

PHEVs and Practical ZEVs

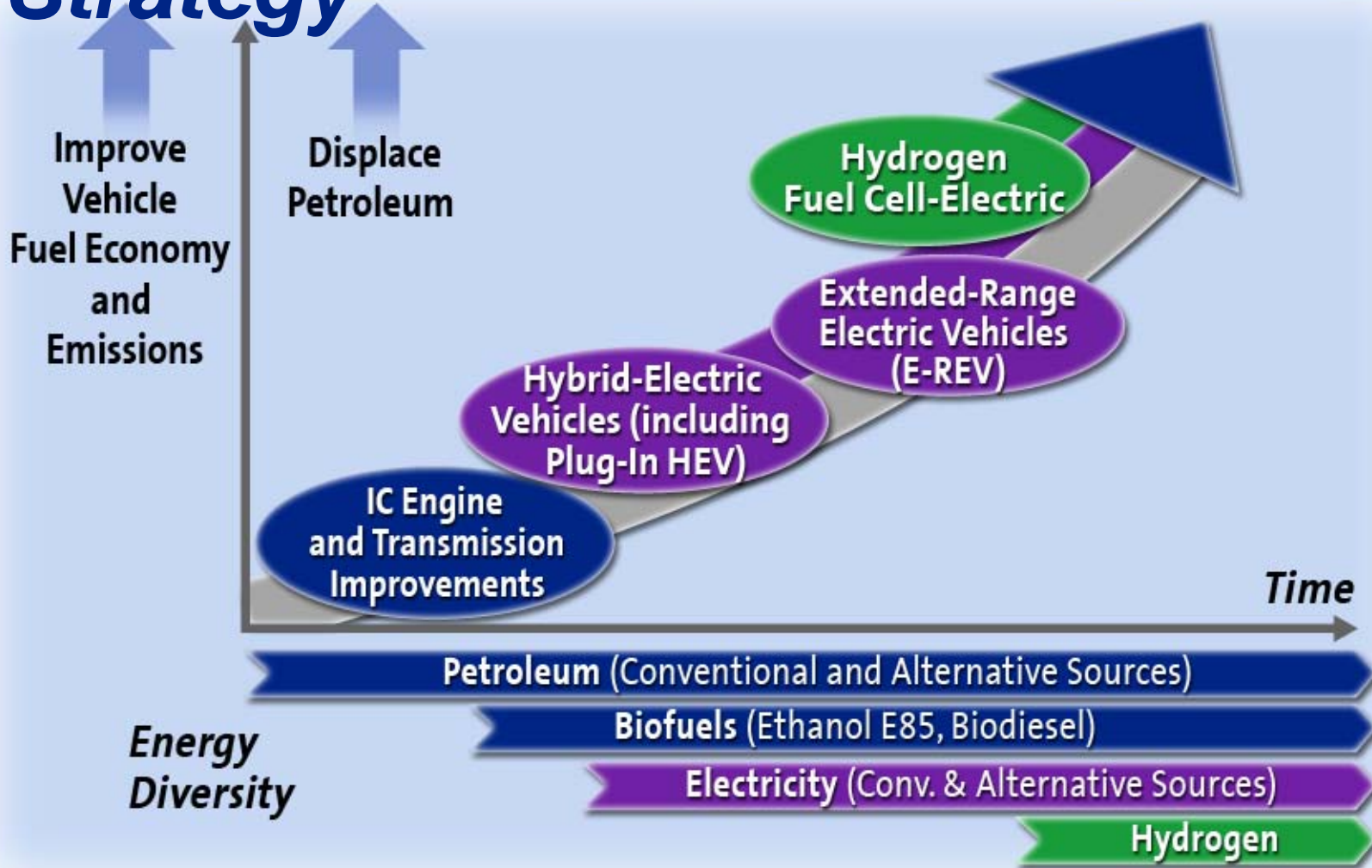


Larry Nitz

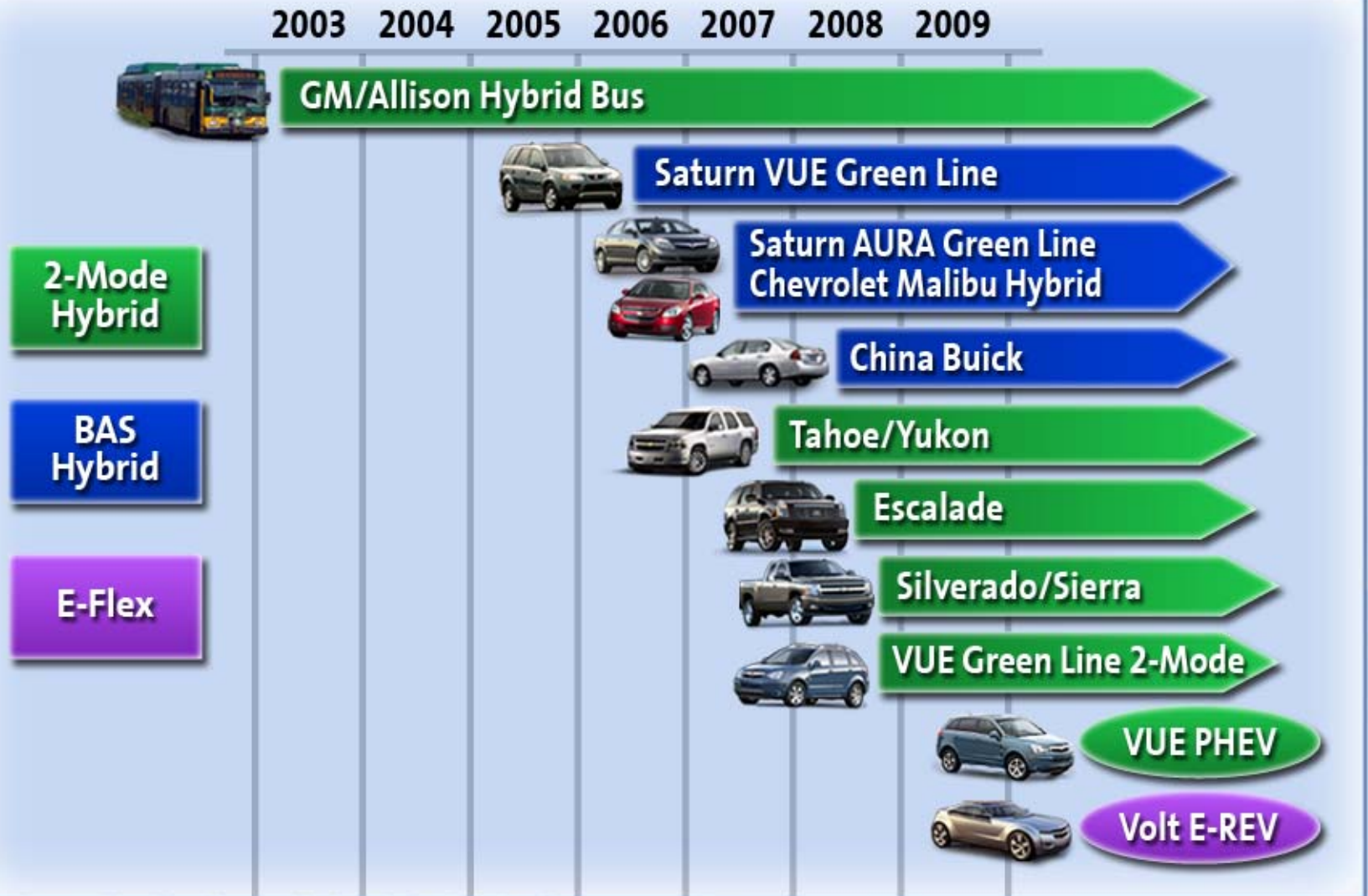
**Executive Director,
Hybrid Powertrain Engineering,
General Motors**

