

# **Innovation in Transportation: Opportunities & Challenges**

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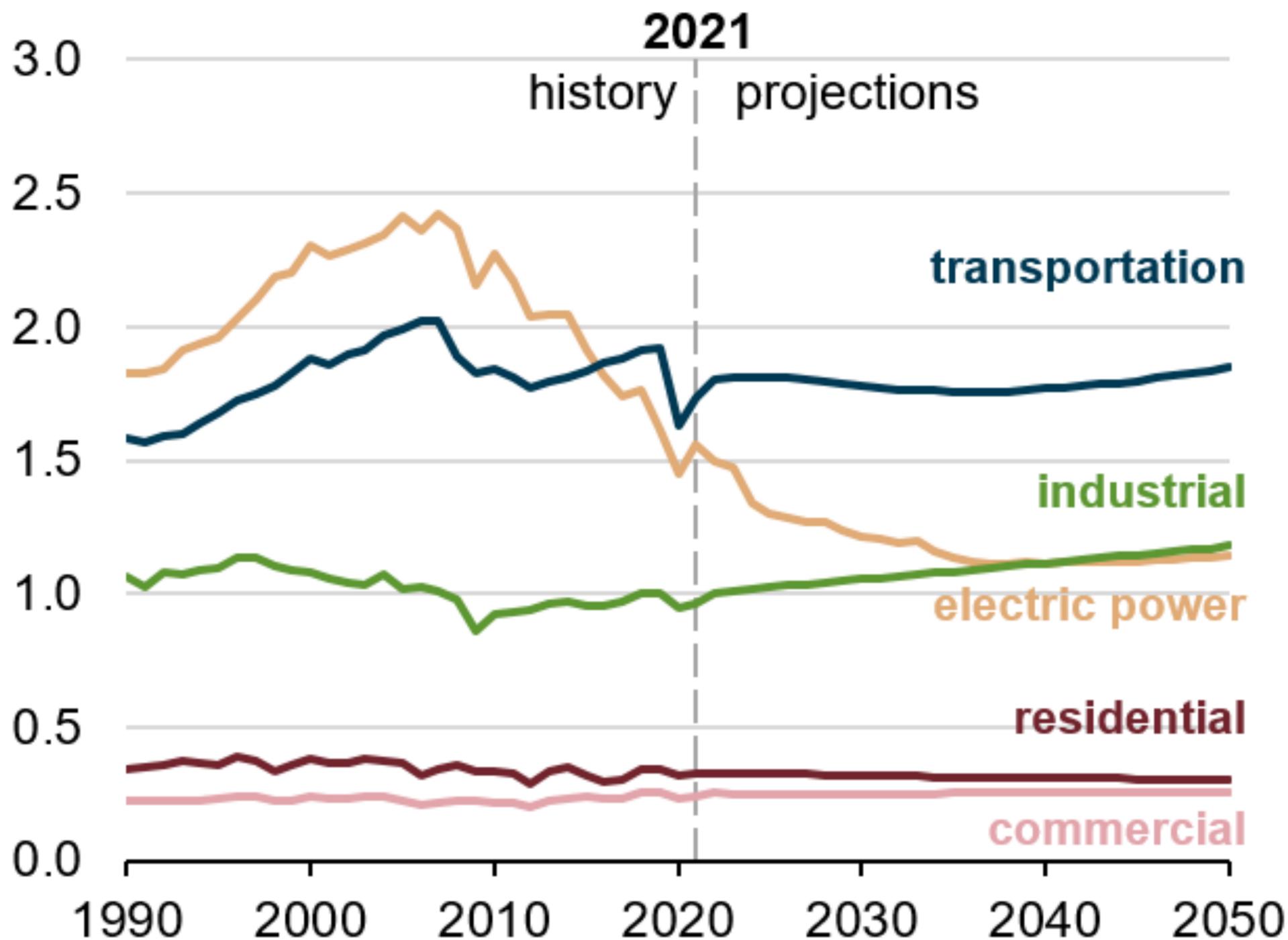
**SF Fed's Climate Risks: Theory and Practice Conference, November 4, 2022**

