Insights into Future Mobility:
A report from the Mobility of the Future study

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MIT Energy Initiative

Overview: Mobility of the Future study

The study

- **3-year study;** final report released in November 2019
- Supported by 11 member **industry consortium**
- **Multidisciplinary team** of MIT researchers

Objectives

To better understand the future of **passenger ground transportation**:

- Which **fuels** will be used
- How **technology** may disrupt the status quo
- How **policies** may establish trajectories of change
- How people make **mobility decisions**

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Report from the Mobility of the Future study

1. Impact of global climate change policies on light-duty vehicle fleet composition, fuel consumption, fuel prices, and economic output
2. Outlook for vehicle ownership and travel in the U.S. and China
3. Techno-economic and emission analysis of alternative vehicle powertrains and fuels
4. Feedbacks between provision of infrastructure for charging and fueling and demand for electric and hydrogen fuel cell vehicles
5. Disruptive role of ride-hailing services and autonomous vehicles in urban areas

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Part 1.
Economically optimal pathways to Paris compliance

Global Climate Policy Scenarios

- ***Reference*** – No implementation of Paris Agreement; No additional climate policies
- ***Paris Forever*** – All nations fulfill their Paris commitments by 2030 but no additional action
- ***Paris to 2°C*** – All nations fulfill Paris commitments by 2030 and then implement global economy-wide carbon pricing thereafter
  - Lower battery electric vehicle costs
  - Additional support for renewables
  - Fuel cell mandate