GM

GM's Advanced Propulsion Strategy



GM Hybrid and Electric Vehicles



GM Hybrid and Electric Vehicles

- Portfolio of solutions for a full range of vehicles
- Provide customer choice
 - Mild hybrids – Belt Alternator Starter
 - Full hybrids – 2-Mode Power-split
 - Plug-in hybrids (PHEV) – 2-Mode Power-split
 - Extended-Range Electric Vehicles (E-REV) – E-Flex

Petroleum and Biofuels (Conventional and Alternative Sources)

Electricity – ZEV Fuel (Conven. and Alt. Sources)



BAS Hybrid



2-Mode



2-Mode PHEV



E-REV

Electrification

PHEV and E-REV Philosophy

2-Mode PHEV



Objective:

- Reduce petroleum consumption

Approach:

- Convert hybrids to use grid energy to displace petroleum

E-REV



Objective:

- Create a practical zero emissions vehicle

Approach:

- New propulsion system with full electric performance
- Redefine vehicle architecture to allow packaging of large battery

ZEV Power, Speed and Energy

Case Study of Southern California Drivers

Driver Data:

- Detailed second-by-second data of 621 drivers from 2003 Southern California Travel Survey (mainly Los Angeles)*

Vehicles Analyzed:

- Typical mid-sized sedan



Propulsion Systems Analyzed:

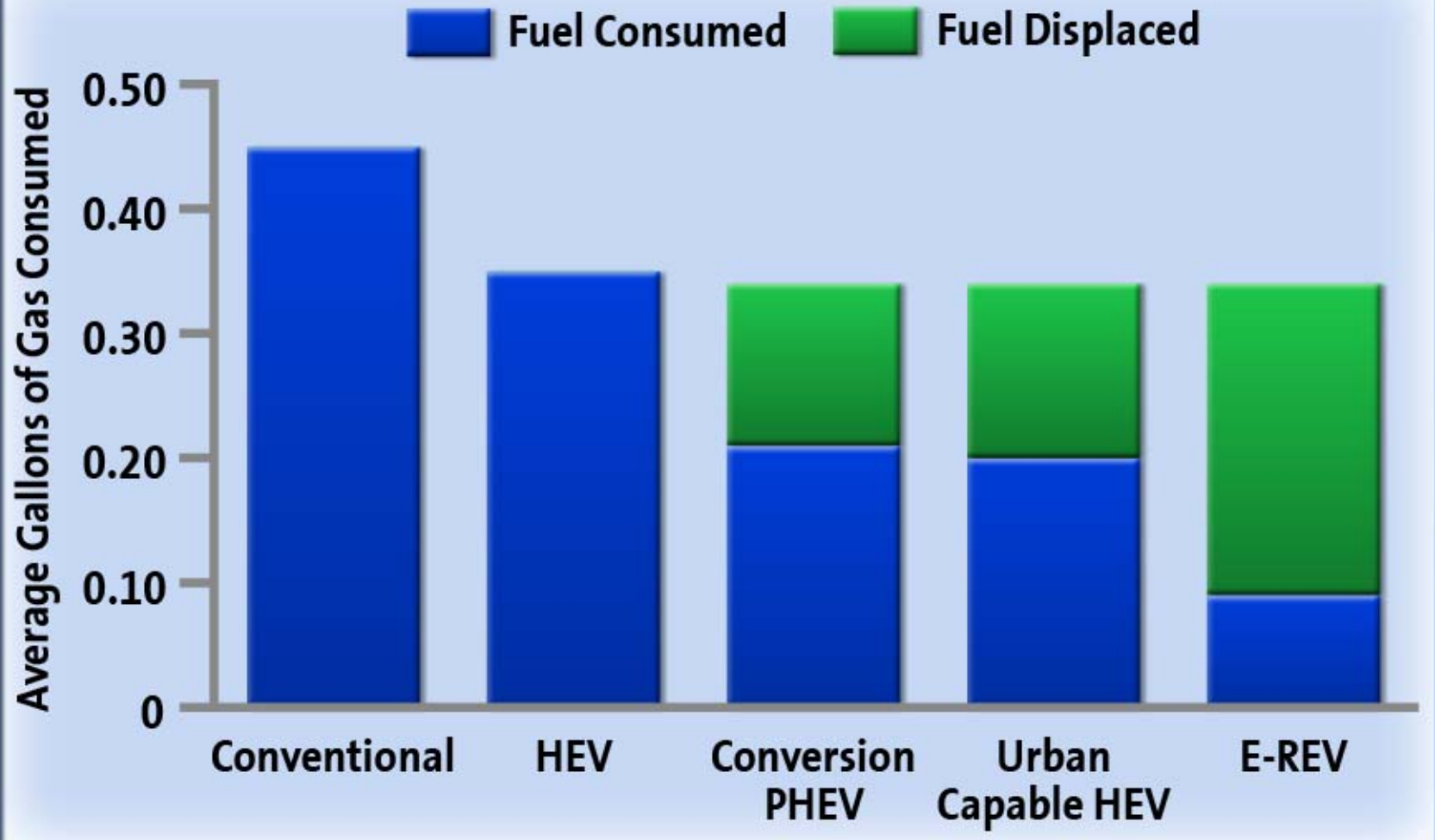
- **PHEVs:**
 - **Conversion PHEV** – Cannot run urban cycle as EV
 - **Urban Capable PHEV** – Can run urban cycle as EV
- **E-REV:** Full performance on all cycles as EV

