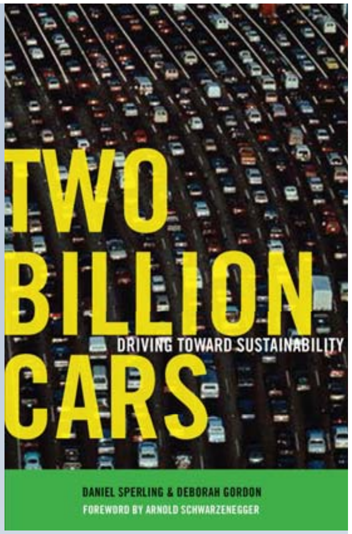

How to Achieve 80% Reduction in Transportation GHG Emissions by 2050

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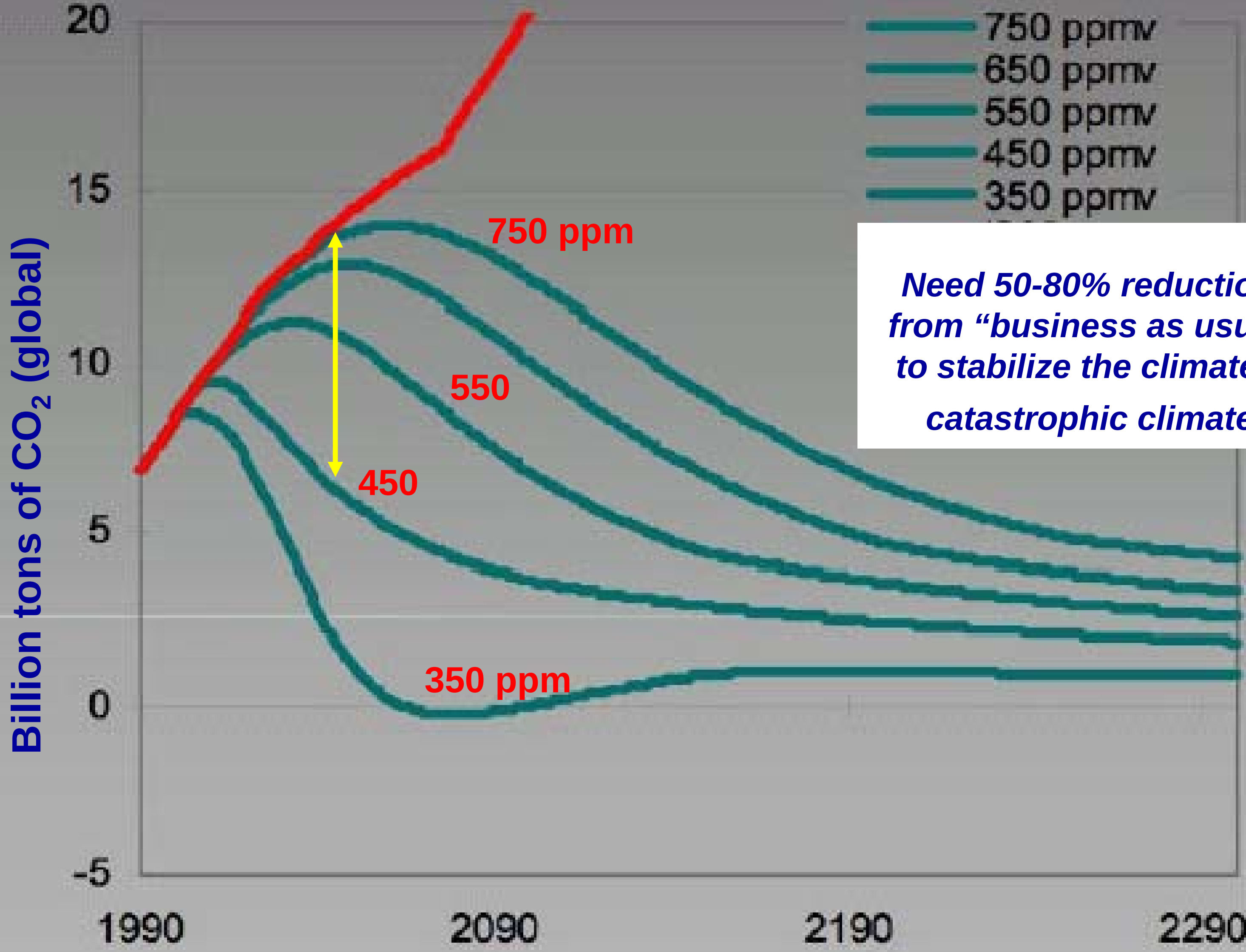
Humans Need to Dramatically Reduce CO_2 Emissions to Stabilize the Climate



Need 50-80% reduction in GHGs from "business as usual" by 2050 to stabilize the climate and avoid catastrophic climate change.

