Autonomous Vehicles: Uncertainties and Energy Implications

For

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By

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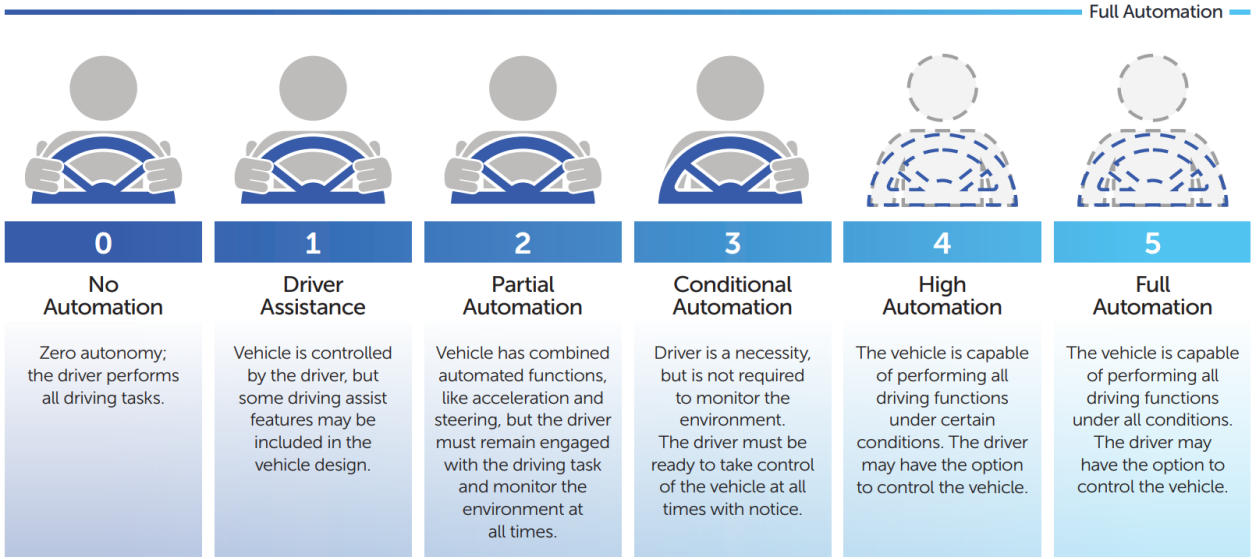
Overview

- Background
- AEO2018 Issues in Focus
- Ongoing work
  - Levels 1-3 automated technology adoption
  - Multiyear effort to model key energy effects of automated vehicles
  - Geographic population density and travel patterns

Background

Definition of vehicle automation

- Operational and safety-critical control functions occur without driver input
- Connected and automated vehicles



Source: U.S. Department of Transportation, Automated Driving Systems 2.0, A Vision for Safety

Potential benefits underlie interest but there are also key uncertainties and obstacles

Benefits

- Road safety
- Increased system efficiency
  - Route harmonization
  - Reduced congestion
- Increased mobility for underserved population
- Less time driving

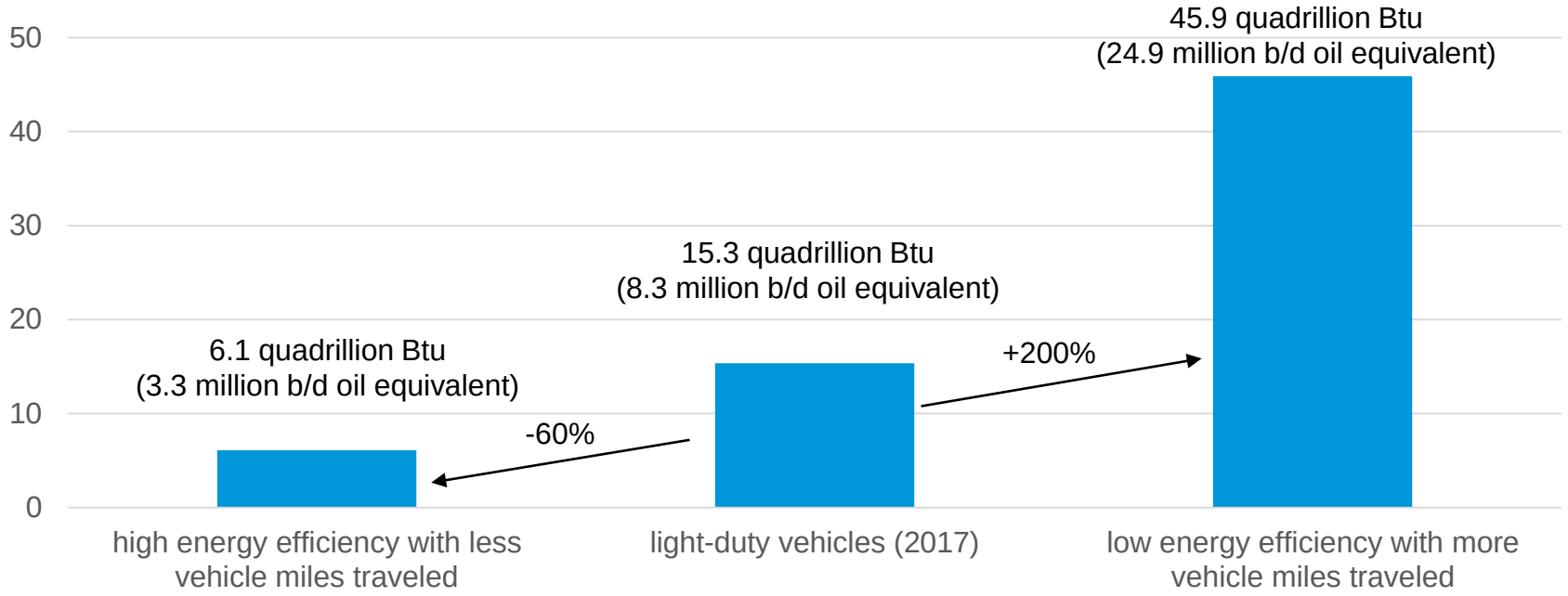
Obstacles

- Consumer acceptance
- Technology cost and function
- Cybersecurity
- Legal framework
- Infrastructure
- Policy