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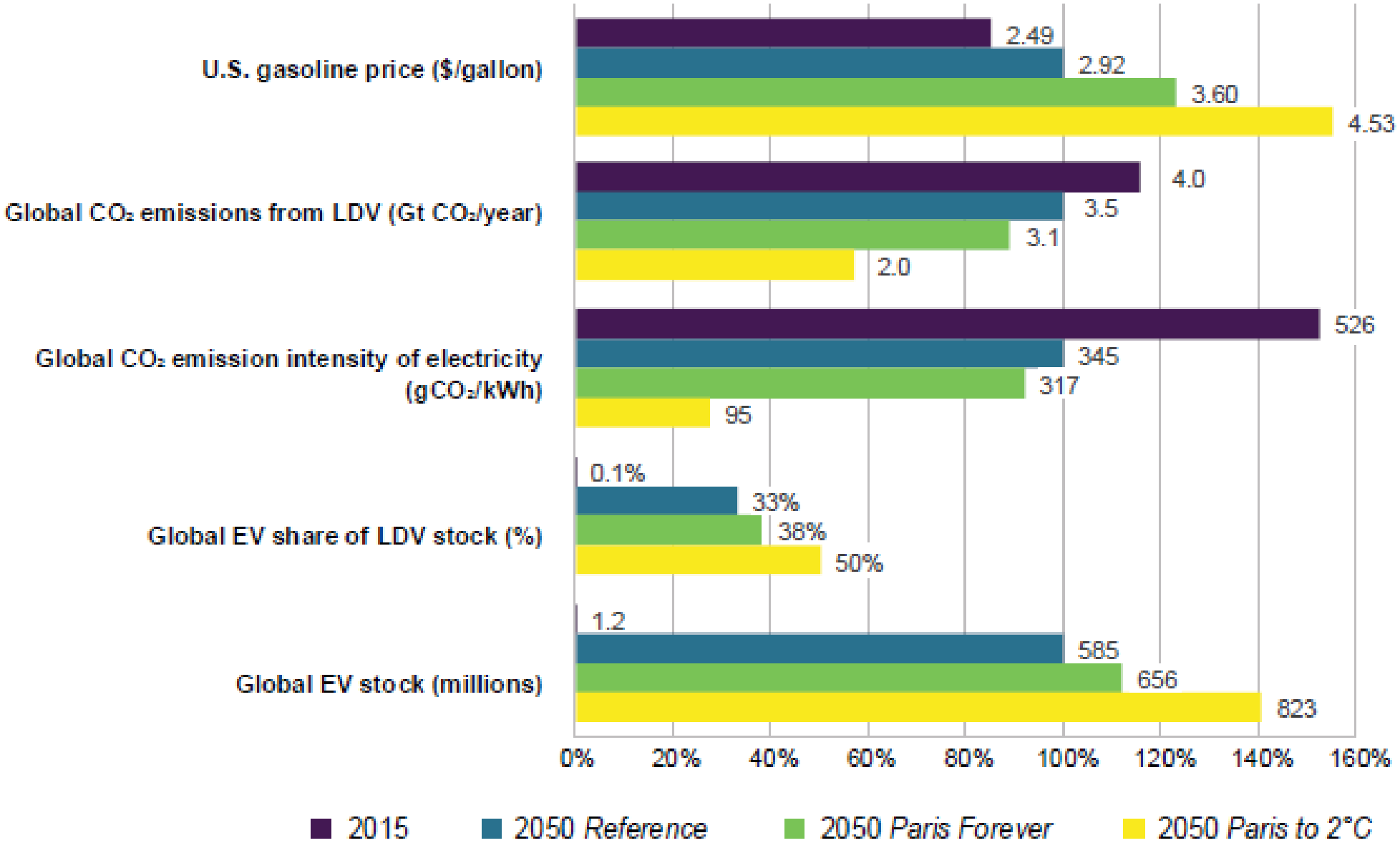
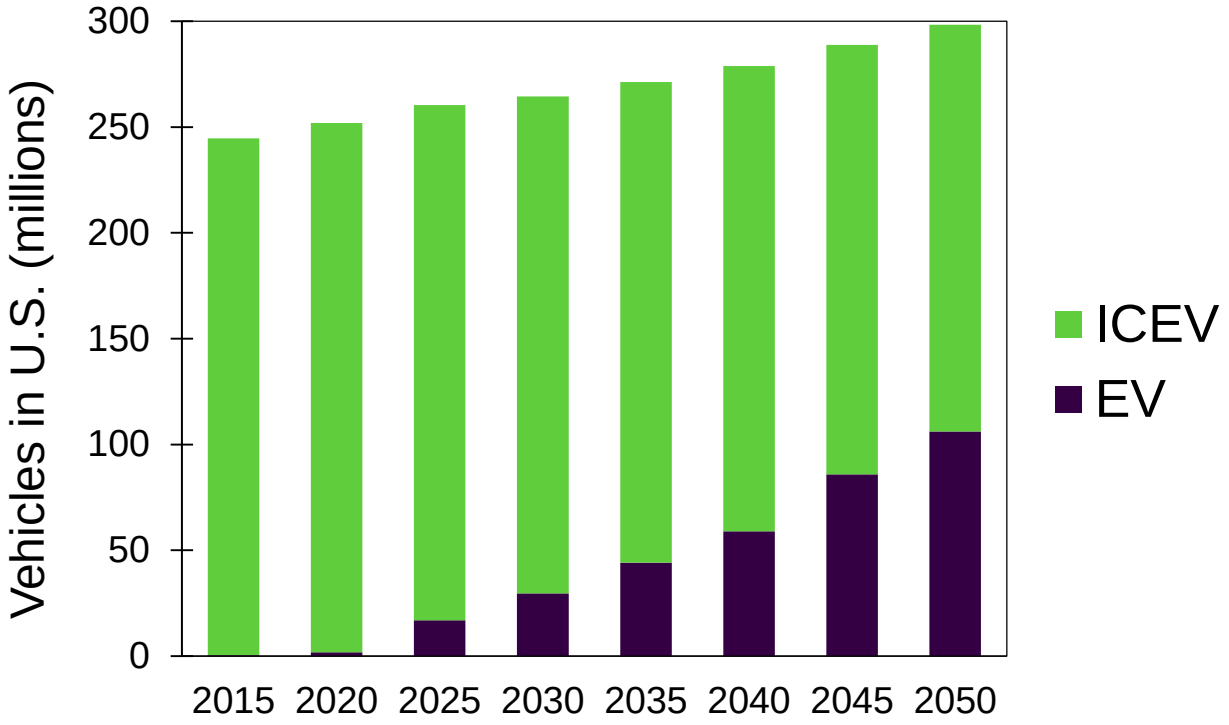
Global Policy Impacts in 2050

