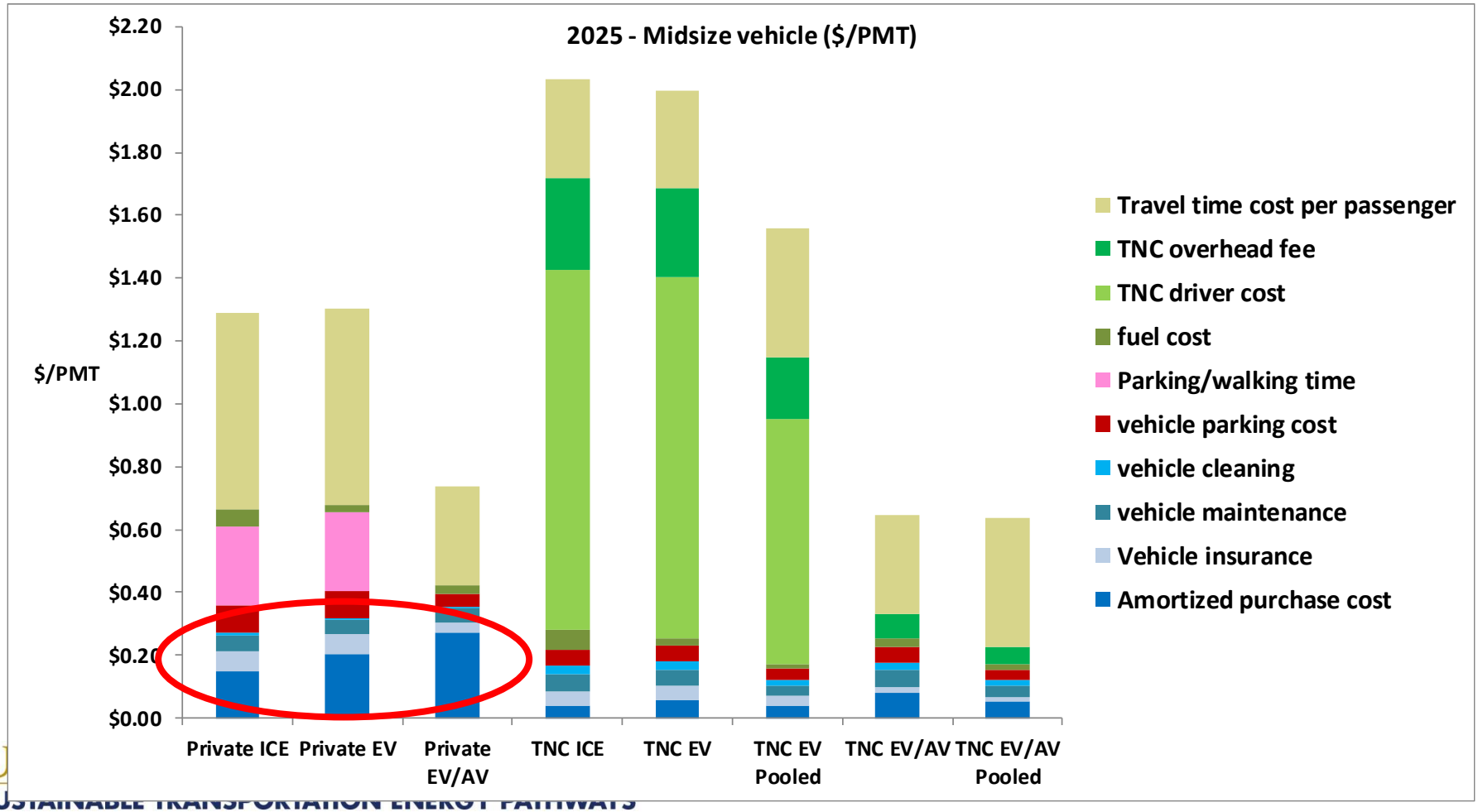
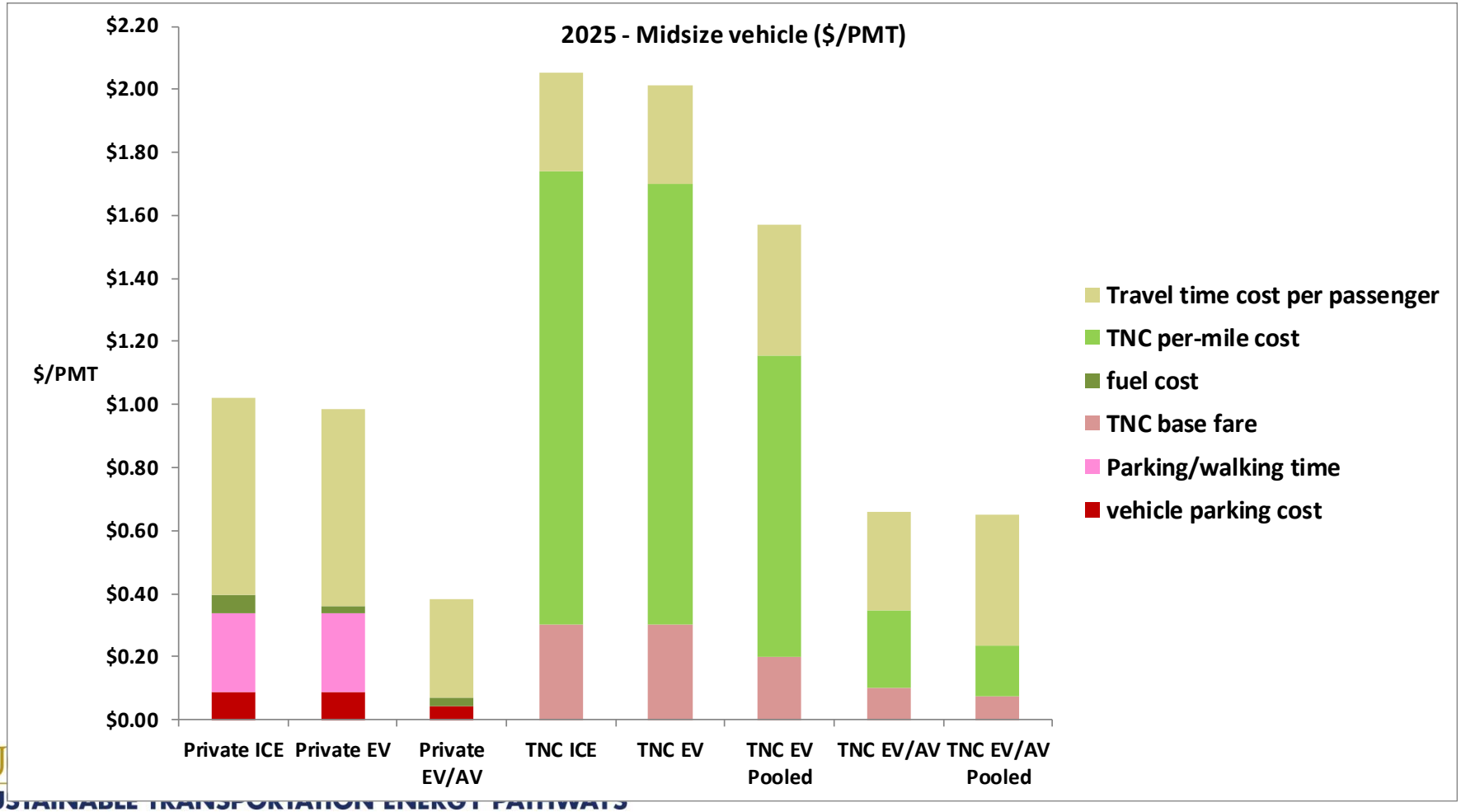


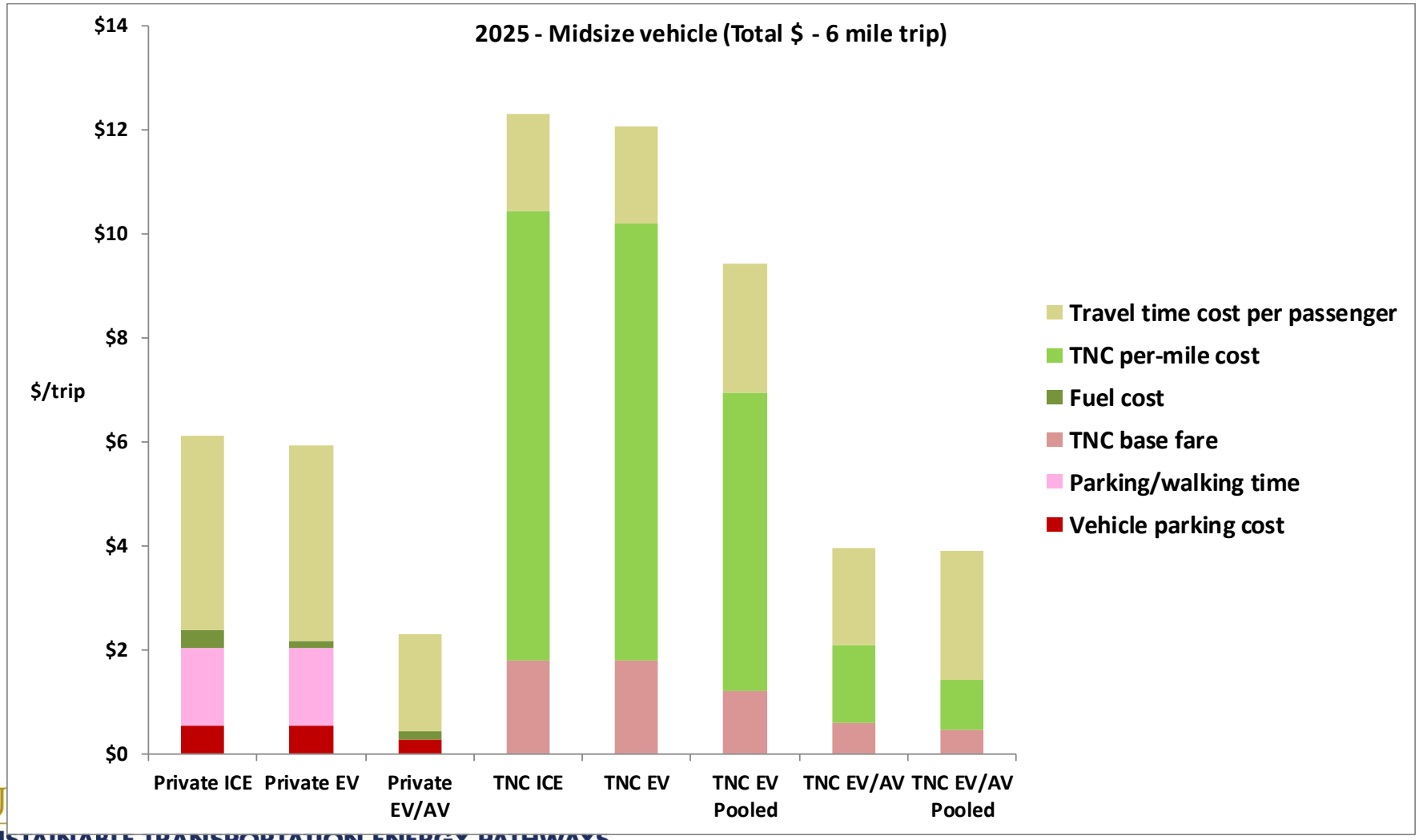
