A Reliable Muddle: Transportation Scenarios for the 80% Greenhouse Gas Reduction Goal for 2050

California Air Resource Board Scenario Meeting

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Presentation Overview

Intro: Reducing LDV GHGs to 80% below 1990 levels

- Transportation sector-specific emissions data and policy concerns.

Part 1: Metrics for the 80% goal: **A Pyramid Framework**

- Three Metrics of the Pyramid Framework
  - **Vehicle Miles Traveled (VMT)**
  - **Vehicle Fuel Economy (FE)**
  - **Fuel Carbon Intensity (CI)**
- Detailed Scenarios
  - VISION tool

Part 2: Major LDV GHG Abatement Strategy: **A Portfolio Approach**

- Policy interactions and the technology innovation process

Conclusion: A multi-faceted policy and technology approach will be required to reach the 80% goal.

Portfolio of Major Transportation Policies that Influence VMT, FE and CI for GHG Reductions

VMT Reduction

- Reduce vehicle miles traveled (**VMT**) with public transportation, land-use planning, mode switching
- Also: higher fuel prices

Corporate Average Fuel Economy (CAFE)

- Sets an average fuel economy (**FE**) for new light duty vehicles.

Renewable Fuel Standard (RFS)

- Reduces fuel carbon intensity (**CI**) through use of biofuels.

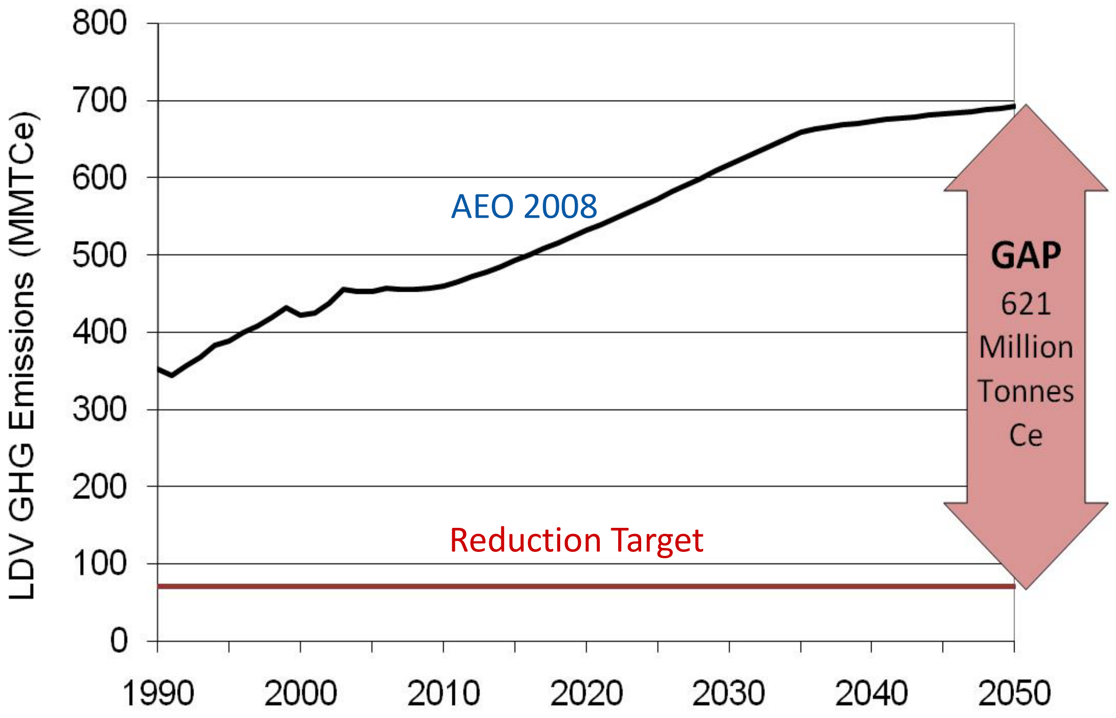
Low Carbon Fuel Standard (LCFS)

- Reduces fuel carbon intensity (**CI**) through use of variety of alternative fuels and vehicles.