# Energy-related CO<sub>2</sub> emissions by sector

## AEO2022 Reference case



billion metric tons

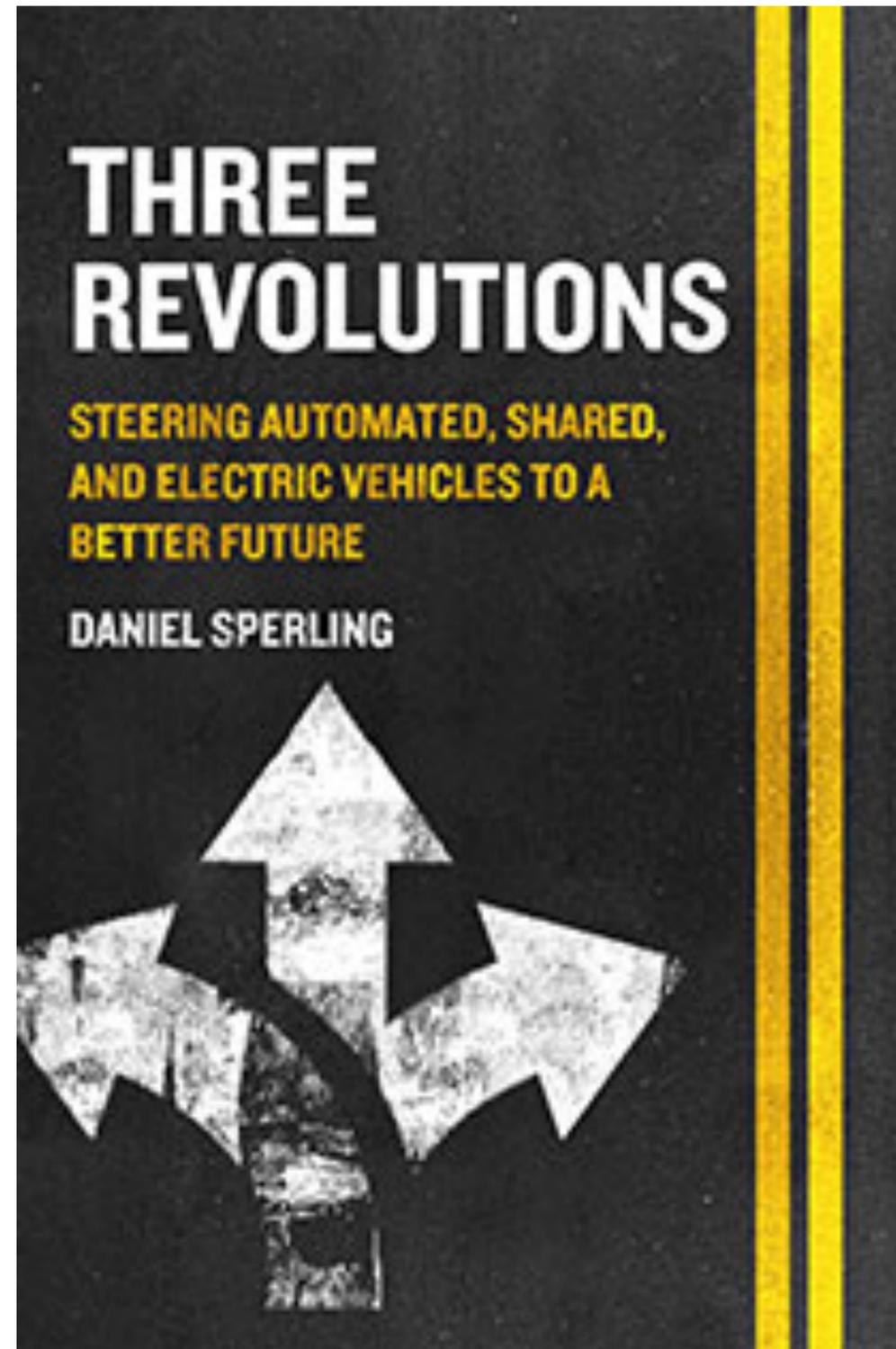


Source: U.S. Energy Information Administration, *Annual Energy Outlook 2022*, March 2022

# Future of Transportation



Source: [autonews.com](http://autonews.com)