Figure with only the trip fixed and per-mile costs shown

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



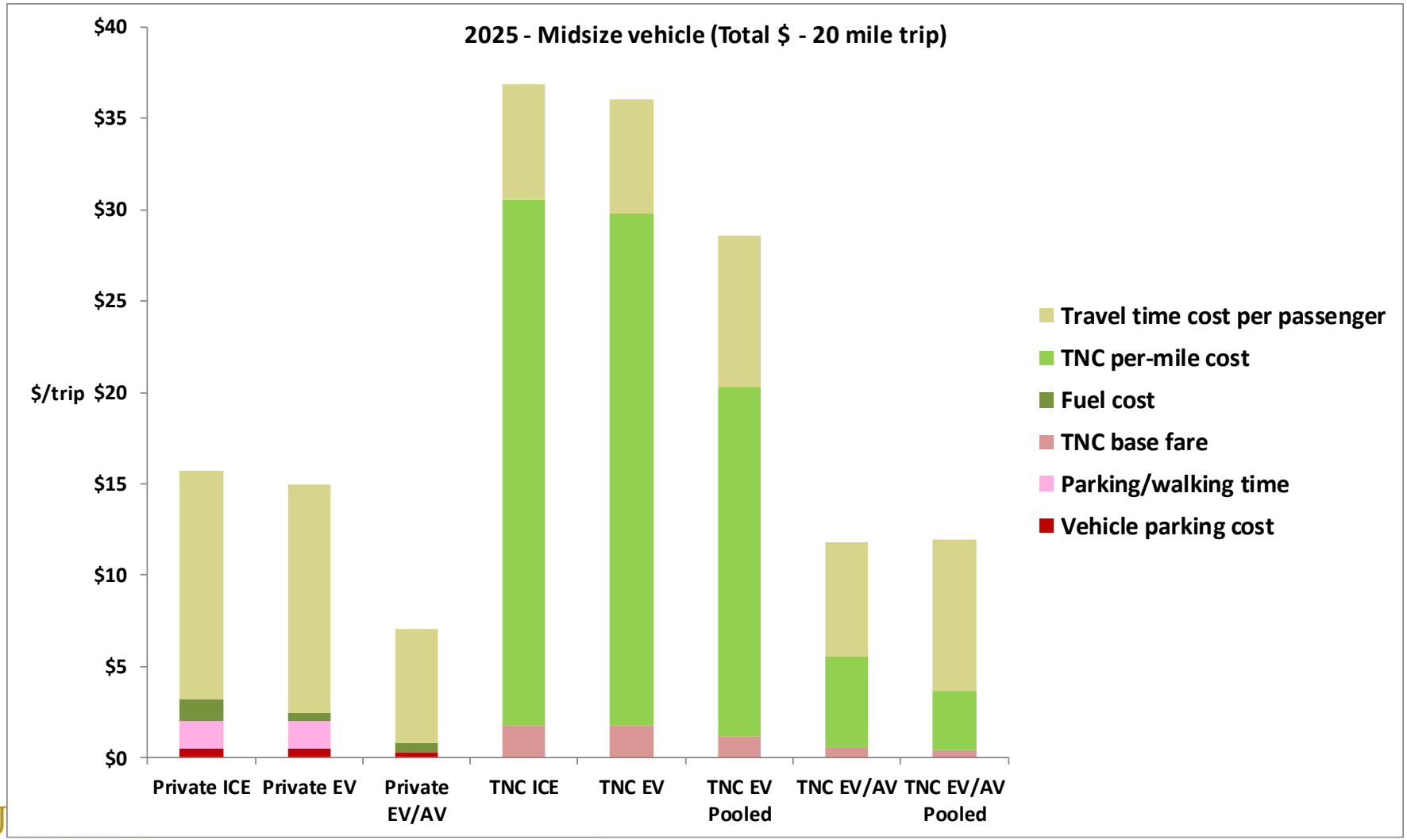