Zero Emission Vehicle Mandates (ZEV)

- Increases fuel economy (**FE**).

Three Metrics Provide a Simple Conceptual Framework: Guiding Equation is C = VMT * CI / FE



National Annual Energy Outlook 'Reference' Metrics for Light-Duty Vehicles

GHGs in 2008: 455 MMTCe

GHGs in 2050: 692 MMTCe

→

Factor Increases between 2008 & 2050

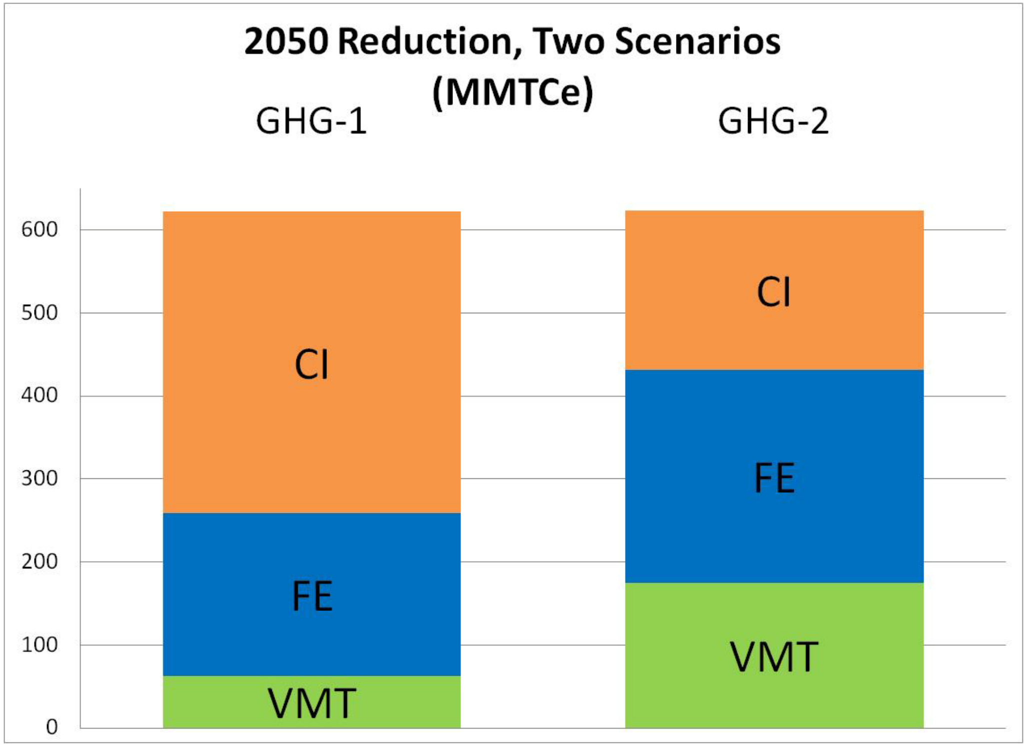
VMT: +80%, FE: +20%, CI: -1% → GHGs: +50%

What GHG reductions are achievable from reducing each of the 3 metrics?