**Source: Sperling (2018)**

# Electrification



# Pooling



# Automation



# Opportunities

## Electrification



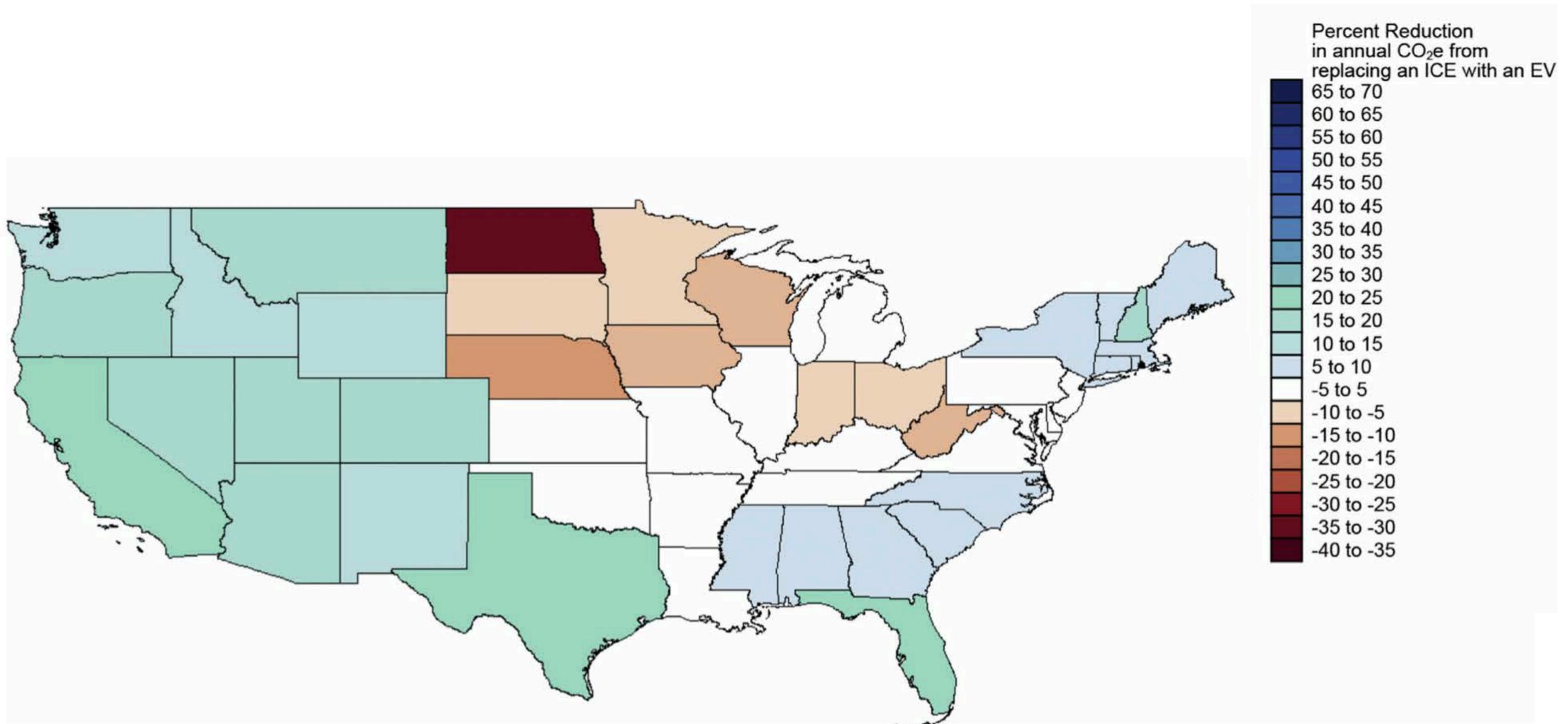
- Large potential for GHG reductions
  - Complementarity with decarbonizing electric grid
- National, state, and local policy support
- Automakers are on board
- Cost of batteries declining, TCO parity by 2035 (Chakraborty, Buch, & Tal 2021)

# Challenges

## Electrification



- Behavioral factors
  - Driven less than ICEVs? (Burlig et al, 2021; Davis, 2021)
- Heterogeneous environmental benefits (Archsmith, Kendall, & Rapson, 2015; Holland et al., 2016)



**Source: Archsmith, Kendall, & Rapson, 2015**

# Challenges

## Electrification



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- Charging access (Nicholas, Hall, & Lutsey, 2019)



# Challenges

## Electrification



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- Heterogeneous environmental benefits (Archsmith, Kendall, & Rapson, 2015; Holland et al., 2016)
- Charging access (Nicholas, Hall, & Lutsey, 2019)
- Poor cost-effectiveness of subsidies (DeShazo, Sheldon, & Carson, 2017)
- Equity (policy & benefits) (Holland et al., 2019; Sheldon, 2022)

# Opportunities

## Pooling



- Engineering estimates -> major potential (Hasan et al., 2020)
  - 57% decrease in vehicle usage
  - 46% decrease in VMT
  - Only 22% increase in ride time
- Complementarity with electrification
  - 3x greater emissions reductions for switching to EV for ride-hailing (Jenn, 2020)