Source: IPCC

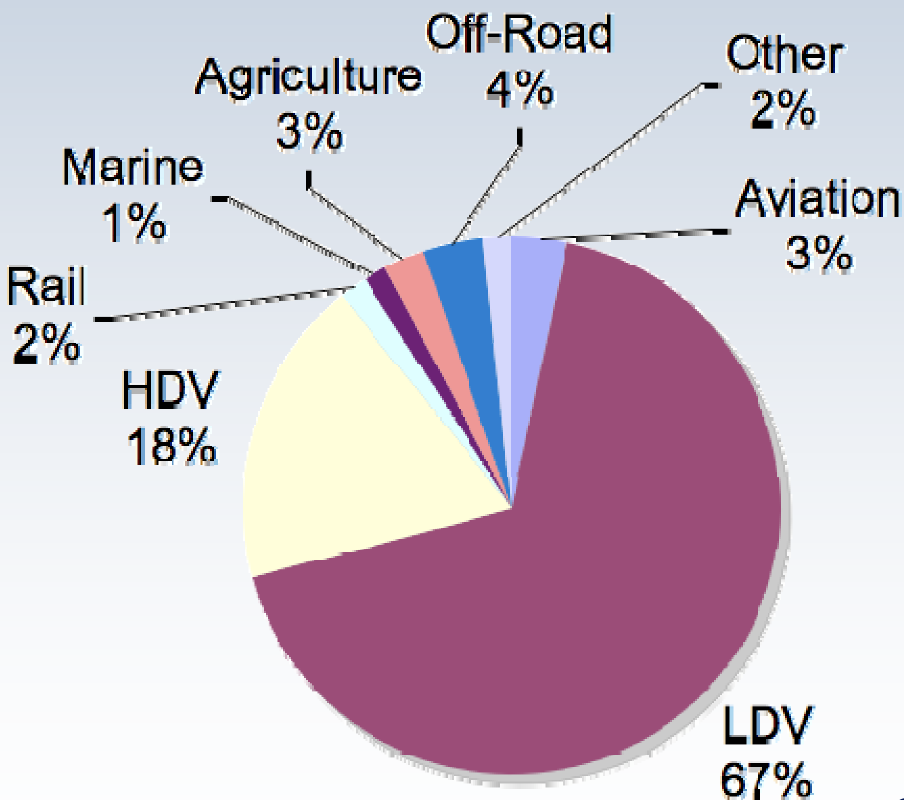
80in50 Project Goals

- Provide snapshots of what 80% reduction in transport could look like

- Provide a simple tool (emissions calculator) that helps explore …
  - Most important areas to target
  - Results and tradeoffs from different assumptions
  - Role of different strategies and policies in reducing GHG emissions from transport sector