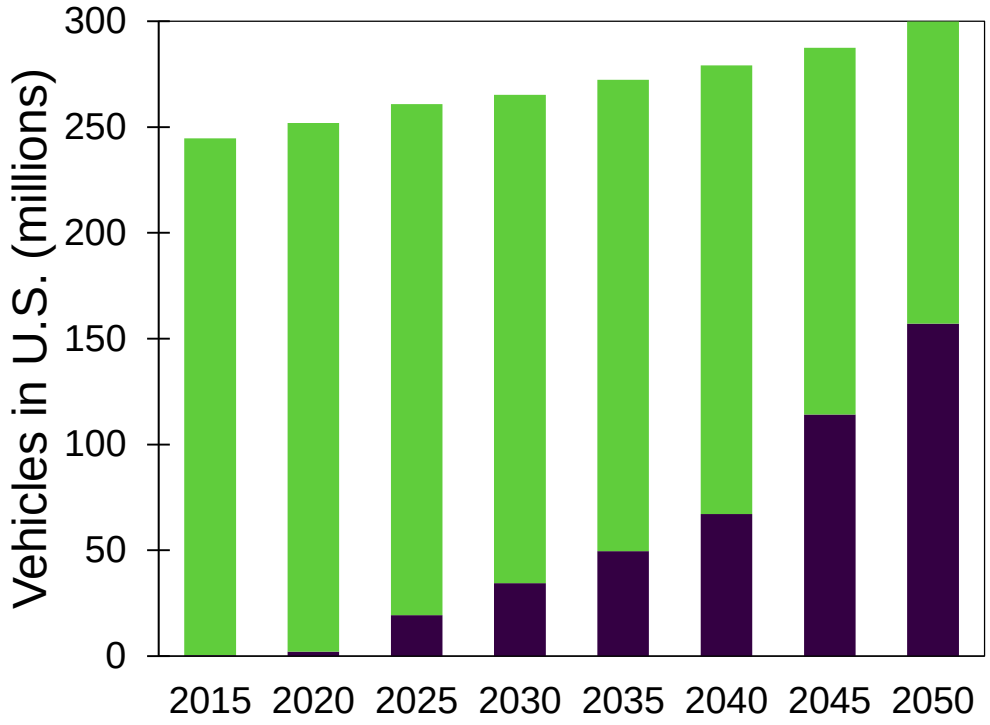


Internal Combustion Engine Vehicles (ICEVs) and Electric Vehicles (EVs) in the United States