*SCAG Regional Transportation Survey Data



ZEV Energy

Study Result: Fuel Consumption Reduction

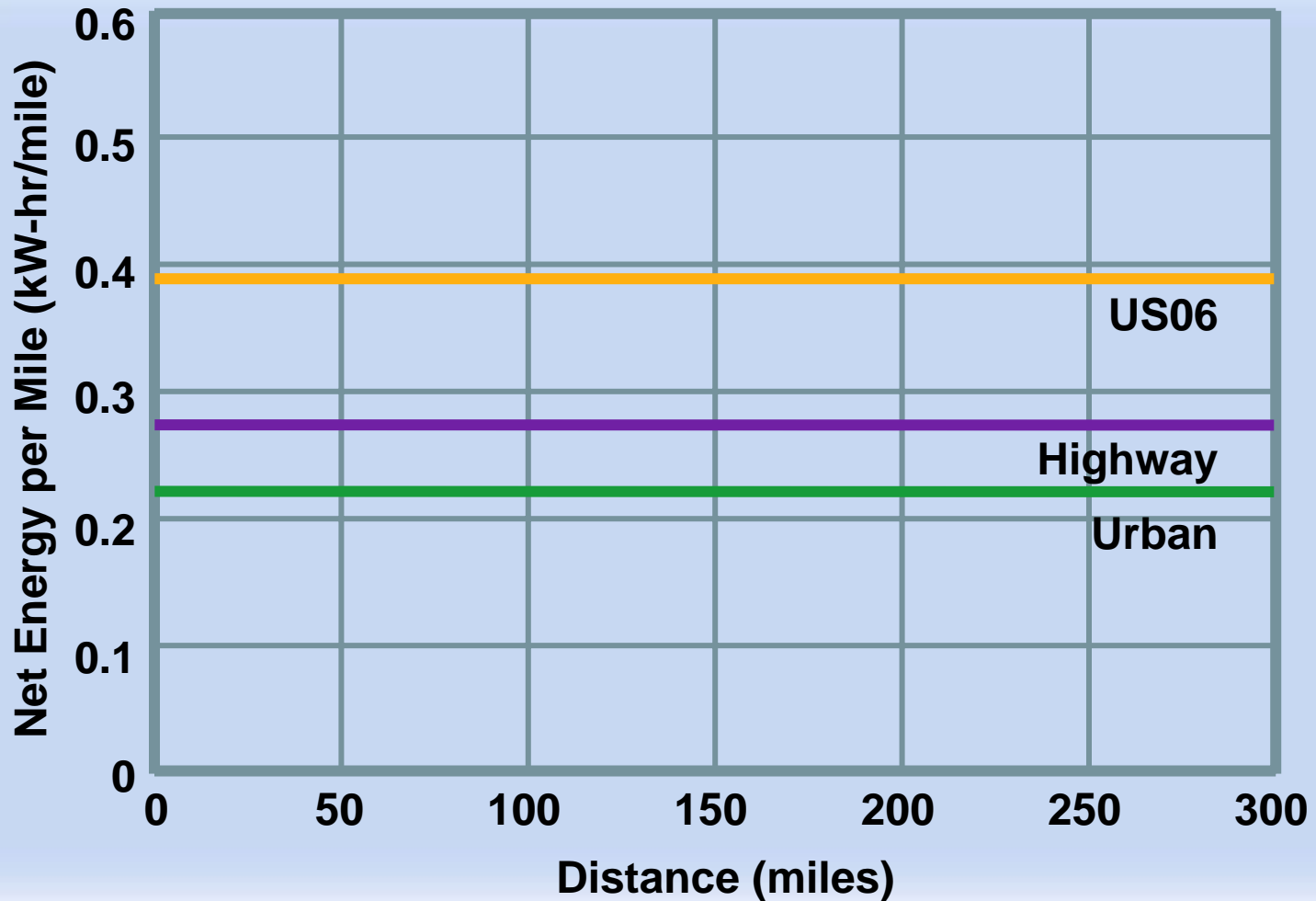


Mid-Sized Vehicle Simulated with Subset of SCAG Regional Transportation Survey Data