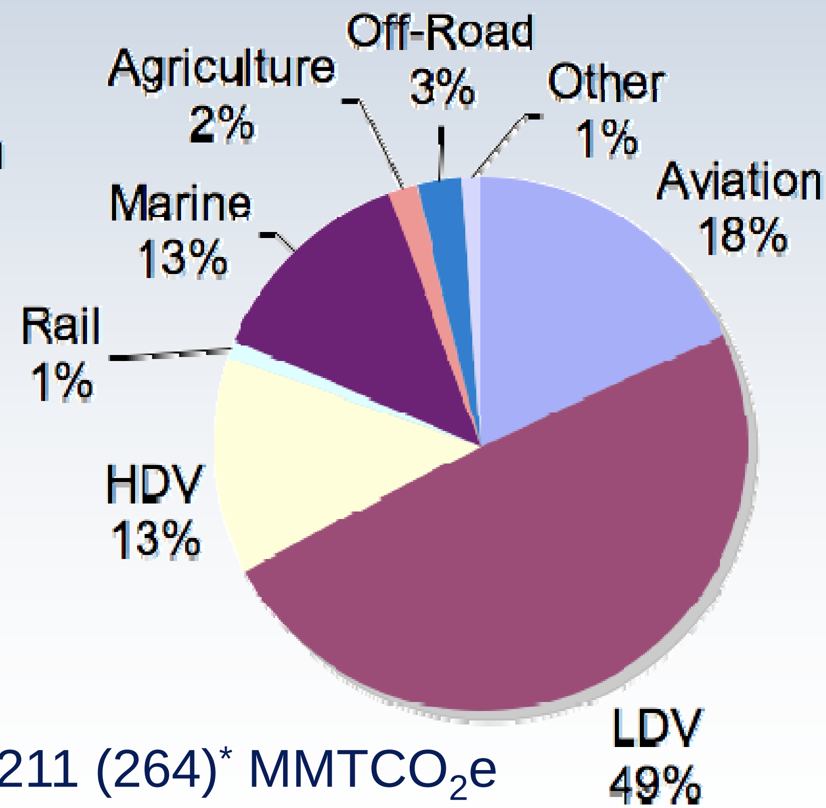
All Transport Activities, California (1990)

"***In-State Emissions***"



152 (193)* MMTCO_2e

"***Overall Emissions***"
(in-state plus ½ out-of-state transport)



211 (264)* MMTCO_2e

Analytical Framework

Kaya decomposition analysis

$$CO_2 \text{ emissions} = \boldsymbol{P} \times \boldsymbol{T} \times \boldsymbol{E} \times \boldsymbol{C}$$

Population California pop.

Transport intensity (e.g., VMT/capita)

Energy Intensity (e.g., MJ/mile)

Carbon Intensity (e.g. gCO_2-eq/MJ)

Each transport sector (e.g. heavy duty), sub-sector (e.g. buses) and individual technology options (e.g. fuel cell hybrid buses) are characterized in terms of these Kaya components

Key Fuel Assumptions

GHG Intensity (g CO_2-eq/MJ)

- Gasoline 95g/MJ
- Biofuels waste (crop/forest residues, MSW): 10g/MJ
- Other biofuels (cellulose and algae): 25g/MJ
- Hydrogen from coal w/CCS 25g/MJ (reduced w/FC)
- Hydrogen from renewables 5g/MJ (reduced w/FC)
- Electricity is 90% decarbonized relative to 1990 (made from mix of renewables, natural gas, coal w/CCS, nuclear)