Range of potential effects of autonomous vehicles on light-duty vehicle energy consumption

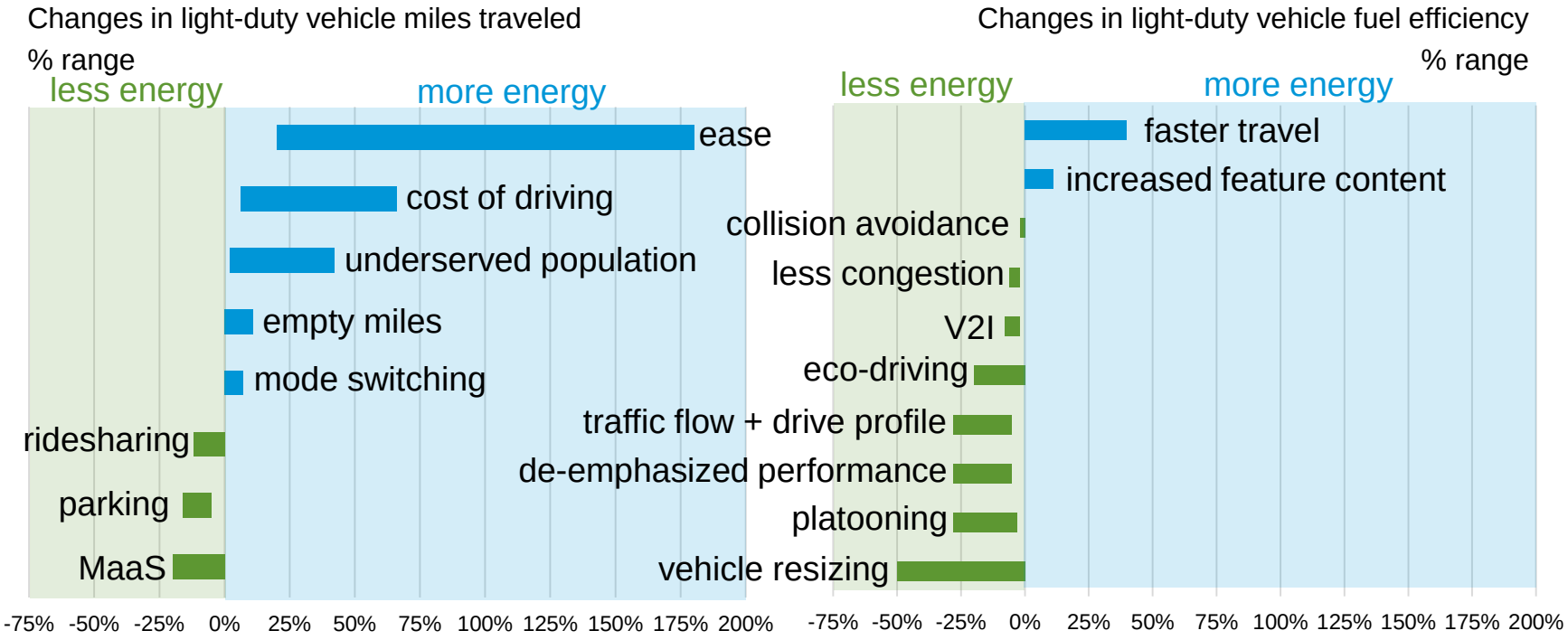
2017 U.S. delivered energy consumption

quadrillion Btu



Source: 2017: EIA, AEO2018 Reference case, extrapolation based on upper and lower limits from Estimated Bounds and Important Factors for Fuel Use and Consumer Costs of Connected and Automated Vehicles (Stephens et al)

There is uncertainty about how highly automated vehicles could affect future transportation energy demand



Sources: Help or Hindrance? The Travel, Energy, and Carbon Impacts of Highly Automated Vehicles (Wadud et al); Estimated Bounds and Important Factors for Fuel Use and Consumer Costs of Connected and Automated Vehicles (Stephens et al)

Additional ways vehicle automation technology could affect transportation energy consumption

- Alternative fuels and energy efficient powertrains
- Commercial trucks
- Mass transit

AEO2018 Issues in Focus—*Autonomous Vehicles: Uncertainties and Energy Implications*

Description of scenarios

- Reference case
  - Autonomous vehicles enter fleet light-duty vehicles
    - 1% of new sales by 2050
  - Autonomous vehicles used more intensively
    - 65,000 miles/year and scrapped more quickly
  - Autonomous vehicle fuel type
    - 100% conventional gasoline internal combustion engine
  - Autonomous vehicles affect mass transit
    - Increases use of commuter rail
    - Decreases use of transit bus and transit rail

Description of scenarios–two scenarios examine energy implications from more widespread use of autonomous vehicles

- Identical assumptions
  - Autonomous vehicles enter household and fleet light-duty vehicles
    - 31% of new sales by 2050
  - Autonomous vehicles used more intensively
    - 65,000 miles/year (fleet) ; +10% miles/year (household) on average
  - Autonomous vehicles affect mass transit modes
    - Increases use of commuter rail
    - Decreases use of transit rail
    - Decreases use of transit bus until mid-2030s, thereafter, increases transit bus use from automation technology
  - Automation technology included on long-haul fleet commercial trucks enables platooning