ZEV Power and Speed

Study Result: Real World Driving

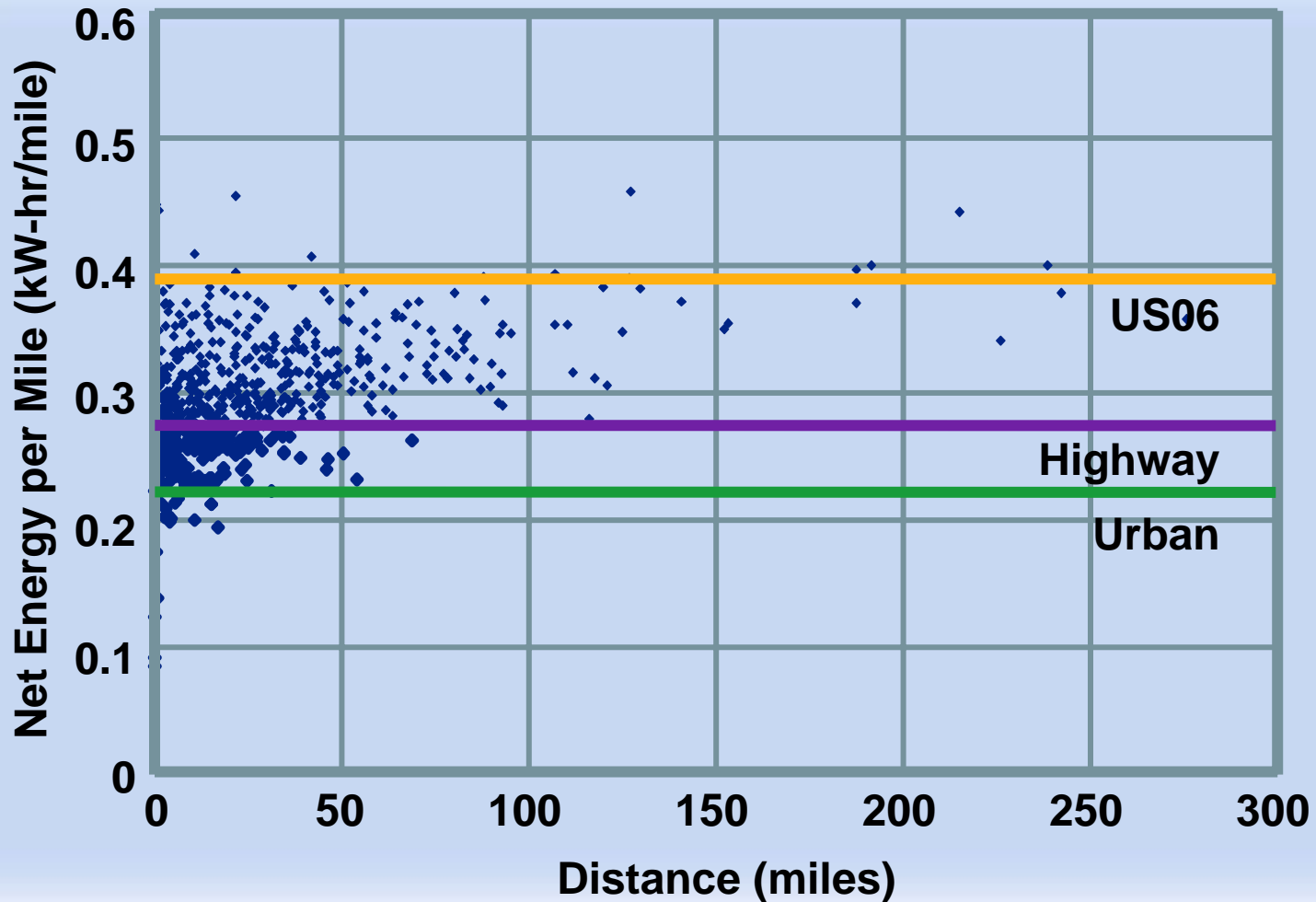


Mid-Sized Vehicle Simulated with SCAG Regional Transportation Survey Data



ZEV Power and Speed

Study Result: Real World Driving

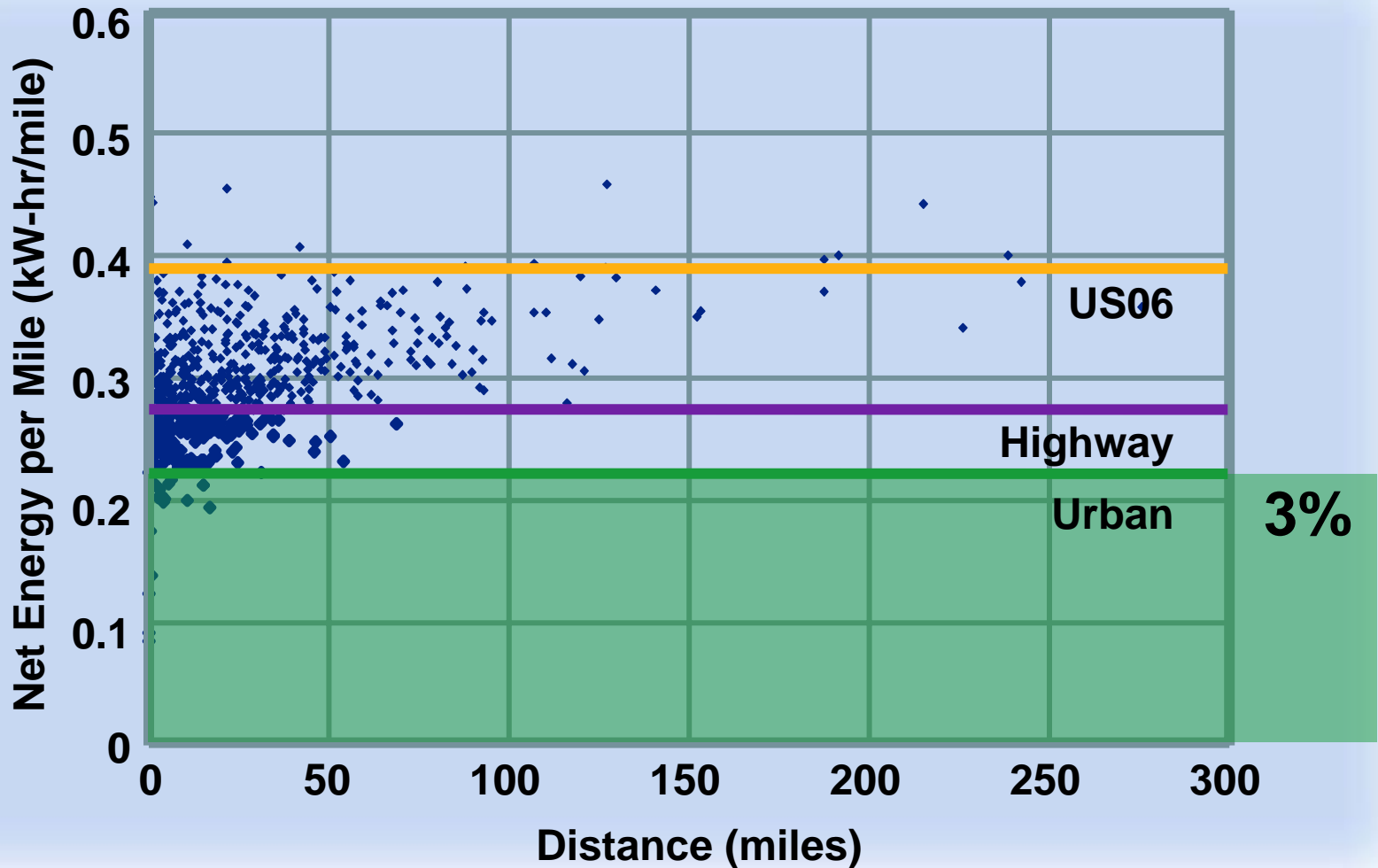


Mid-Sized Vehicle Simulated with SCAG Regional Transportation Survey Data



ZEV Power and Speed

Study Result: Real World Driving

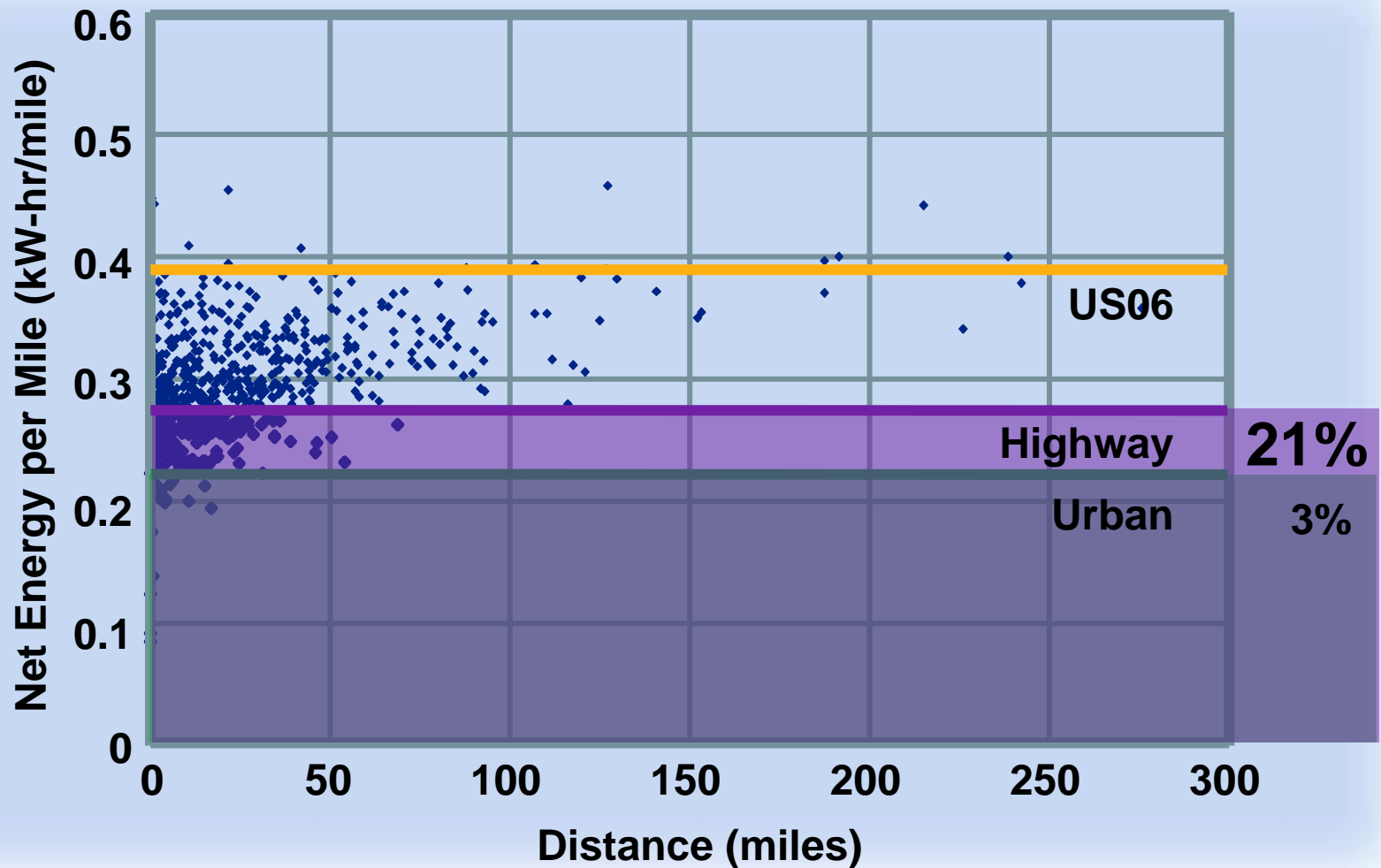


Mid-Sized Vehicle Simulated with SCAG Regional Transportation Survey Data



ZEV Power and Speed

Study Result: Real World Driving