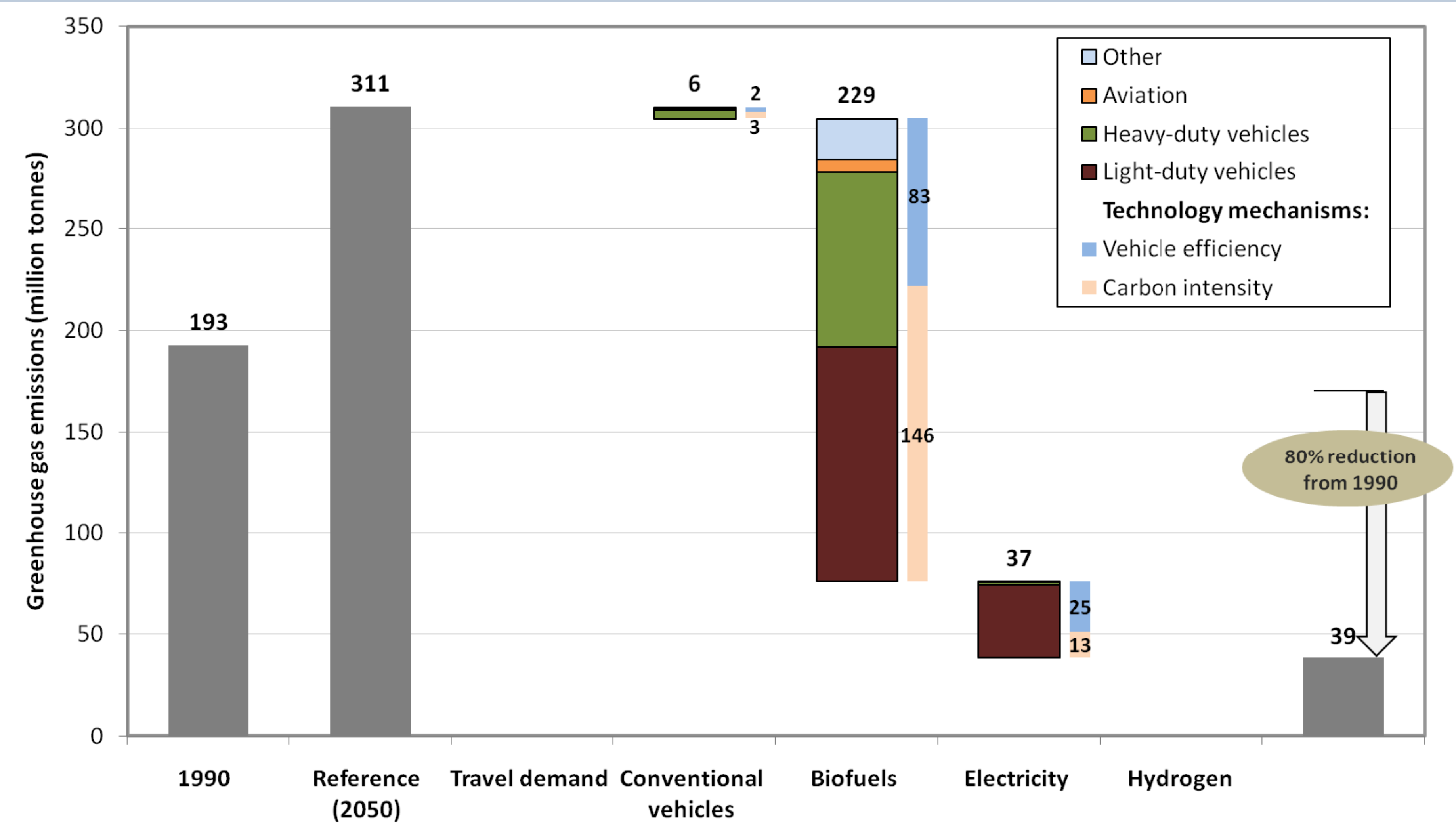
Key Vehicle Assumptions

- HD trucks are mix of hybrids using mostly biofuels and fuel cells using hydrogen
- Most LD vehicles operate on either electricity or hydrogen
- Battery EVs dominate in smaller vehicles
- PHEVs sales greatly expand after 2015 but fade after 2035 (as batteries improve and GHG targets get stronger)
- On-road fuel economy of vehicles in MPG (gasoline-equivalent) in 2050:
  - Gasoline PHEV: 75 mpg-ge
  - H2 FCV: 82 mpg-ge
  - Battery EV: 117 mpg-ge