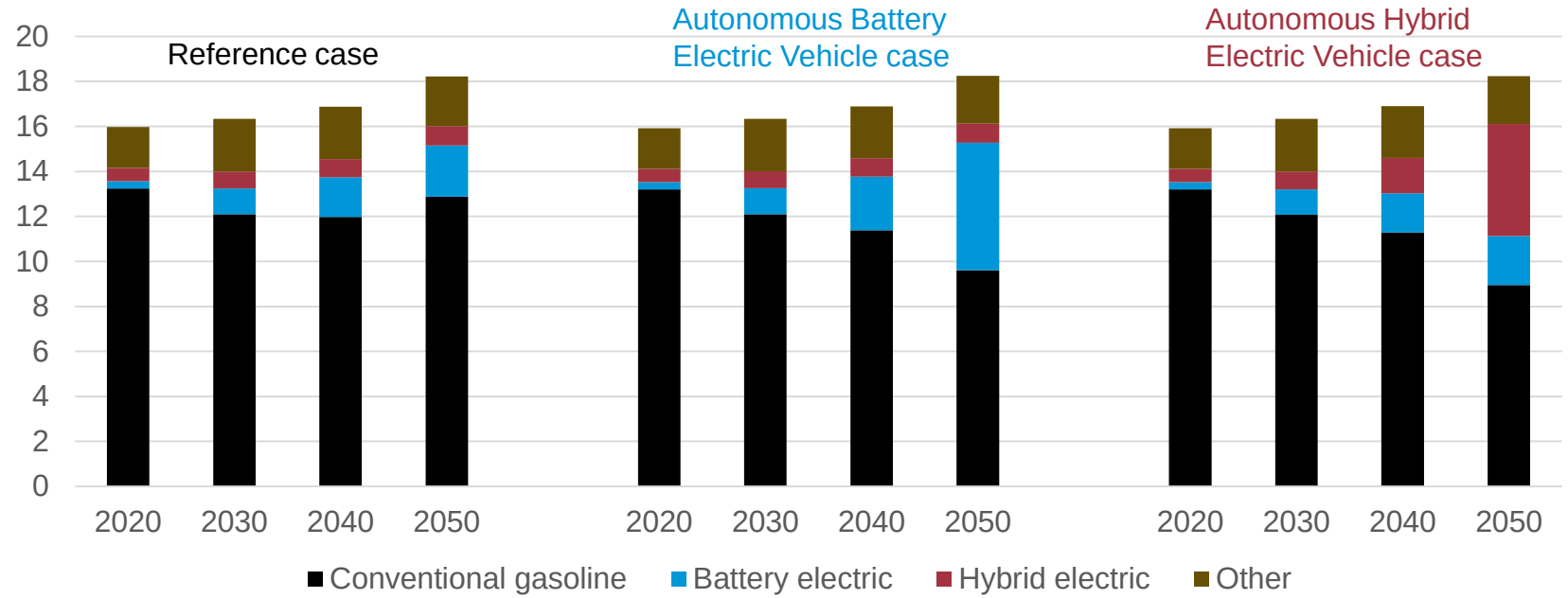
Description of scenarios–two scenarios examine energy implications from more widespread use of autonomous vehicles

- Autonomous Battery Electric Vehicle case
  - Increasing share of autonomous vehicles are battery electric through 2050
    - 96% of fleet and 82% of household autonomous vehicles by 2050
- Autonomous Hybrid Electric Vehicle case
  - Increasing share of autonomous vehicles are hybrid electric through 2050
    - 96% of fleet and 71% of household autonomous vehicles by 2050

Light-duty vehicle sales by fuel type across scenarios

U.S. light-duty vehicle sales

million

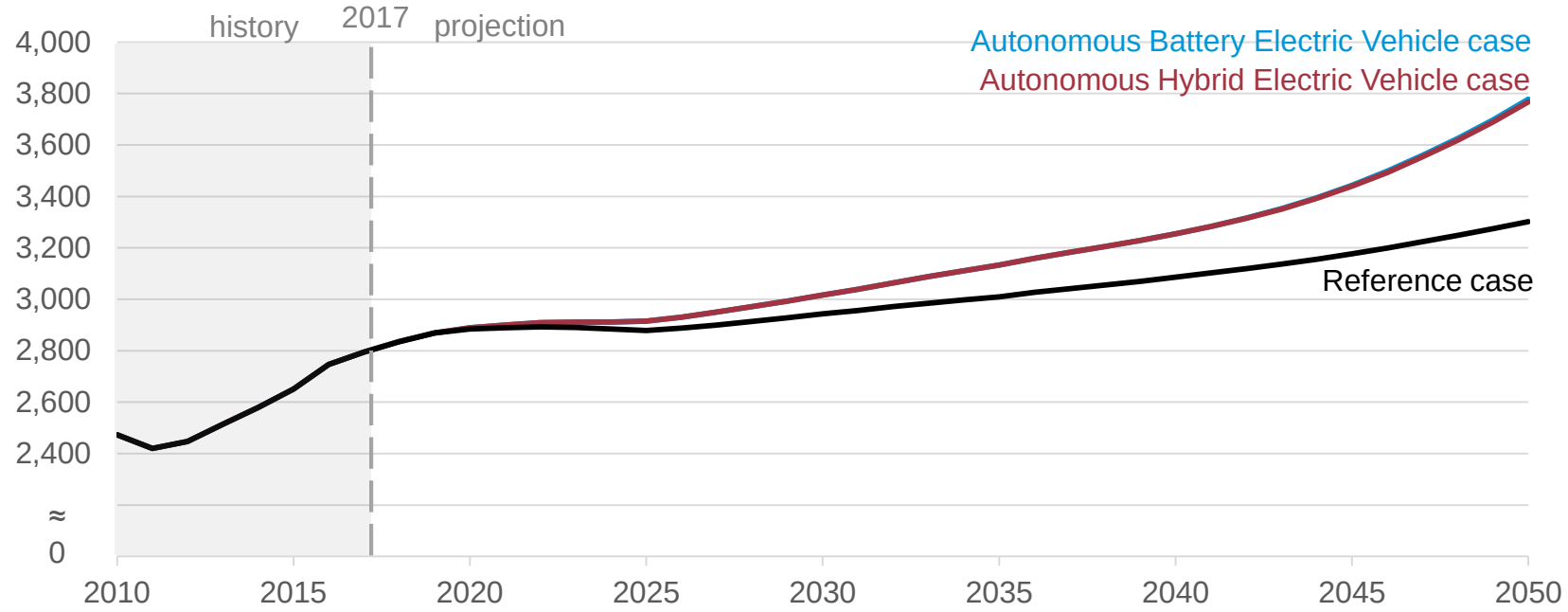


Source: EIA, AEO2018 Reference case, Autonomous Battery Electric Vehicle case, Autonomous Hybrid Electric Vehicle case