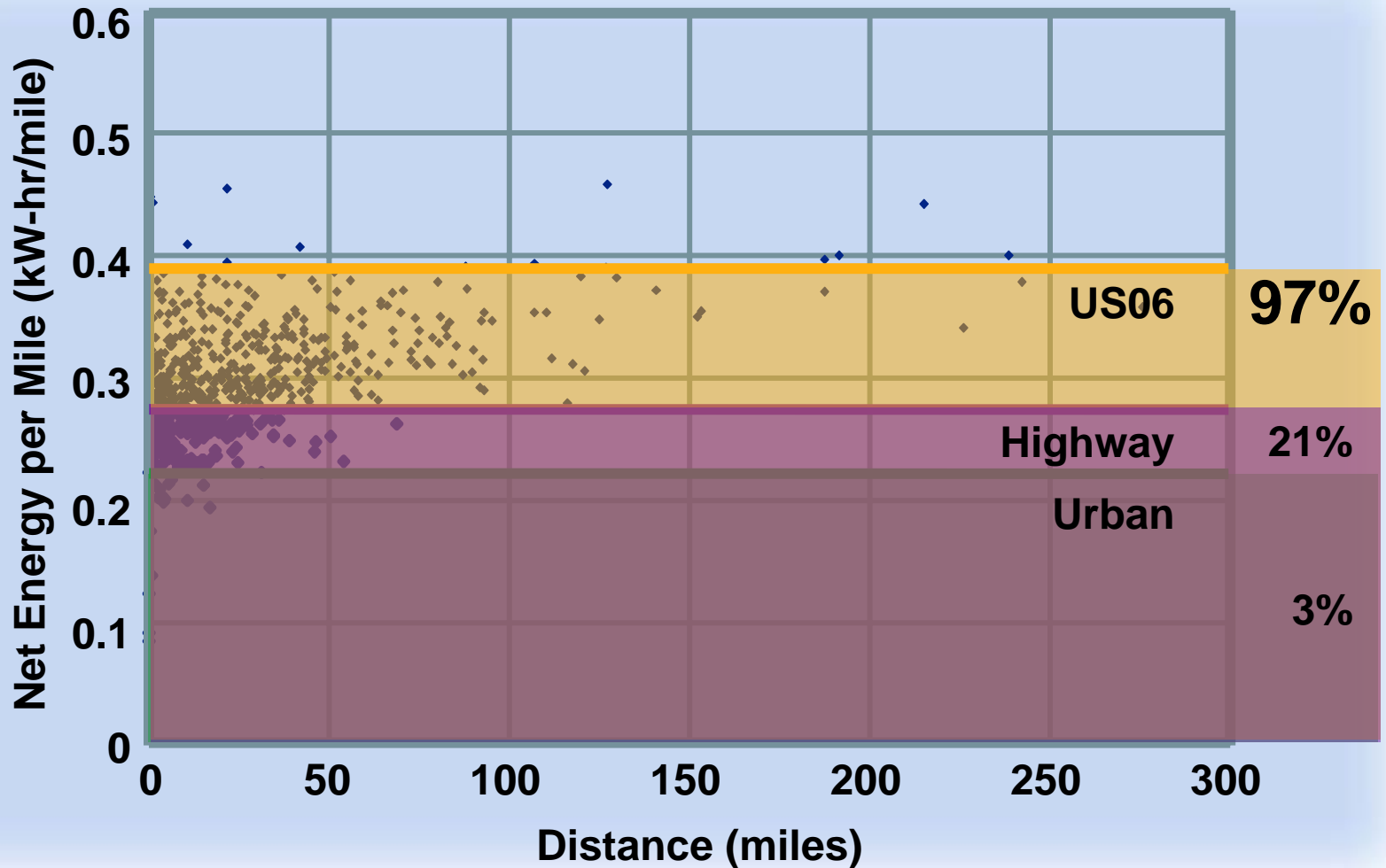


Mid-Sized Vehicle Simulated with SCAG Regional Transportation Survey Data



ZEV Power and Speed

Study Result: Real World Driving

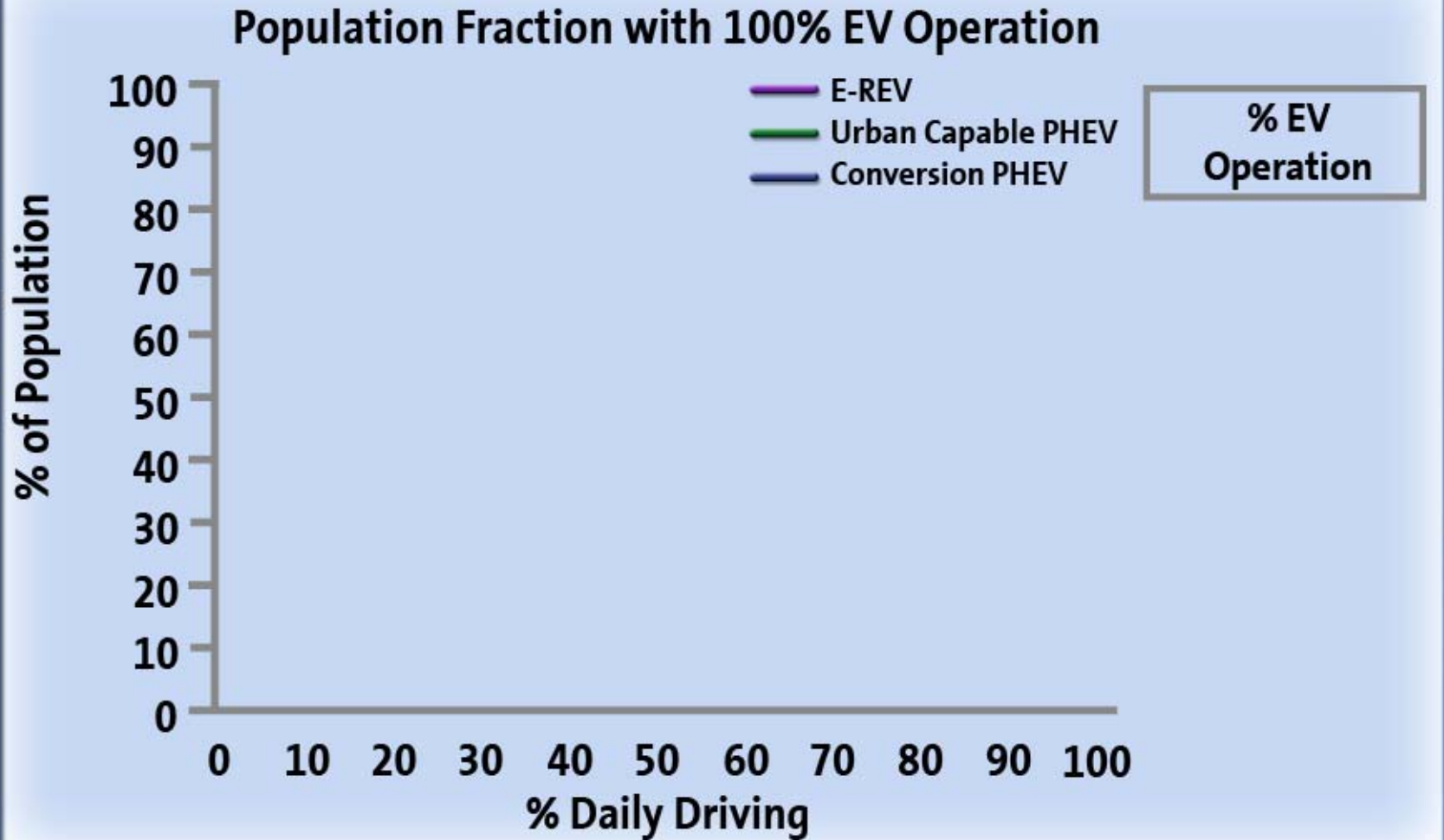


Mid-Sized Vehicle Simulated with SCAG Regional Transportation Survey Data



ZEV Power, Speed and Energy

Study Result: Zero Emission Operation

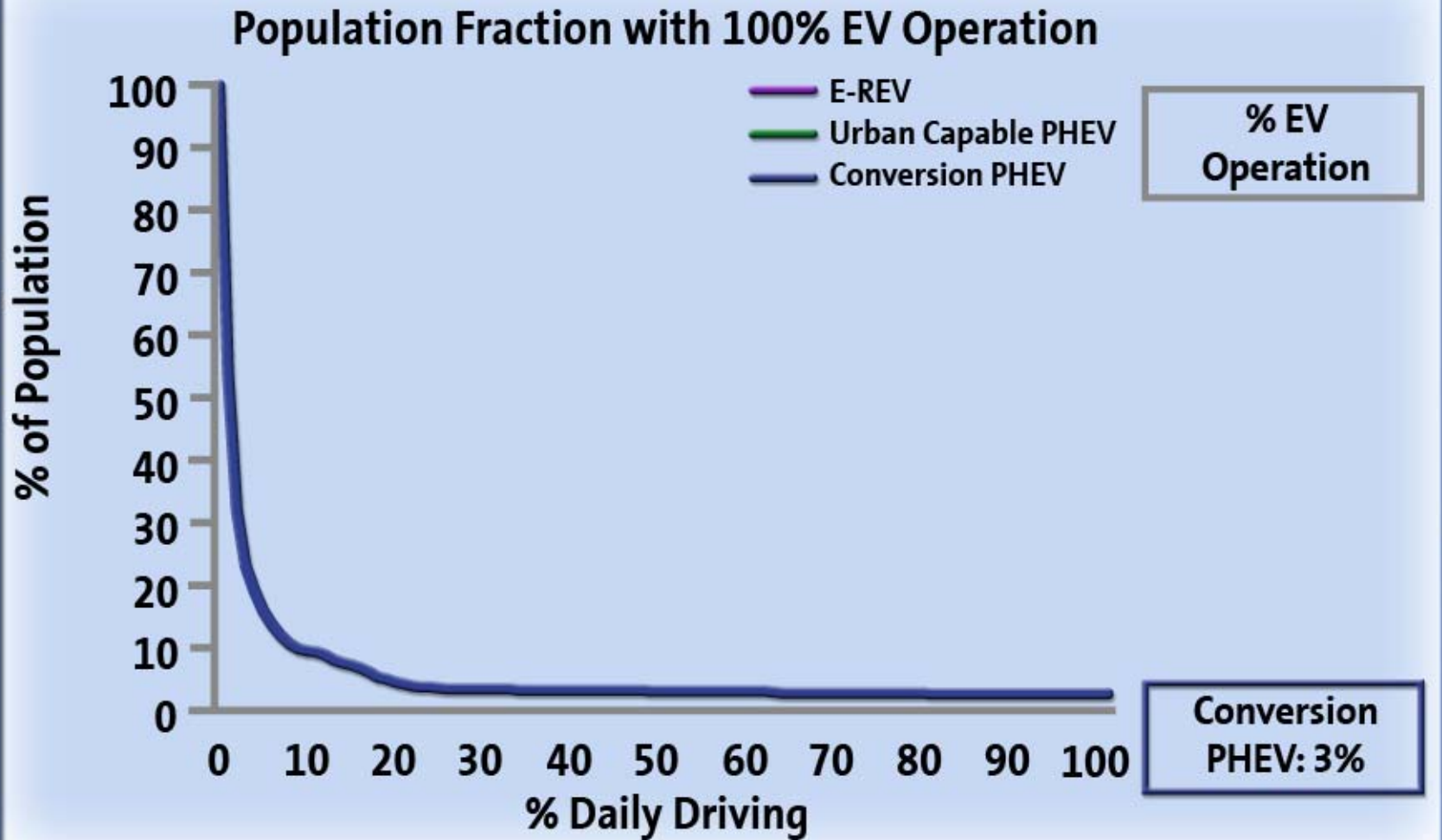


Mid-Sized Vehicle Simulated with SCAG Regional Transportation Survey Data



ZEV Power, Speed and Energy

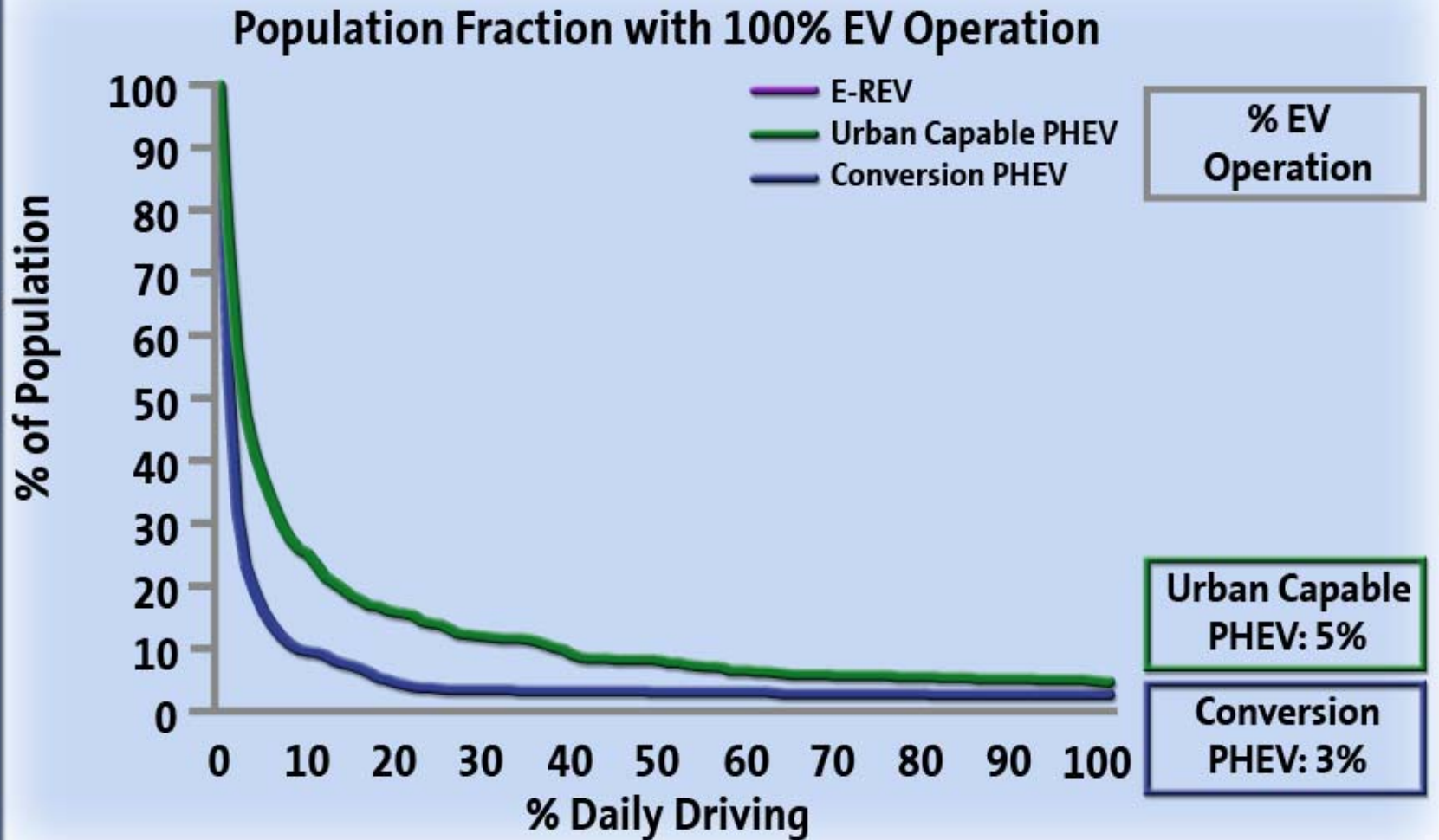
Study Result: Zero Emission Operation