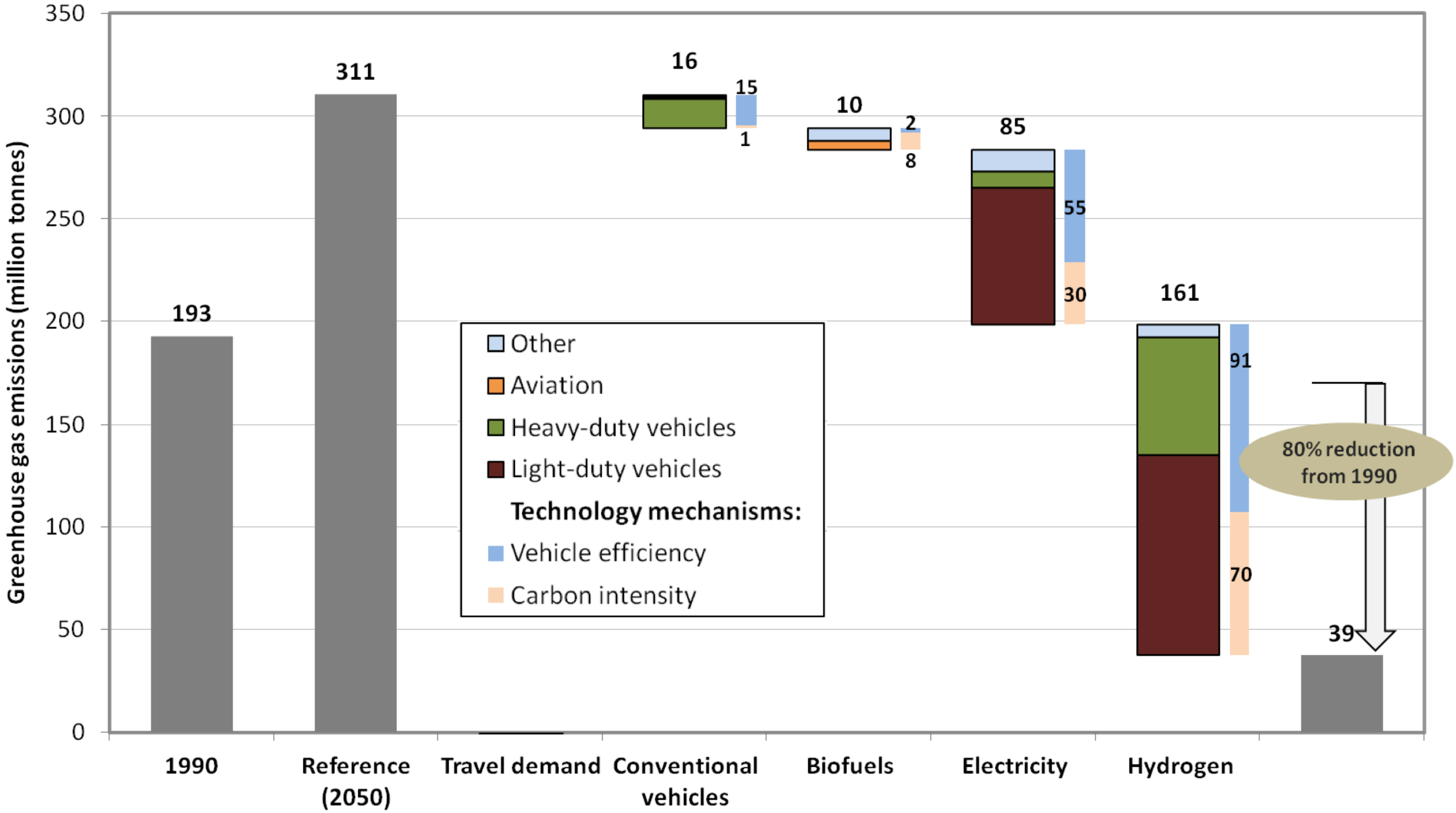
Key Travel Activity Assumptions

- Population increases 35% (85% from 1990)
- VMT/capita decreases 20%
  - 1/4 of reduction is from mode switching and rest from reduced vehicle use
- Large per-capita increase in intercity rail (including high speed)
- In-state air travel decreases (per capita)
- HD truck miles increase (per capita)