Light-duty vehicle miles traveled 14% above Reference case in 2050 and 35% higher in 2050 than in 2017

U.S. light-duty vehicle miles traveled

billion

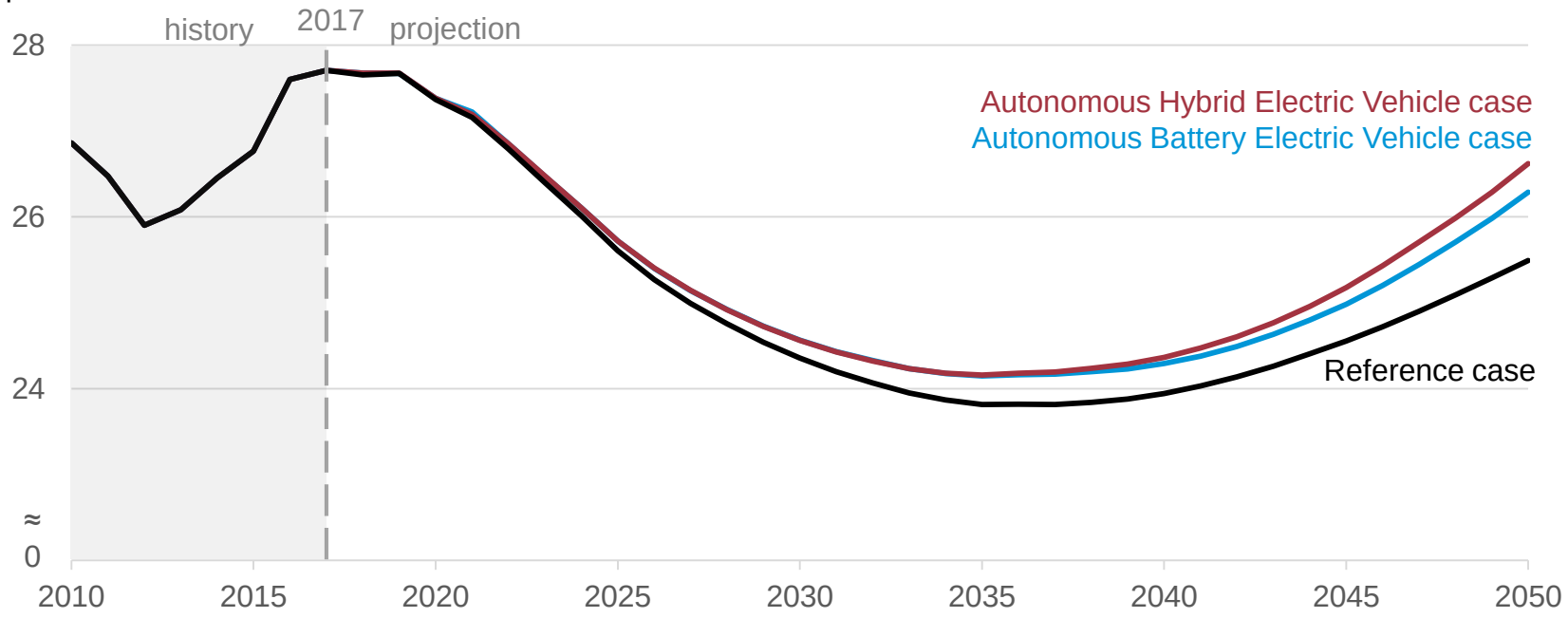


Source: EIA, AEO2018 Reference case, Autonomous Battery Electric Vehicle case, Autonomous Hybrid Electric Vehicle case

Transportation energy consumption higher in both cases compared to Reference case but still lower than 2017

U.S. transportation energy consumption

quadrillion Btu

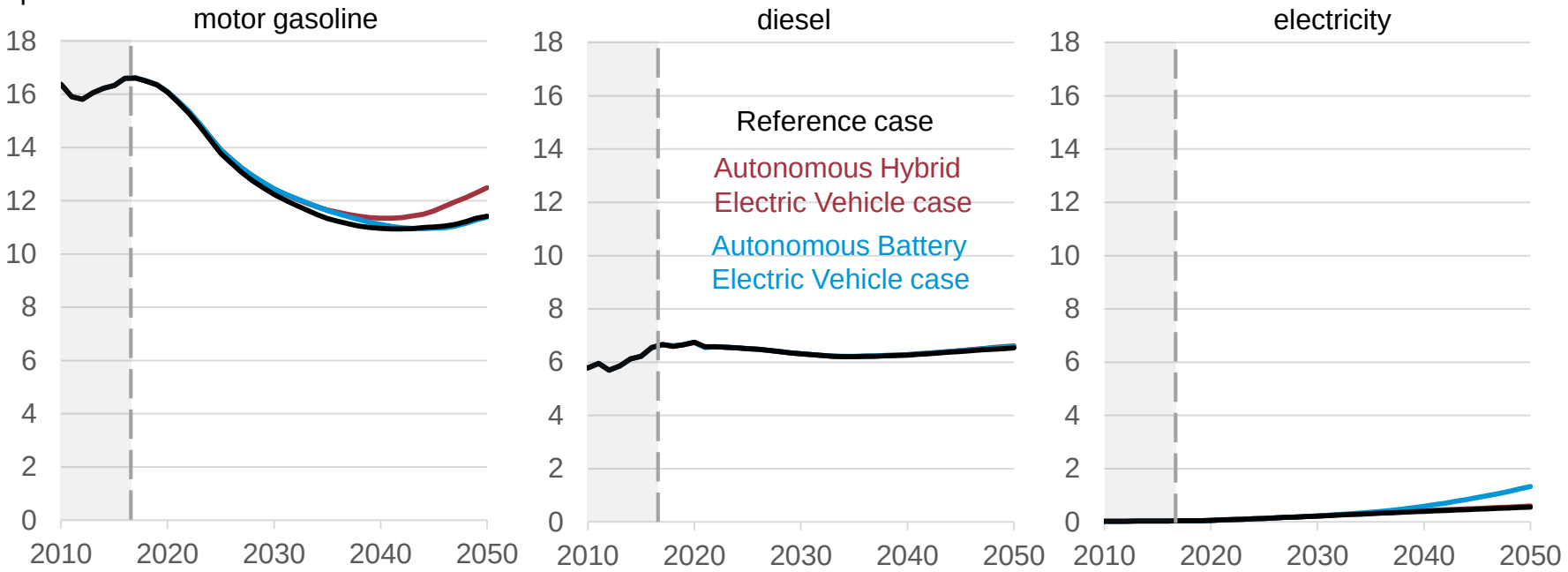


Source: EIA, AEO2018 Reference case, Autonomous Battery Electric Vehicle case, Autonomous Hybrid Electric Vehicle case