Mid-Sized Vehicle Simulated with SCAG Regional Transportation Survey Data

ZEV Power, Speed and Energy

Study Result: Zero Emission Operation

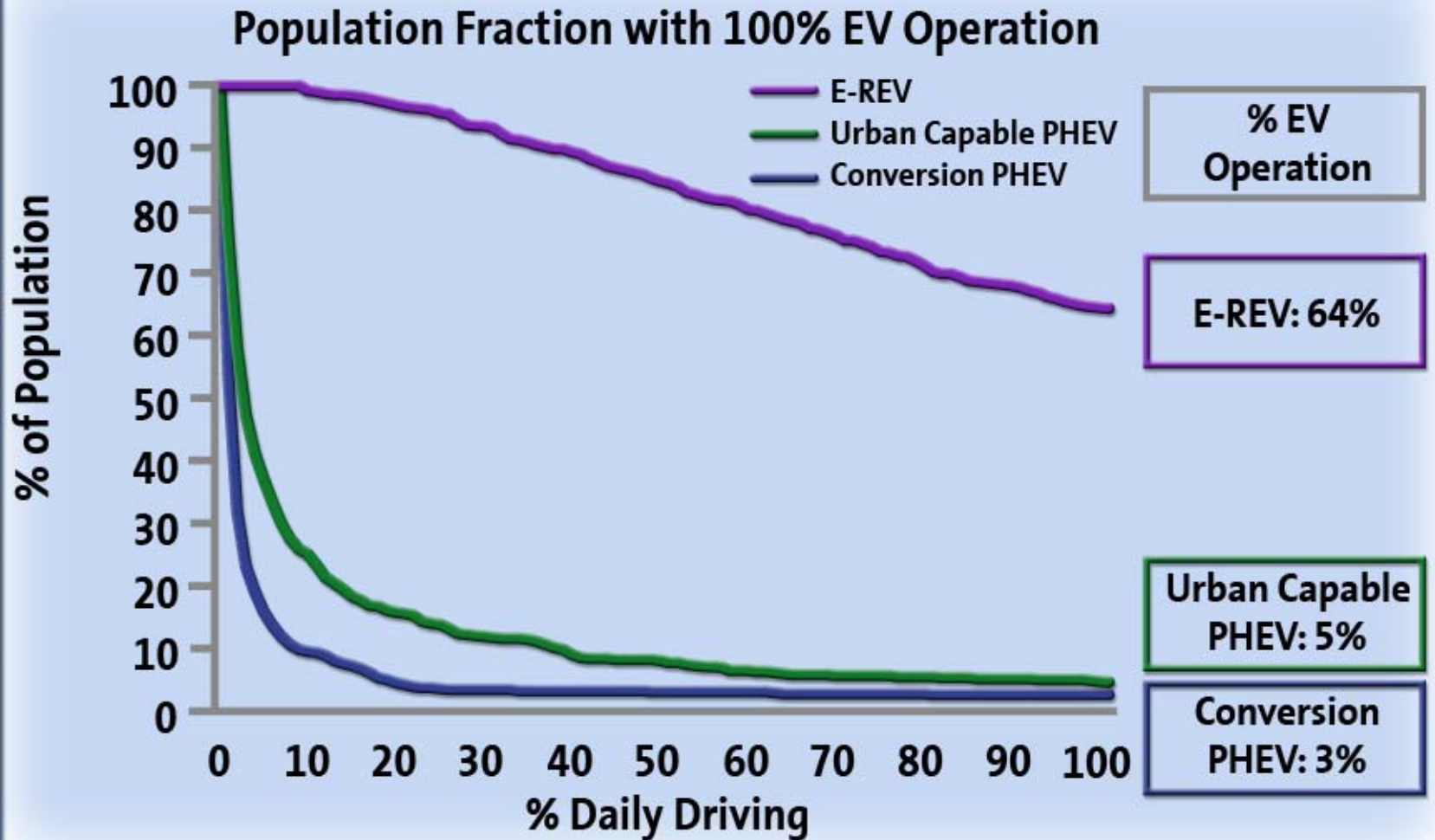


Mid-Sized Vehicle Simulated with SCAG Regional Transportation Survey Data



ZEV Power, Speed and Energy

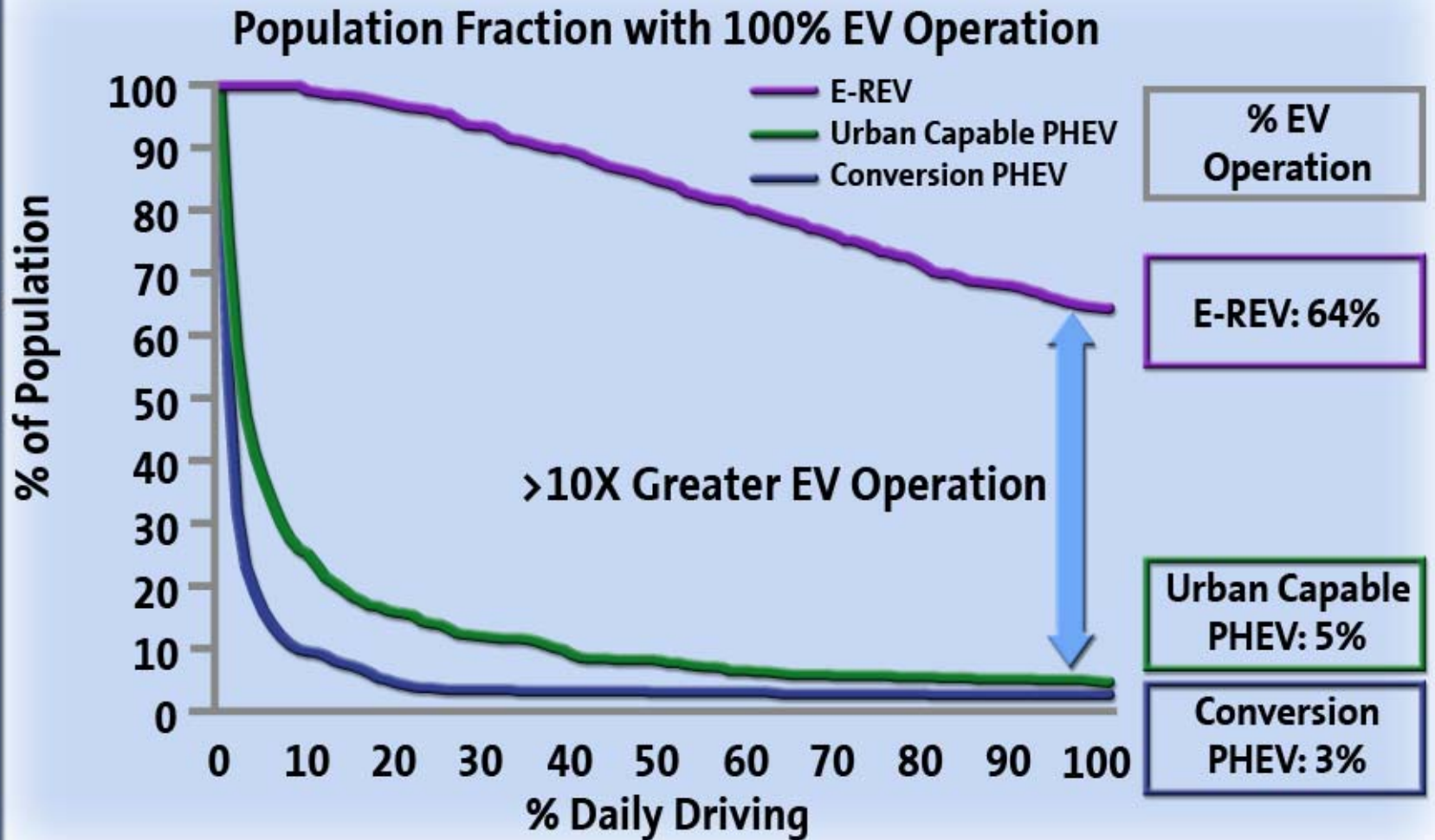
Study Result: Zero Emission Operation



Mid-Sized Vehicle Simulated with SCAG Regional Transportation Survey Data

ZEV Power, Speed and Energy

Study Result: Zero Emission Operation



Mid-Sized Vehicle Simulated with SCAG Regional Transportation Survey Data