Efficient Biofuels 80in50

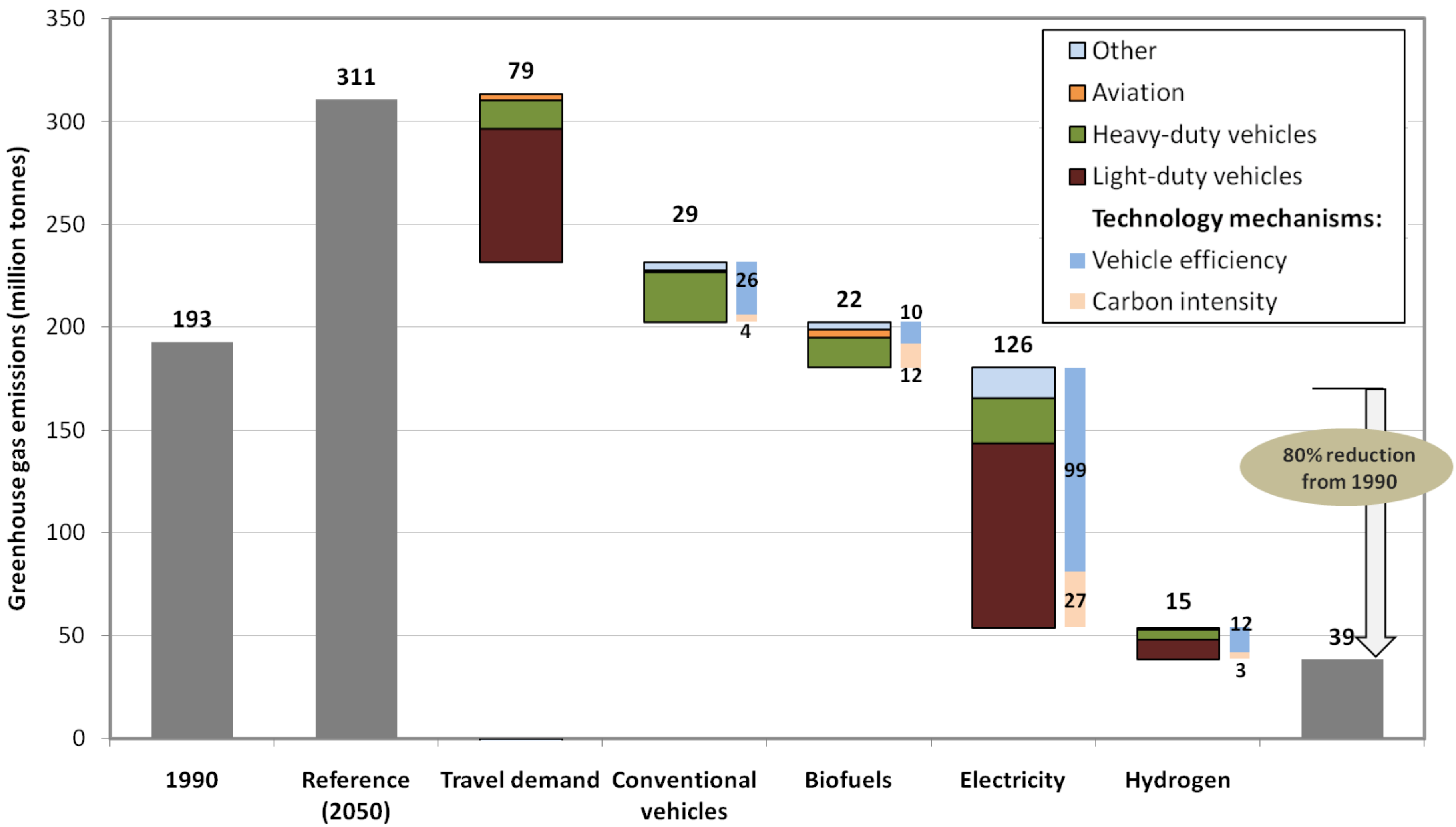


Electric-drive 80in50

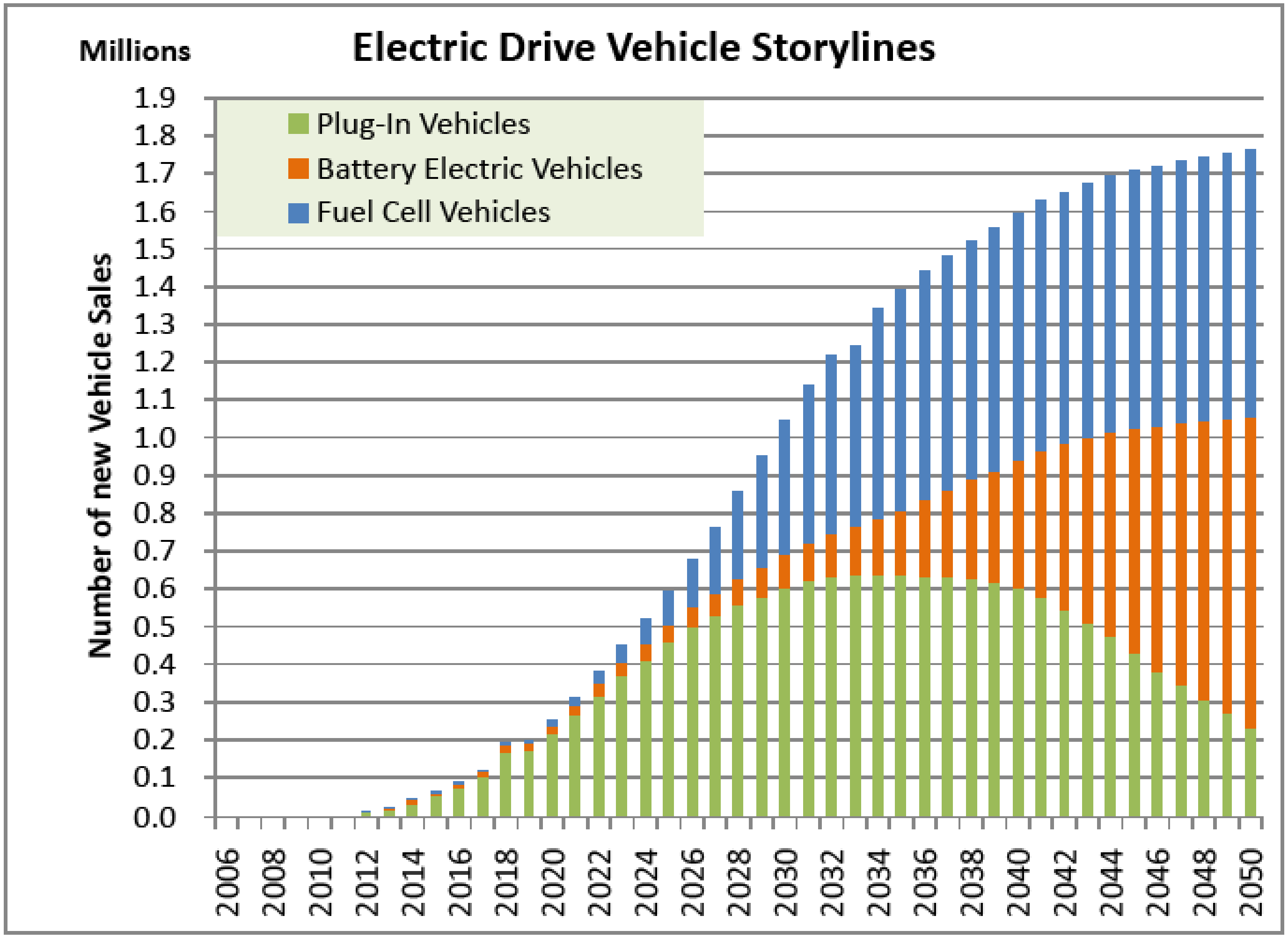


2050 "Portfolio" Scenario

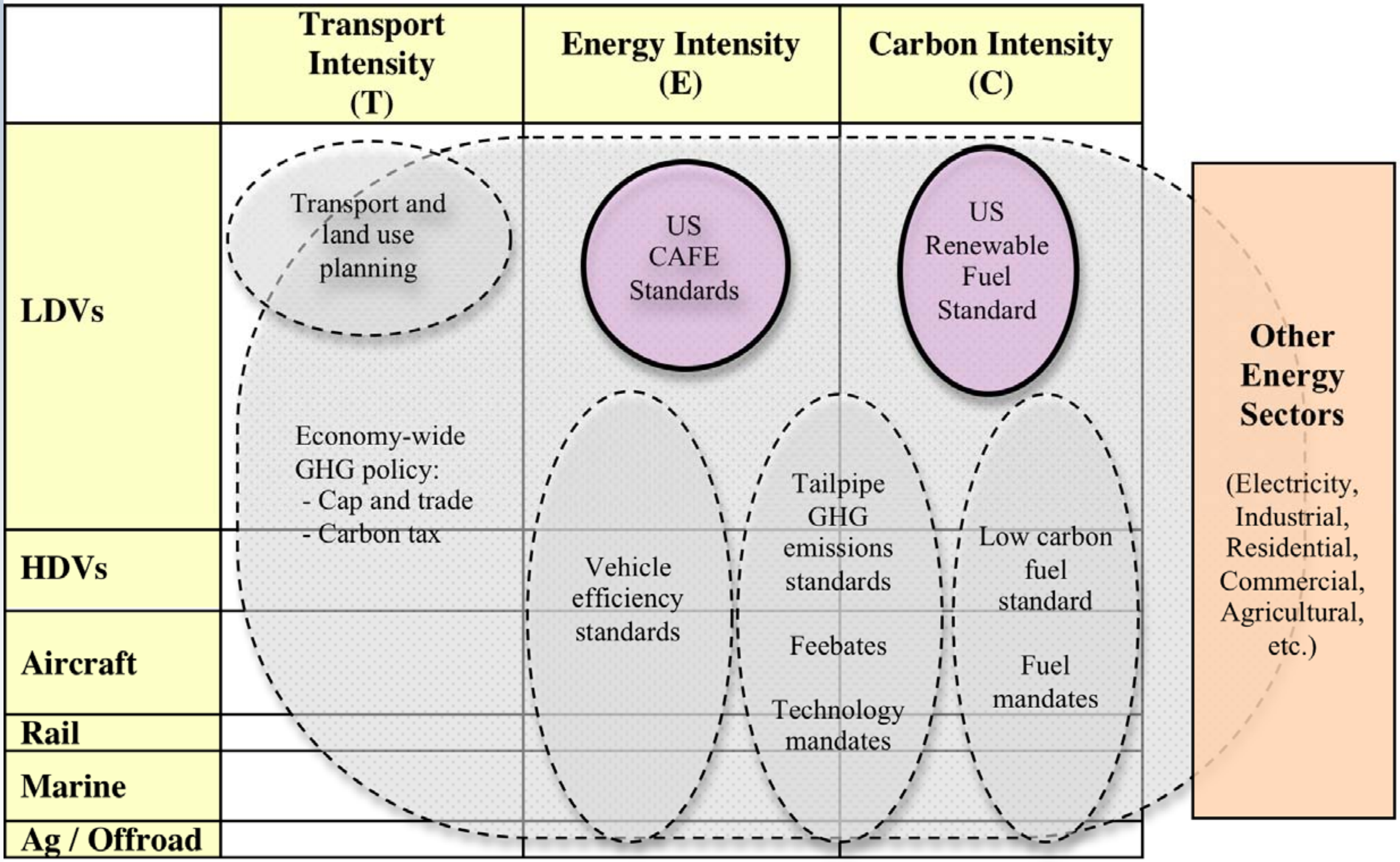
(reductions from business-as-usual forecast)



Virtually All Vehicles in 2050 Will Have Electric Drive Propulsion (BEVs, PHEVs, FCVs)



Policy Mechanisms



Notes:
- Solid bubbles represent current policies. Dashed bubbles are potential future policies.
- Current policies (CAFE and RFS) are not GHG policies, though they do have GHG reduction benefits.
- Size of subsector box indicates relative emissions contribution in 1990 (*Overall* case).
- Economy-wide GHG policies such as carbon taxes or cap-and-trade could potentially cover all subsectors in addition energy sectors outside of transportation