2 Illustrative Scenarios for the U.S.:

'GHG-1' and **'GHG-2'**

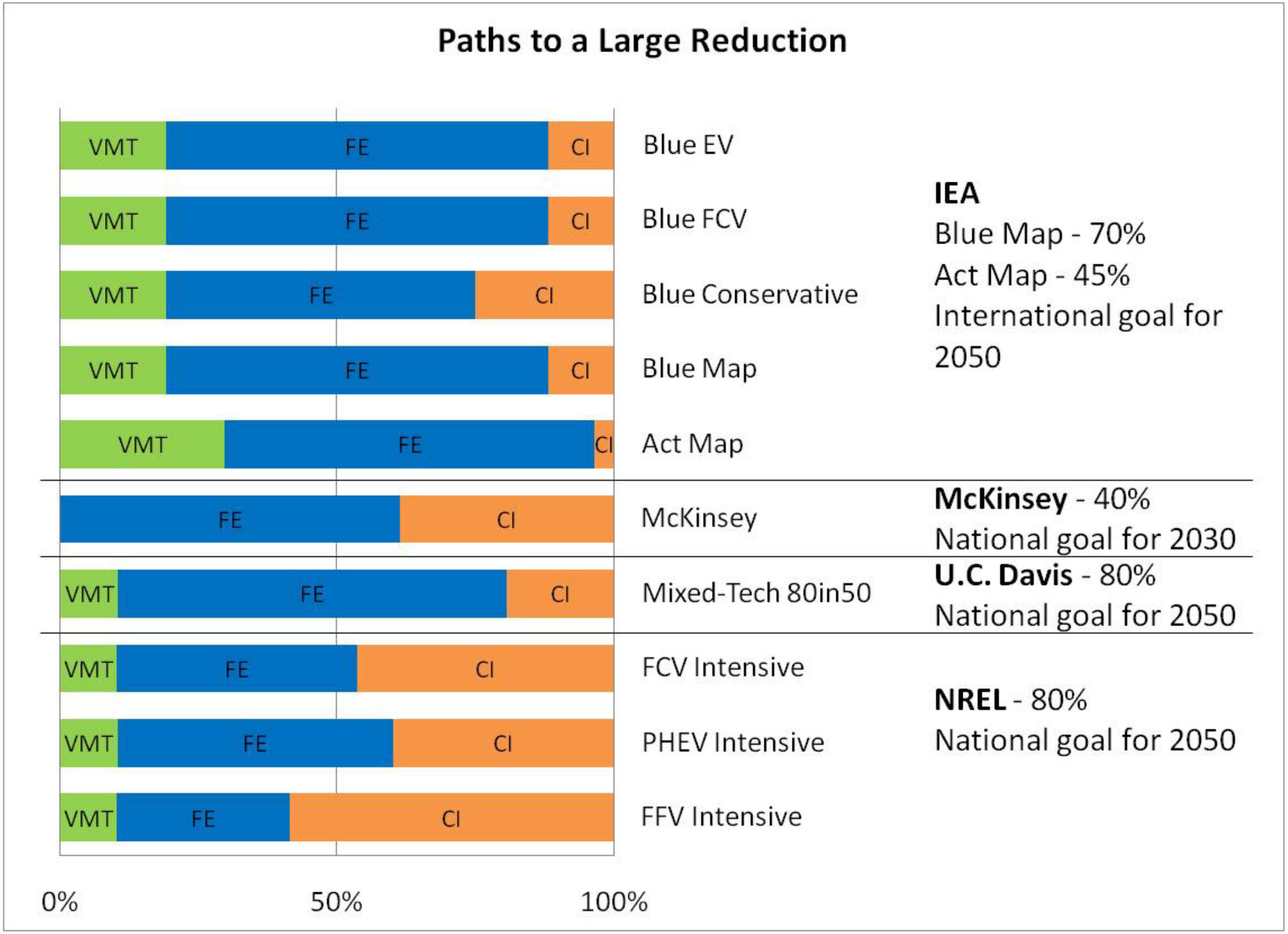
- Each GHG scenario achieves the 2050 goal
- Scenarios are illustrative, not predictive
- Intent of scenarios is to demonstrate types of change needed for 80% GHG goal
- Baseline is AEO 2008.