***Paris Forever* scenario**



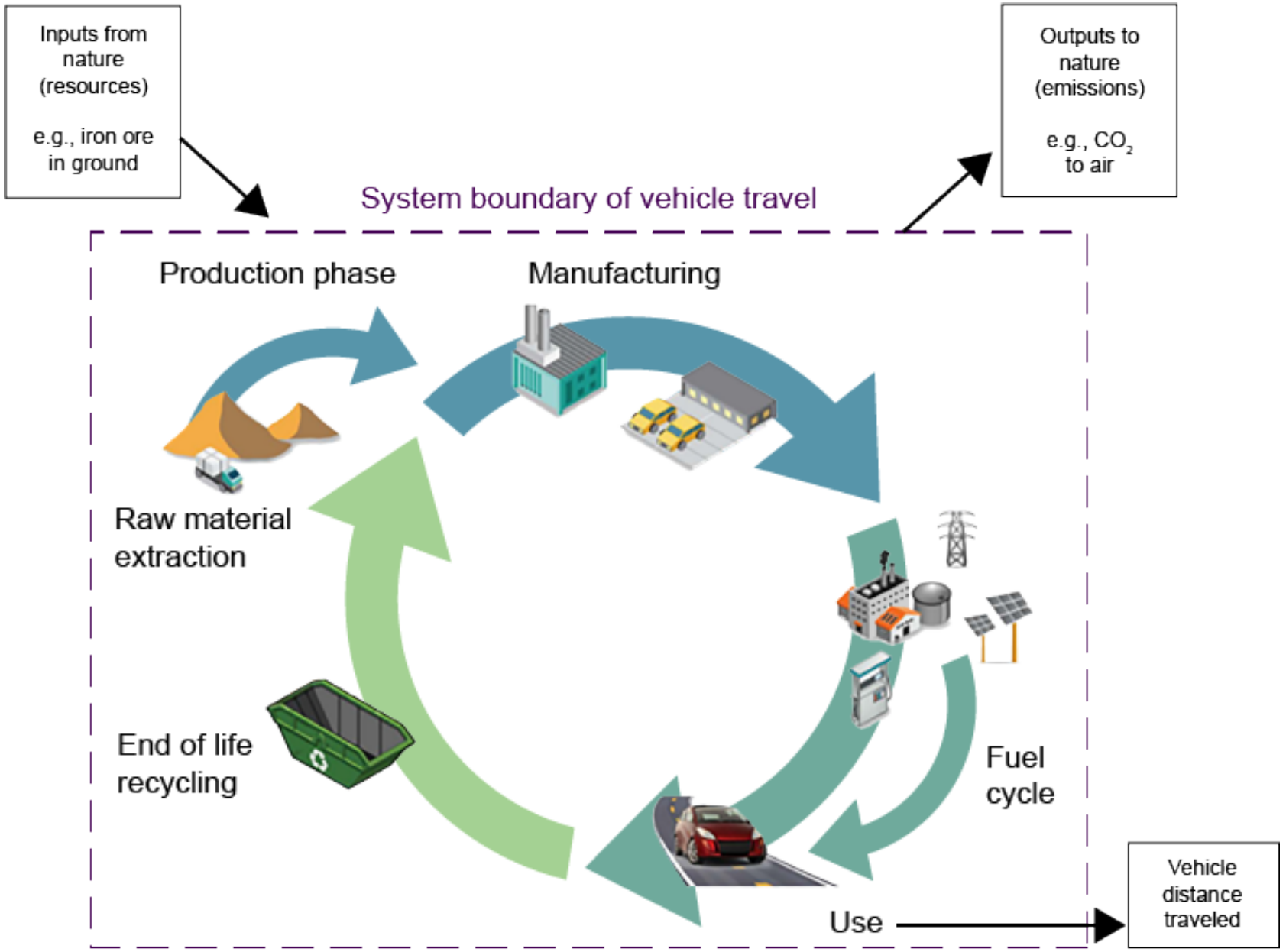
***Paris Forever* with lower EV costs**



- By 2050, USA still has a substantial share of ICEV; these vehicles are projected to have more than 50% higher fuel efficiency than today.