Same scenario, but shown as total costs for a six mile trip

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



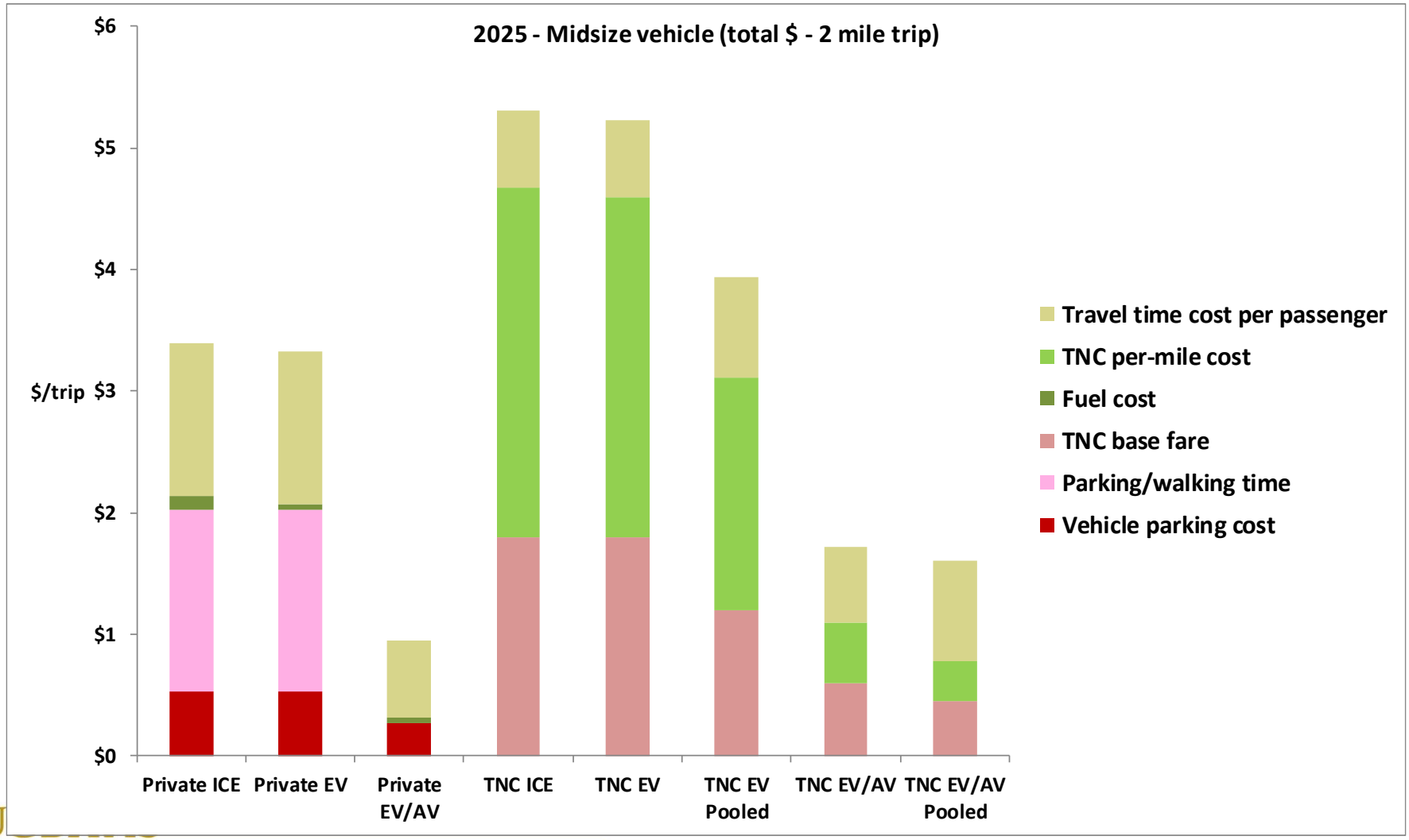