Transportation fuel consumption differs between cases because of changes in light-duty vehicle fuel type

Transportation energy consumption by fuel

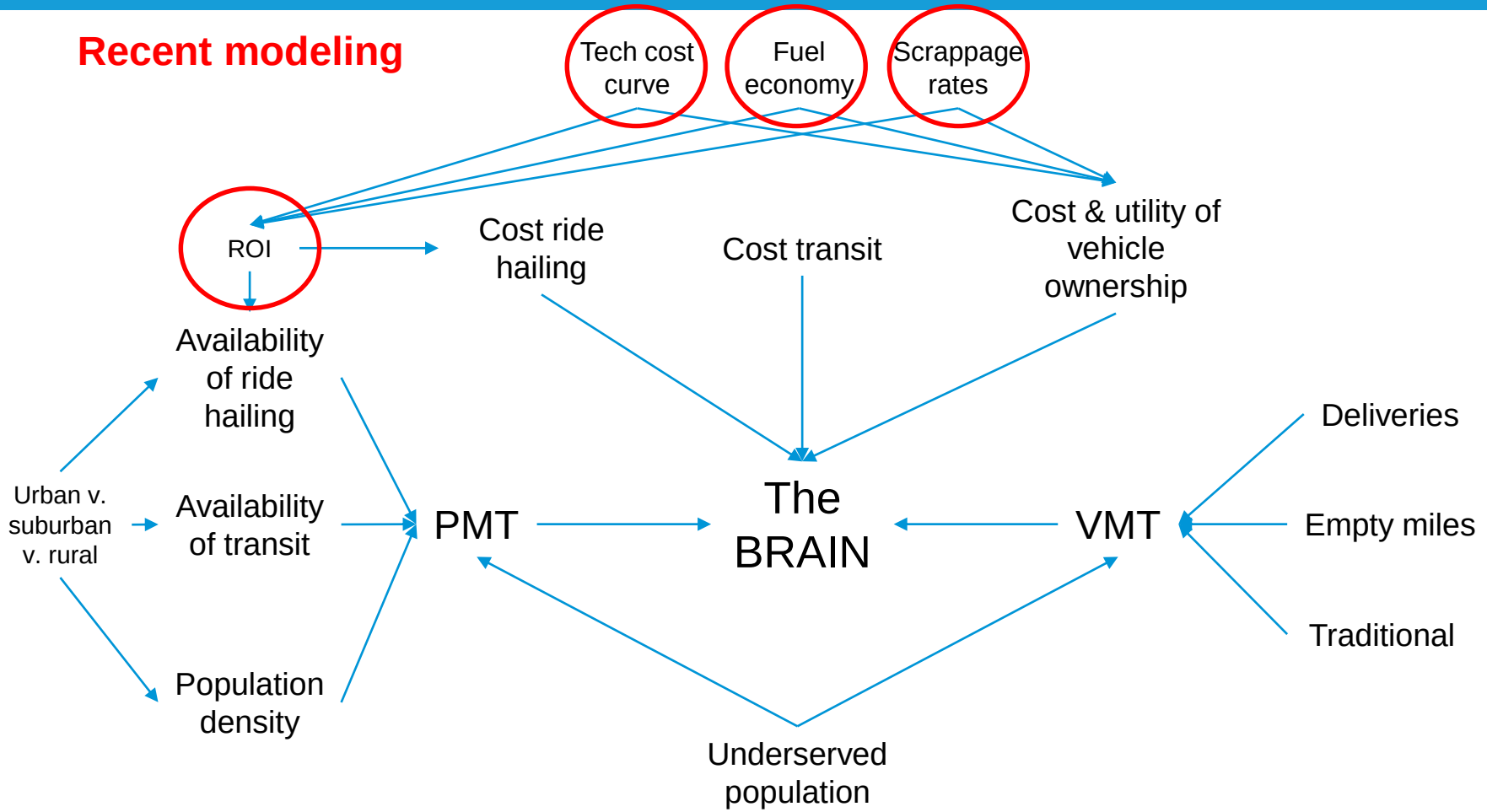
quadrillion Btu



Source: EIA, AEO2018 Reference case, Autonomous Battery Electric Vehicle case, Autonomous Hybrid Electric Vehicle case