GHG-1: Modest improvements in **VMT** and **FE**;
CI improvements achieve remainder of 2050 goal reductions

GHG-2: Aggressive improvements in **VMT** and **FE**;
CI improvements achieve remainder of 2050 goal reductions

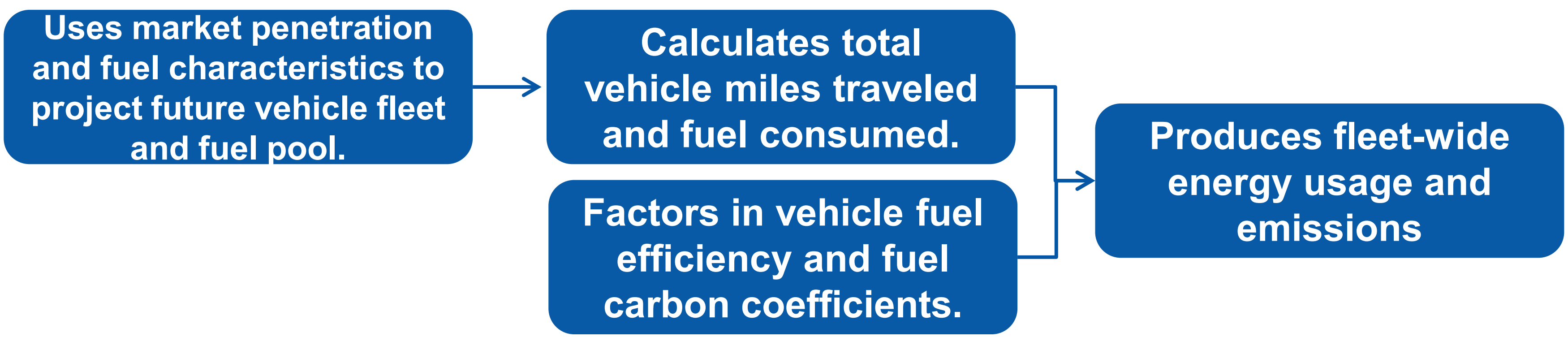
Multiple Pathways: A variety of suggestions have emerged with differing emphasis on metrics



Source: DRAFT NREL Analysis

Specific scenario characteristics can be elucidated with Argonne's VISION model.

- Argonne model for estimating fleet-wide energy use, oil use and carbon emissions. Inputs include:
  - Advanced vehicle market penetration, VMT/LDV, Fuel characteristics, New car fuel efficiency, Fuel-Cycle carbon coefficients (from GREET, based on AEO)
- VISION's calculations are based on vehicle survival and age-dependent vehicle usage characteristics.



- Market penetration and fuel economy assumptions are determined exogenously (scenario development).