Data converted to per-trip costs for a 20 mile trip

- 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/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

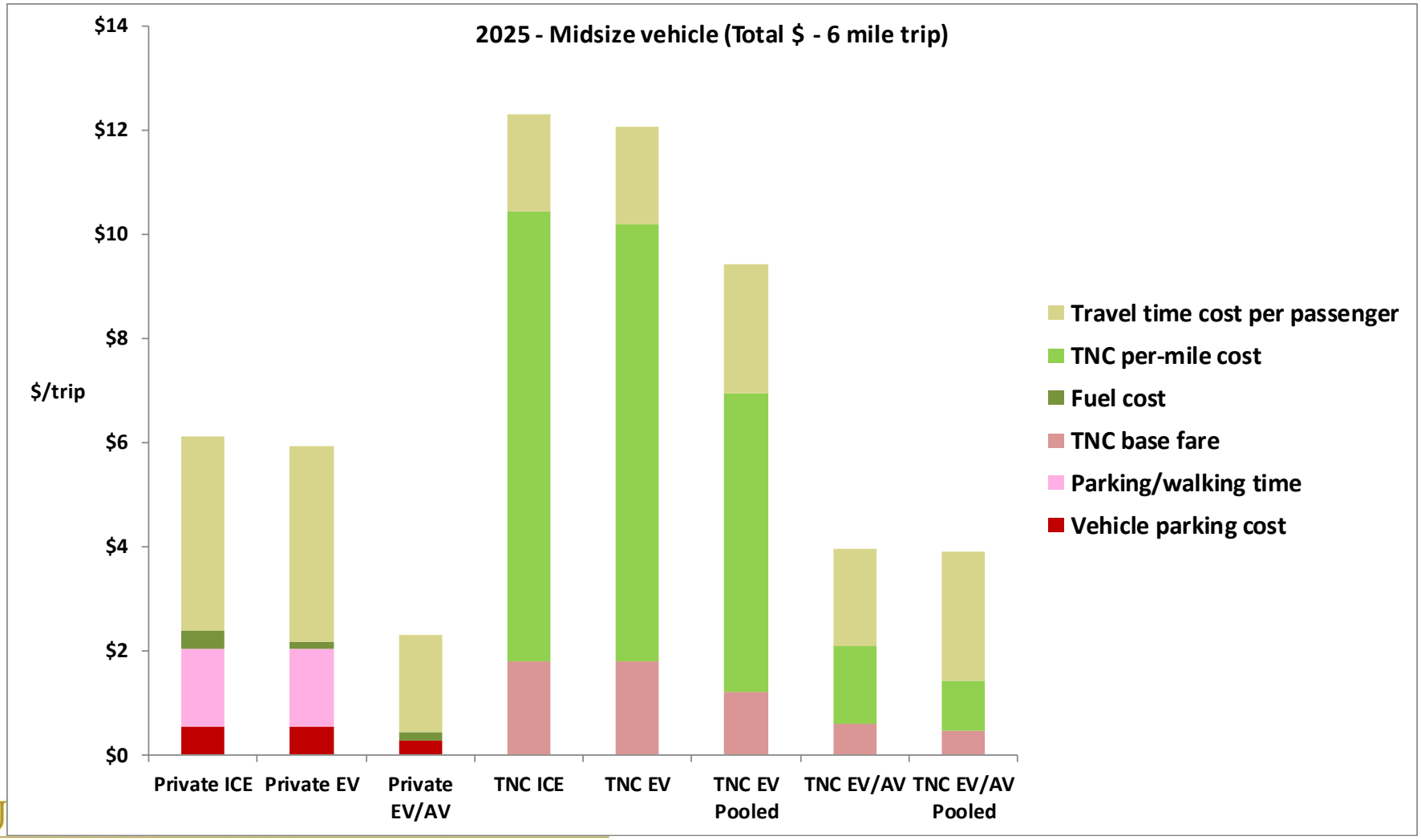
Simple $15/hour time cost analysis across activities