Ongoing work

Recent modeling



Recent modeling focus: adding levels of highly automated vehicles—

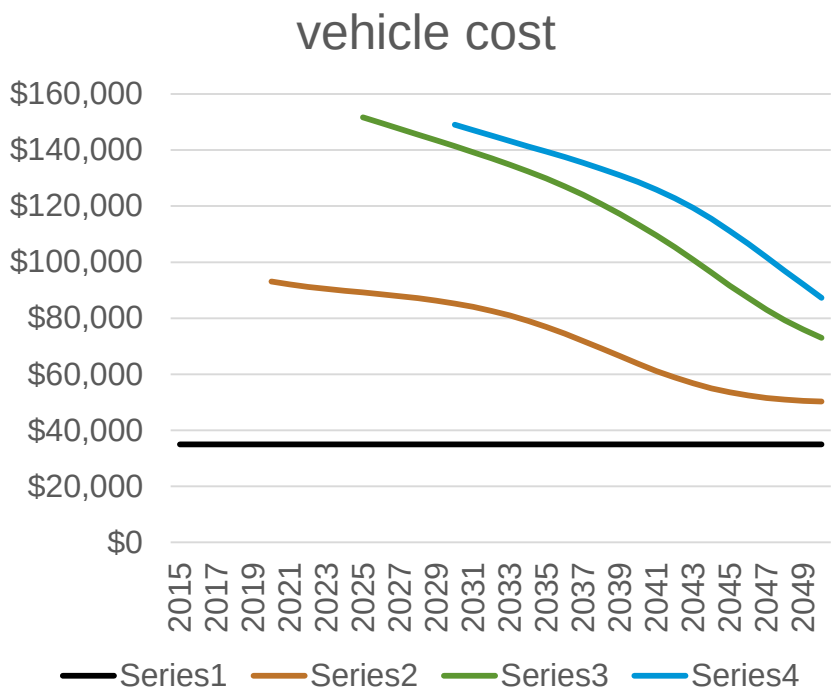
- Levels of vehicle automation (introduction year, cost, weight, fuel economy, etc.):

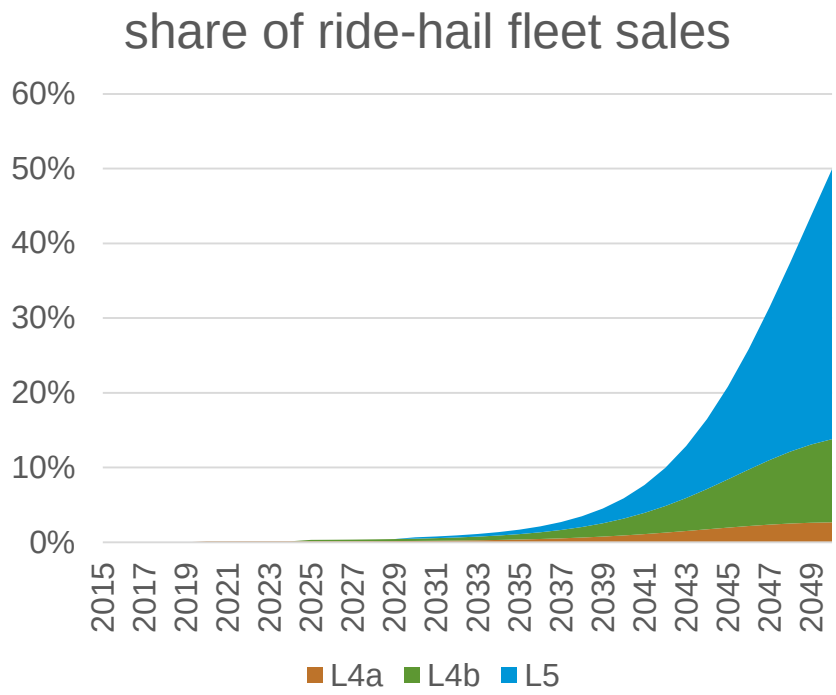
automation level	description
Level 1	driver assistance technology
Level 2	partial automation technology
Level 3	conditional automation technology
Level 4a	low speed (<35 mpg) operation in limited geofenced areas such as urban centers
Level 4b	full speed operation in limited geofenced areas such as limited access highways
Level 5	fully autonomous vehicle that can operate on all roads and all speeds

Recent modeling focus–and the economics of ride-hailing fleet adoption

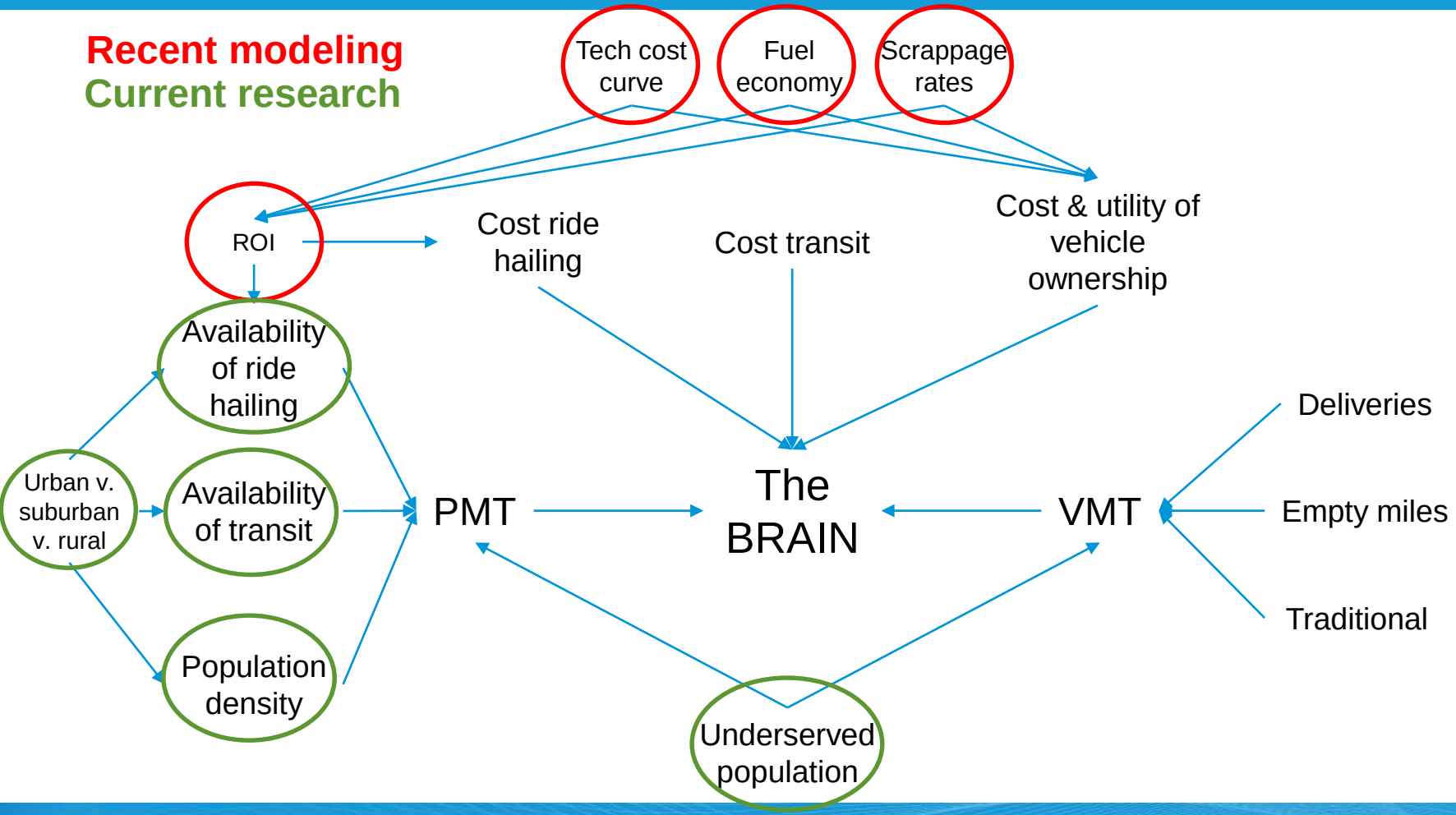
- Separates taxi fleet (taxi and future Transport Network Companies) with unique VMT and scrappage curves
- Economics of adoption:
  - **Return on Investment (ROI)** as net present value (NPV) of fare revenue minus operating cost (driver, revenue miles, data costs, etc.)
  - **Logit function** adoption with (dis)utilities related to new technology and operational domain parameters
  - **Technology cost**:
    - LiDAR system (low-resolution and high-resolution) as experience function with time-based R&D
    - HAV system as time-based R&D function