Total Range

Building on the Positive EV1 Experience

- Great passion for petroleum-free driving
 - Home charging, fun to drive, quiet and clean
- Broad market appeal required some improvements
 - Functionality required for use as a primary vehicle
 - Flexibility to eliminate “range anxiety”



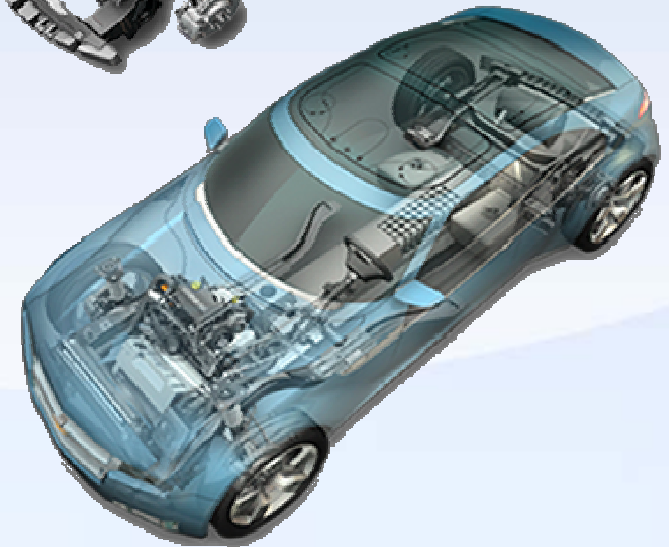
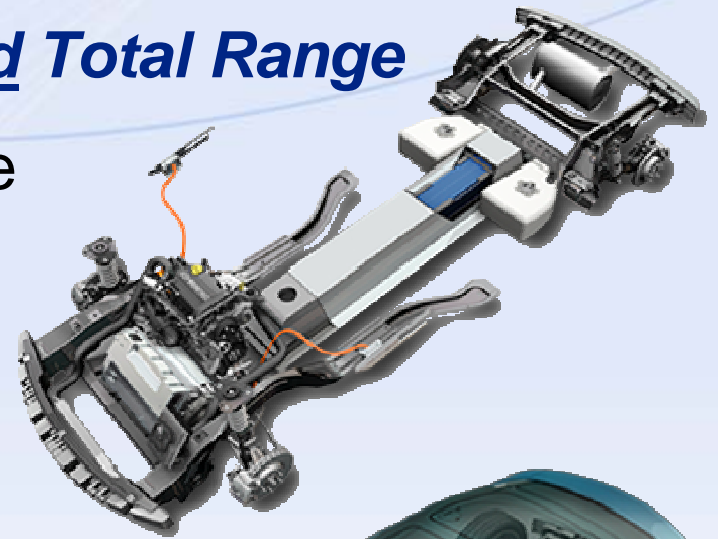
Practical ZEVs need a total range >300 miles
with primary vehicle utility



Practical ZEV

ZEV Power, Speed, Energy and Total Range

- Full performance electric drive
 - 135 kW electric drive
- Four-passenger capacity
- 40 mile EV urban range
 - Li-Ion battery in the tunnel
- >300 mile total range
 - Small efficient gasoline engine
- Recharging with existing infrastructure
 - 110 volt, 15 amp service



VOLT



Summary

- GM has a comprehensive Advanced Propulsion Strategy based on providing customer choice:

HEV: Petroleum Reduction
PHEV: Petroleum Displacement
E-REV: Practical ZEV

- Analysis of “real world” driving indicated that creating a practical ZEV requires:

ZEV Speed and Power	→	US06 Capable
+ ZEV Energy	→	40 Mile EV
+ Total Range	→	>300 Miles
=Practical ZEV	→	VOLT



GM