(Example of a 6 mile, 12 minute trip, 30 miles per hour)

- 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

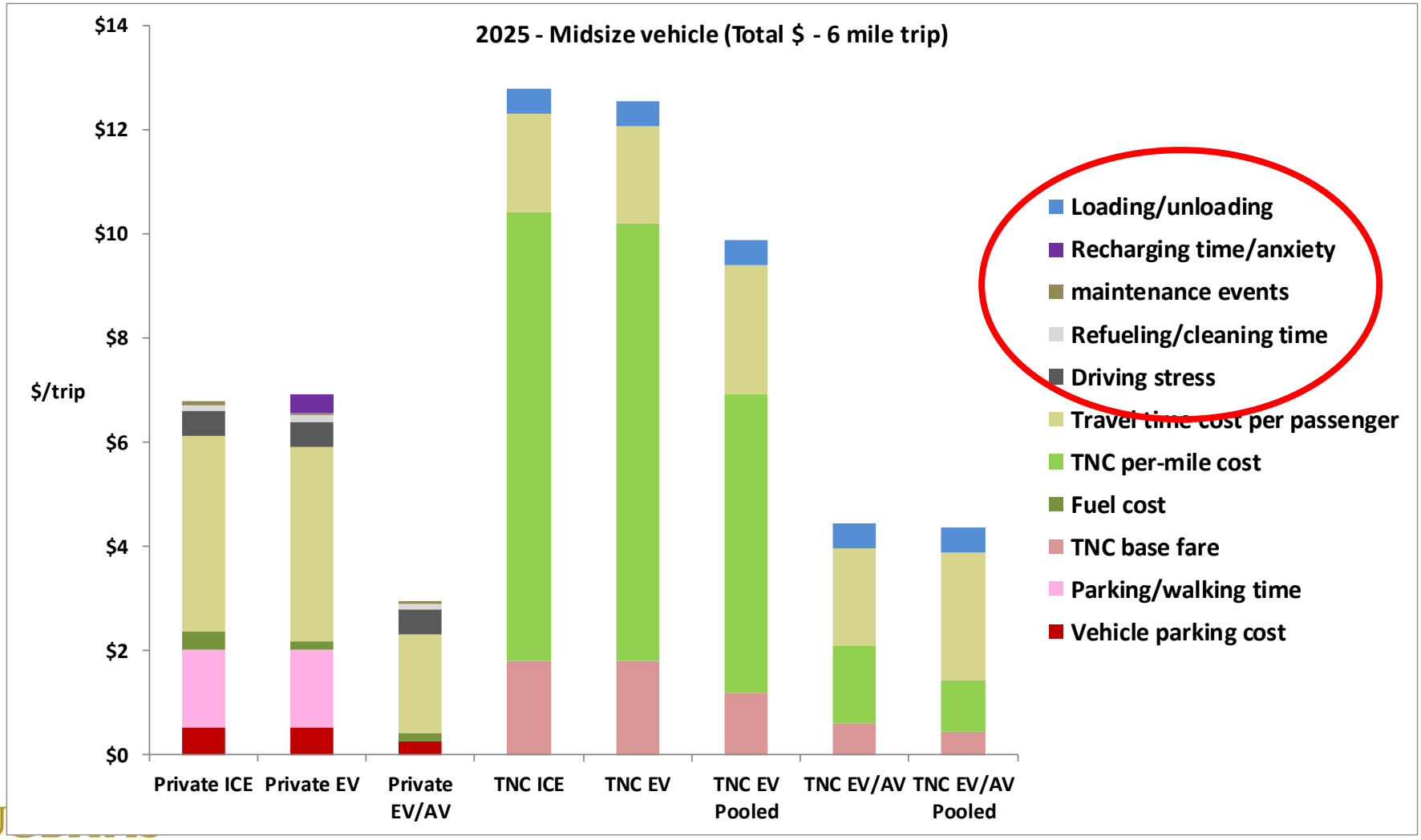
Back to our 6 mile trip

- 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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