Example of highly automated vehicle cost and sales into ride-hailing fleet



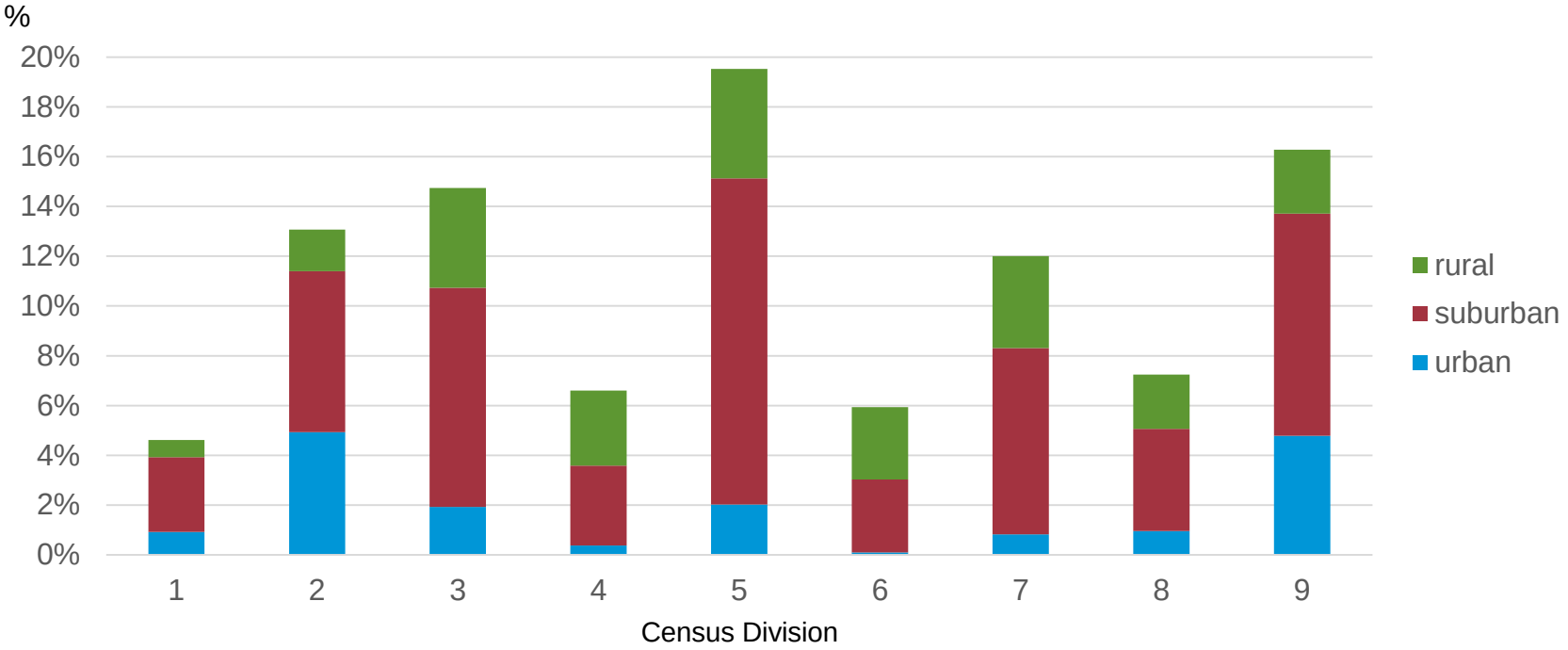


Recent modeling
Current research



U.S. population by geographic density and Census Division

Share of U.S. population by geographic density



Source: U.S. Census Bureau, American Community Survey (ACS) 2015

Thank you

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Autonomous Vehicles: Uncertainties and Energy Implications | https://www.eia.gov/outlooks/aeo/section_issues.php#av