Conclusions

- Meeting 80% reduction goal will be major challenge
  - Need transformation of vehicles, fuels, and transportation systems
- Not all sectors and subsectors should be reduced equally
- Light-duty vehicles tend to be more amenable to large GHG reductions than other vehicles and subsectors
- Many uncertainties affect findings, including quantity of waste biomass available for energy use, costs of future batteries and renewable hydrogen, effectiveness and cost of carbon sequestration, use of hydrogen and electricity in trucks, marine, ag/offroad, and aviation.
- Biofuels are most applicable across all transport subsectors, but are limited by resource availability and often have relatively high GHG emissions (unless made from waste materials).
- Hydrogen and electricity can be made from a wide range of resources, but limited by applicability to some transport subsectors (especially aviation, marine and off-road) and uncertain costs.
- Slowing growth in travel demand is most challenging but has large co-benefits.

For More Detail…

- Christopher Yang, David McCollum, Ryan McCarthy, Wayne Leighty, “Meeting an 80% reduction in greenhouse gas emissions from transportation by 2050: A case study in California,” *Transportation Research D (2009). For background report see http://steps.ucdavis.edu/research/Thread_6/80in50*
- David McCollum, Christopher Yang, “Achieving deep reductions in US transport greenhouse gas emissions: scenario analysis and policy implications,” *Energy Policy* (2010)

THANKS