A large number of input options are combined

Gasoline,
CI = 93.4 gCO_2e/MJ

Diesel ,
CI = 93.2 gCO_2e/MJ

Ethanol ,
CI = -10 – 75 gCO_2e/MJ

Hydrogen,
CI = 15 – 300 gCO_2e/MJ

Electricity,
CI = 50 – 225 gCO_2e/MJ

Biodiesel ,
CI = 0 – 90 gCO_2e/MJ

Gas ICE,
Efficiency ratio = 1.0

Diesel ICE,
Efficiency ratio = 1.2

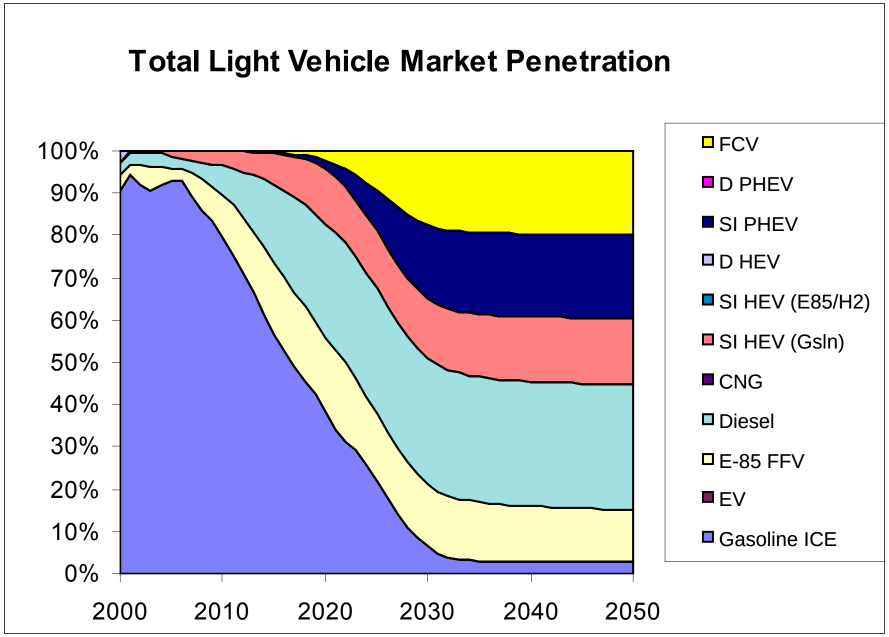
E-85 FFV,
Efficiency ratio = 1.0

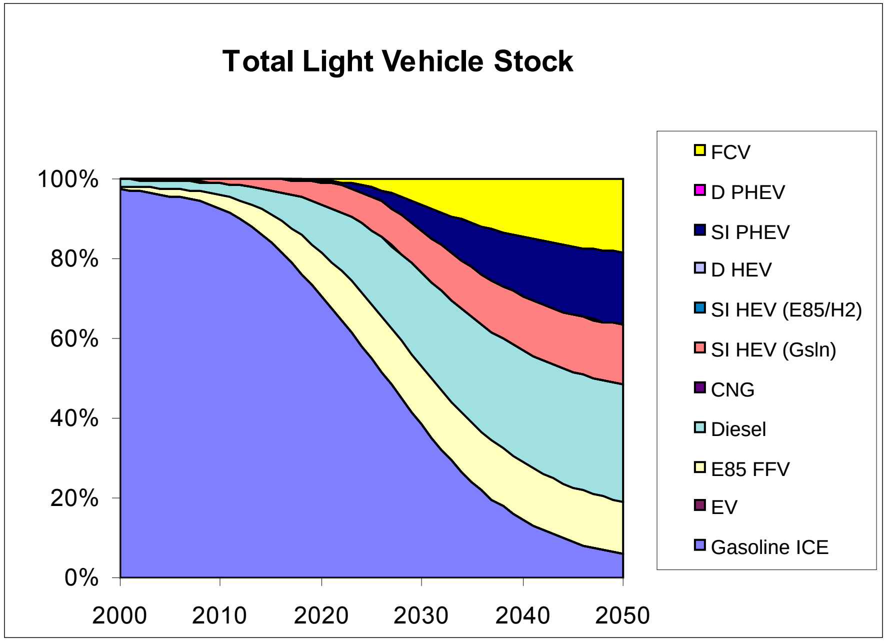
FCV,
Efficiency ratio = 2.3

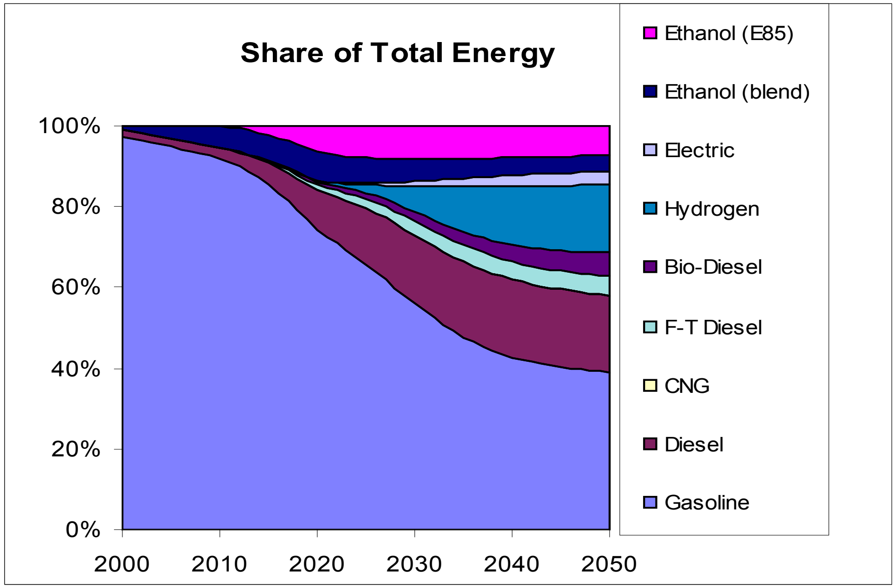
PHEV,
Efficiency ratio = 3.0

Fleet-wide
VMT, FE & CI

VISION models the entire population of light-duty and heavy-duty vehicles and fuels over time.