Part 2.
Lifecycle analysis of alternative powertrains

Considering the full lifecycle emissions of the vehicle and fuel

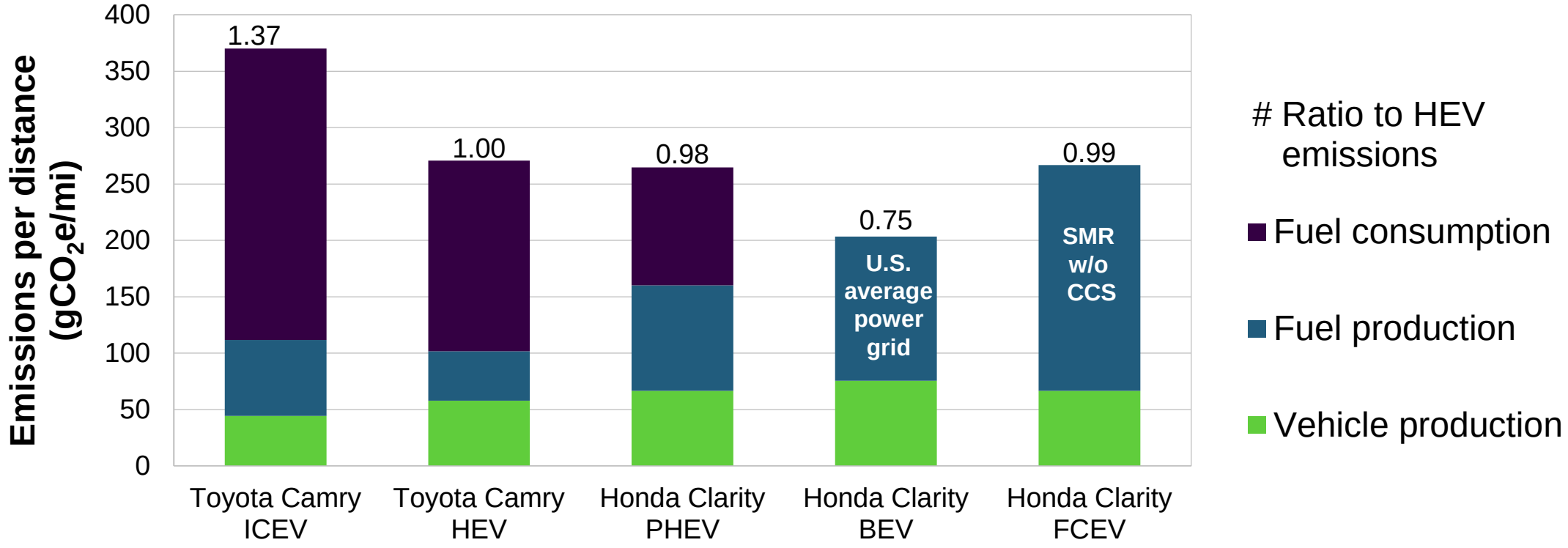


Emissions comparisons:

Similar car models chosen to minimize differences in non-powertrain features

	Toyota Camry ICEV	Toyota Camry HEV	Honda Clarity PHEV	Honda Clarity BEV	Honda Clarity FCEV
					
Interior volume (ft^3):	115	115	117	116	113

Greenhouse gas (GHG) emissions for vehicles with different powertrains in the U.S. today



- **BEV lifecycle emissions are about 55% of comparable ICEVs.**
- HEV, PHEV and FCEV emissions are all similar and fall between ICEV and BEV emissions.
- BEV emissions are based on the average carbon-intensity of U.S. electricity today
- FCEV emissions are based on hydrogen from steam methane reforming (SMR), no carbon capture system (CCS)

GHG emissions for vehicles with different powertrains in the U.S. today are highly sensitive to:

Carbon intensity of the power grid

	BEV/HEV emissions ratio
Nominal: Average U.S. electricity grid with carbon intensity = 436 gCO_2e/kWh	0.75
Lowest carbon intensity electricity grid in U.S. (WA) = 101 gCO_2e/kWh	0.39 (-48%)
Highest carbon intensity electricity grid in U.S. (WV) = 946 gCO_2e/kWh	1.30 (+72%)
Average China electricity grid with carbon intensity = 774 gCO_2e/kWh	1.13 (+51%)

Hydrogen production method

	FCEV/HEV emissions ratio
Nominal: Conventional steam methane reforming (SMR)	0.99
Coal gasification	1.56 (+58%)
Electrolysis with U.S. average electricity	1.49 (+51%)
SMR with carbon capture (CCS)	0.56 (-43%)
Electrolysis with lowest carbon intensity electricity grid in U.S. (WA)	0.62 (-37%)

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Key Takeaways

- Decarbonization of transportation requires ongoing decarbonization of energy supply (electricity and fuels)
- Substantial EV penetration is expected in the light-duty vehicle market in the years ahead, but the rate of adoption is dependent on:
  - Technology (mostly battery) costs and functionality
  - Government policy: consumer incentives, including purchase rebates
  - Recharging infrastructure provision
  - Costs of internal combustion engine vehicles and gasoline/diesel fuels
- ICEVs are not going away overnight, so continued improvement in their fuel efficiency is part of the solution

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