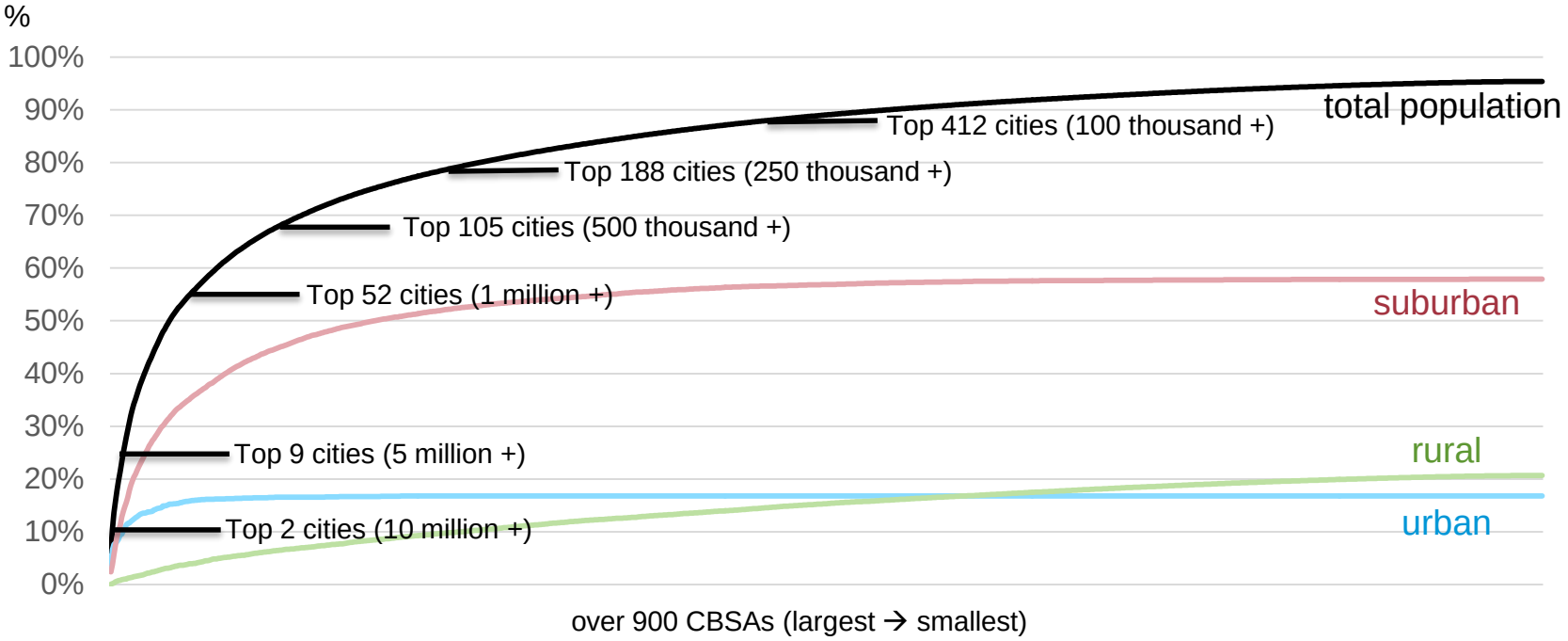
U.S. Energy Information Administration home page | www.eia.gov

Annual Energy Outlook | www.eia.gov/outlooks/aeo

Supplemental slides

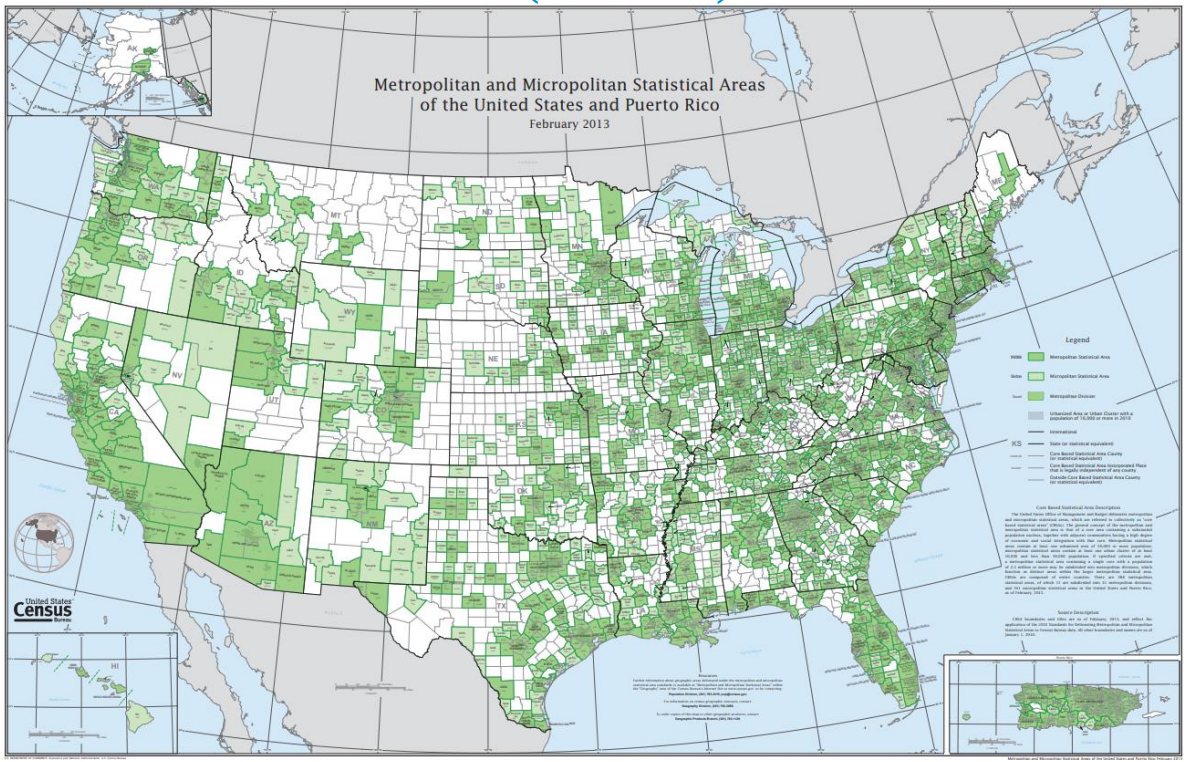
U.S. population living in Core Based Statistical Areas (CBSAs) by geographic density

Share of U.S. population within CBSAs by geographic density



Source: U.S. Census Bureau, American Community Survey (ACS) 2015

Core Based Statistical Areas (CBSAs) define commuter regions



Source: U.S. Census