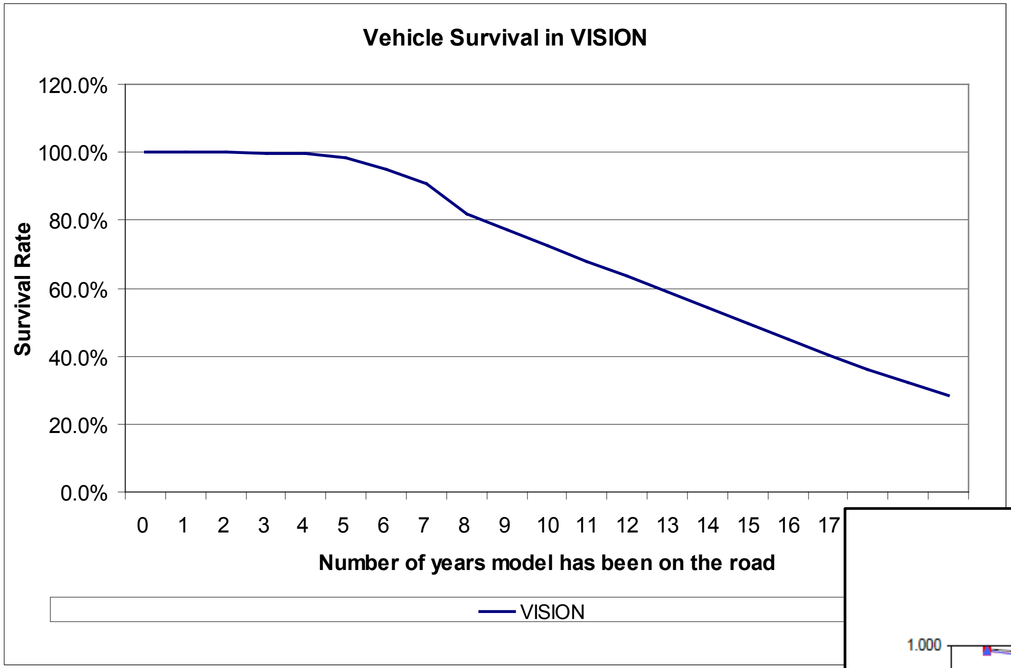




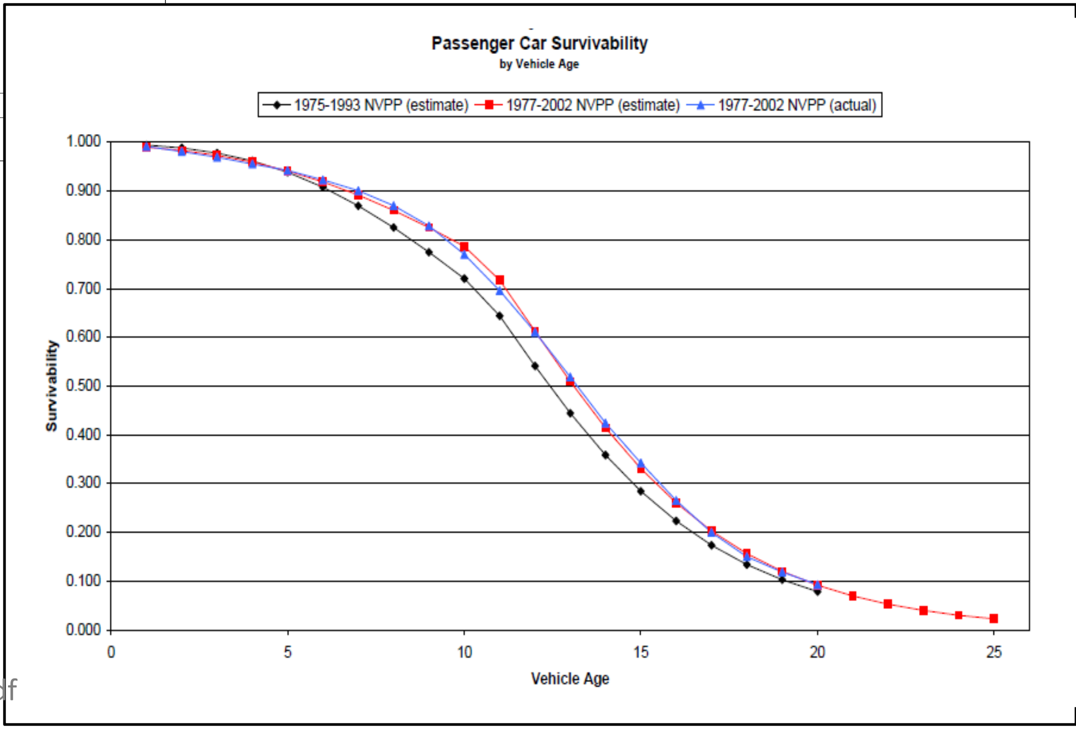


NOT REAL DATA – EXAMPLE ONLY

VISION is a ‘stock flow’ or ‘bucket’ model that explicitly tracks vehicle and fuel characteristics over time.



Source: DRAFT NREL Analysis



Source: NHTSA, http://www-nrd.nhtsa.dot.gov/Pubs/809952.pdf

VISION-CI

Modified version of the Argonne VISION model.

Incorporates fleet-wide average fuel carbon intensity calculations for different fuels and aggregate vehicle fleet scenarios.

Scalable for region-specific analyses.

Capable of storing and analyzing multiple regions and technology scenarios.

Currently incorporating data for California, Texas and on a national level.

A work in progress.

Examples of Single Technology Scenarios that would fall within the GHG-2 National Compliance Pathway

FFV fleet running on Cellulosic

VMT (billion miles)	4,621
FE (mpg)	35.1
CI (MMTCe/Quad)	4.3

Producing enough ethanol for this scenario may not be feasible. Current projection for corn stover cellulosic CI is 3.0 MMTCe/Quad

FCV fleet running on Hydrogen

VMT (billion miles)	4,621
FE (mpg)	42.5
CI (MMTCe/Quad)	5.2

Current Projection for biomass derived hydrogen CI is 10.22 MMTCe/Quad, and for solar derived 5.67 MMTCe/Quad

PHEV fleet running on Cellulosic Ethanol and Low-Carbon Electricity

Cellulosic	
VMT (billion miles)	2,911
FE (mpg)	29.7
CI (MMTCe/Quad)	4.3
Low-C Electricity	
VMT (billion miles)	1,710
FE (mpg)	75.2
CI (MMTCe/Quad)	11.7

Current projection for a renewable grid CI in 2050 is 22.4 MMtCe/Quad. Assume 37% VMT on electricity.