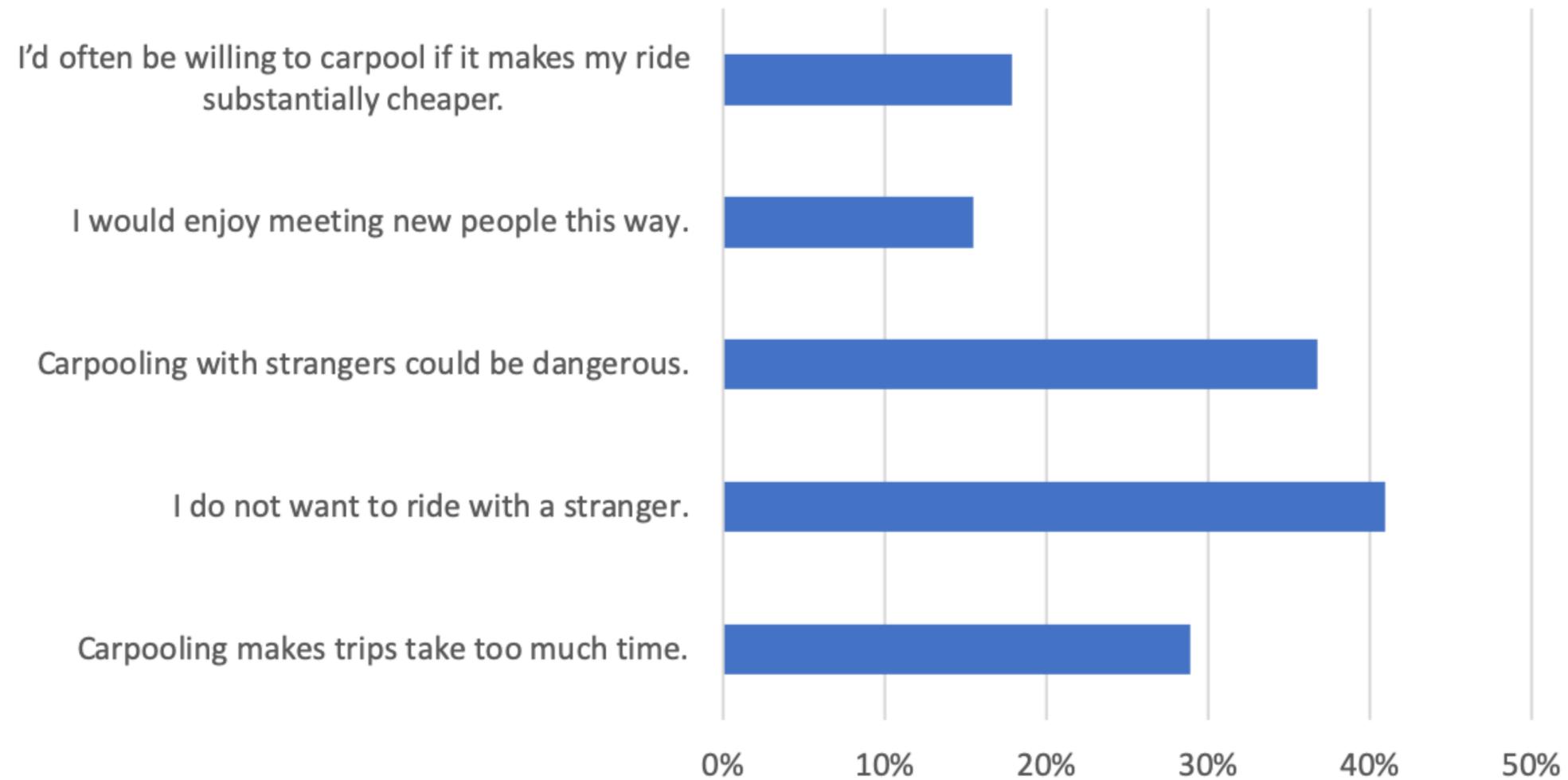
# Challenges

## Pooling

- People don't want to carpool with others!



- Ride time constant, consumers WTP \$3.66 (median) and \$23.45 (mean) less to carpool



**Source: Sheldon and Dua, working paper**

# Challenges

## Pooling



- People don't want to carpool with others!
- Public transit users and commuter (versus leisure) trips more willing to carpool (Asgari, Jin, & Corkery, 2018; Lavieri & Bhat, 2019)

# Opportunities

## Automation



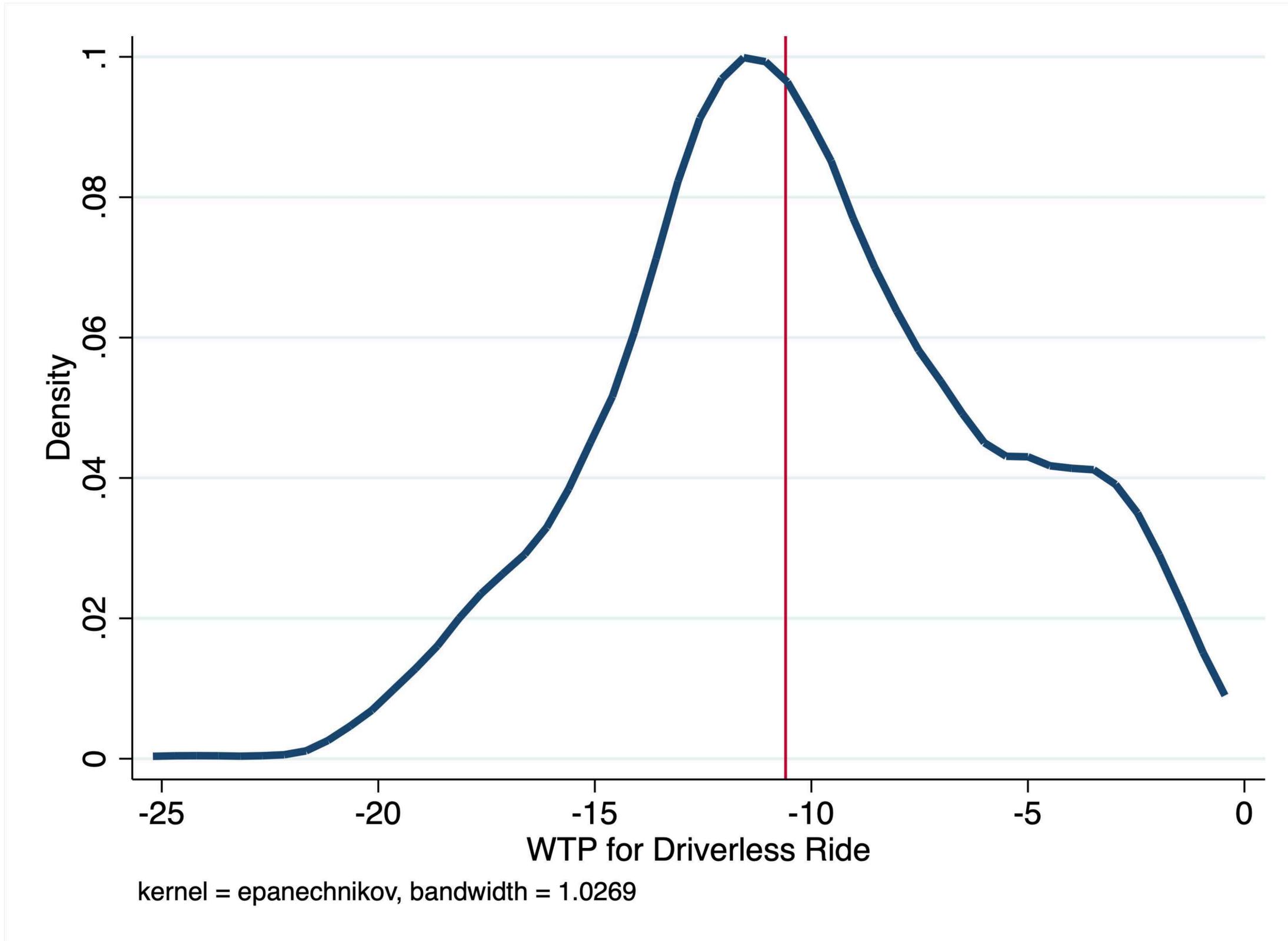
- Increased access (Fagnant & Kockelman, 2015)
- Lower operating cost of on-demand services (reduce demand for private cars) (Bösch et al., 2018)
  - 88% of conventional taxi cost due to labor
  - 0.41 CHF per km for autonomous taxi (vs. 2.73)
- More energy efficient (Liu et al., 2019)
- Complementarity with electrification & pooling

# Challenges

## Automation



- Safety concerns
- Regulations, liability, and cybersecurity (Fagnant & Kockleman, 2015)
- Consumer aversion to driverless cars



**Source: Sheldon and Dua, working paper**

# Challenges

## Automation



- Safety concerns
- Regulations, liability, and cybersecurity (Fagnant & Kockleman, 2015)
- Consumer aversion to driverless cars
- Increased VMT & congestion (Wadud, MacKenzie, & Leiby, 2016; Oh et al., 2020)
  - Increased access
  - Lower cost (& lower disutility?)
  - Substitute for public transit
  - Empty trips

# Electrification



# Pooling



# Automation



**Innovating for climate solutions- it's not just about technology, but also about behavior.**

**Thank you!**

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