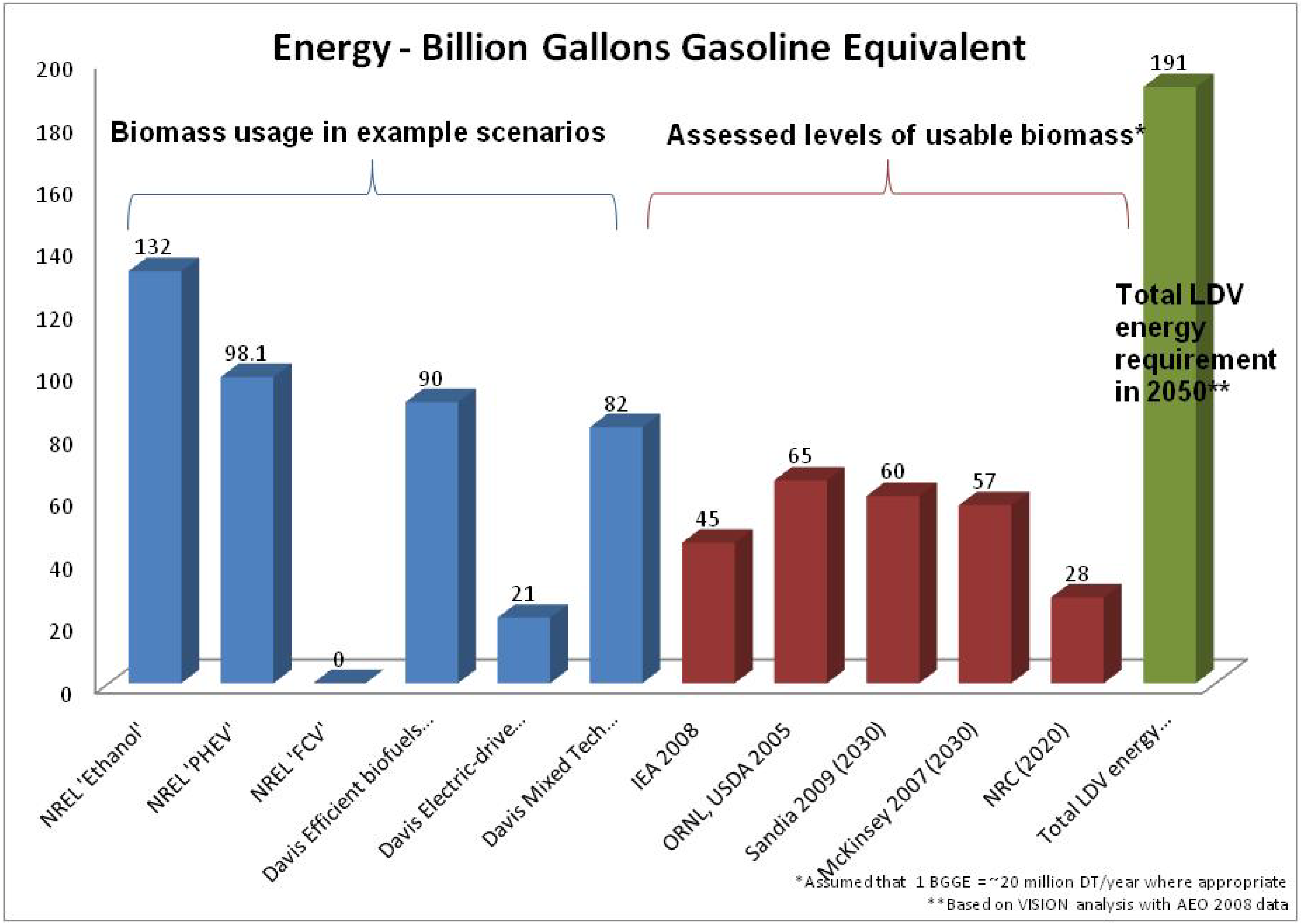
Many different combinations of vehicles and fuels are conceivable.

These are simplified examples of (unlikely) "silver bullet" success stories.

Source: DRAFT NREL 80 in 2050 Transportation Scenario Analysis

Biofuels Limitations

The amount of biofuel available for transportation is still unclear.



Source: DRAFT NREL Analysis

Considerations

The Transportation Sector is Unique

- Long-term support for a portfolio of transportation-specific policies is key to deep reductions in GHGs

Scenarios developed in VISION elucidate issues to be addressed for achieving 80% in 2050.

No Silver Bullet

- Though support for specific technologies is warranted (e.g., batteries), there is no clear winner among viable long-term, low-carbon vehicle/fuel combinations
- Communication among stakeholders (e.g., autos and fuel suppliers) is key to effective alignment of more stringent policies

Local and Regional Variability

- Due to the broad range of vehicles, fuels, market conditions, and the geographic distribution of low-carbon energy resources, policy impacts will vary from city-to-city and region-to-region

Questions?