2050 Light-Duty Vehicle Greenhouse Gas Analysis

Public Workshop

Air Resources Board

October 28, 2009

Board Resolution 08-24

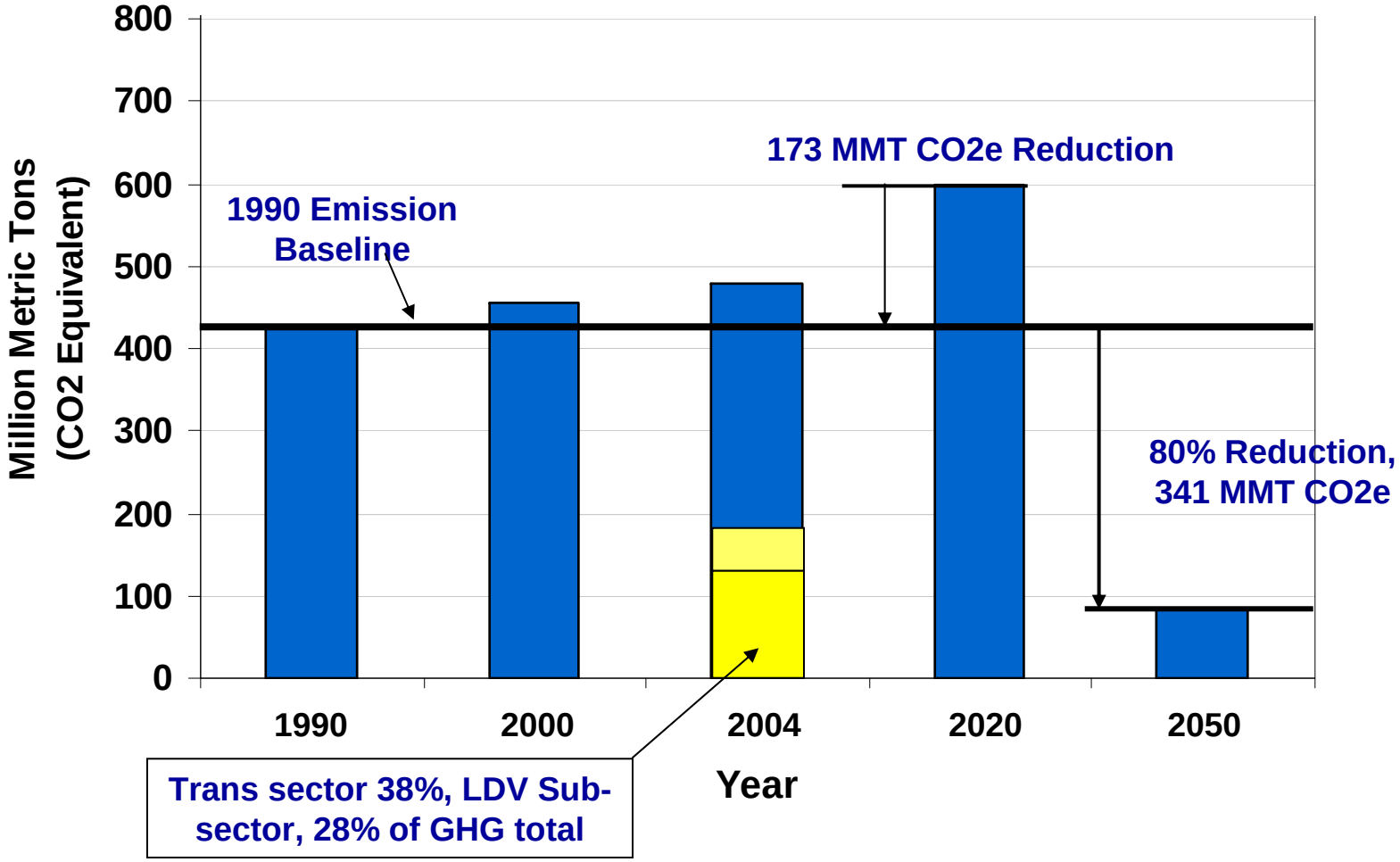
- Staff is to review the LEV, Pavley, and ZEV programs, keeping in mind the need to reduce criteria pollutant emissions, climate change emissions, and dependence on petroleum
- Strengthen the ZEV program for model years 2015 and subsequent, focusing on zero emission vehicles and enhanced AT PZEVs
- Ensure California is the center of ZEV commercialization development

Policy Development

- Information update to Board (Dec 9, 2009)
  - Staff White Paper and attachments to be released Nov 10
  - Policy structure concepts
  - 2050 GHG analysis and context for ZEVs
- Regulatory proposal to Board (Q4, 2010)
  - Public workshops (Q1 – Q2 2010)
  - ISOR Staff report (Q3 2010)
  - Coordination with Pavley & LEV Regulations

Total GHG Emissions

California's 2020 GHG Regulation (AB 32) and 2050 GHG Goal (EO S-03-05)



2050 LDV GHG Analysis

- Purpose
  - "How many when?": Consider revised ZEV volumes for 2015 -2017 (and beyond) to achieve 2050 GHG goals
  - "Multiple solutions": Outline risk of missing 2050 target under various technology and market scenarios
- General Approach
  - Context: LDV segment, CA perspective (fleet, grid, etc)
  - Evaluation of external research for
    - Fleet and sales (*vehicle stock turn-over, market growth)*
    - Technology progression (*market launch, vehicle costs*)
    - Resource restrictions (*biomass, CCS, growth of renewables*)
  - Sensitivity study of key parameters

2050 LDV GHG Analysis

- Modeling Methodology

  <u>Task 1: Identify modeling tool</u>

  – US DOE's Vision 2008 model – transportation scenarios
    - LDV stock turn-over model (fleet growth & retirement), and cumulative energy & emissions
    - Coordination with NREL (also developing Vision tool for state policy analysis) and CEC (AB118 2050 GHG analysis)

  – *Not an economic model – consumer choice and costs are not considered*

2050 LDV GHG Analysis

- Modeling Methodology

  Task 2: Identify basic parameters (common all scenarios)

  – Used ARB EMFAC dataset and GHG inventory

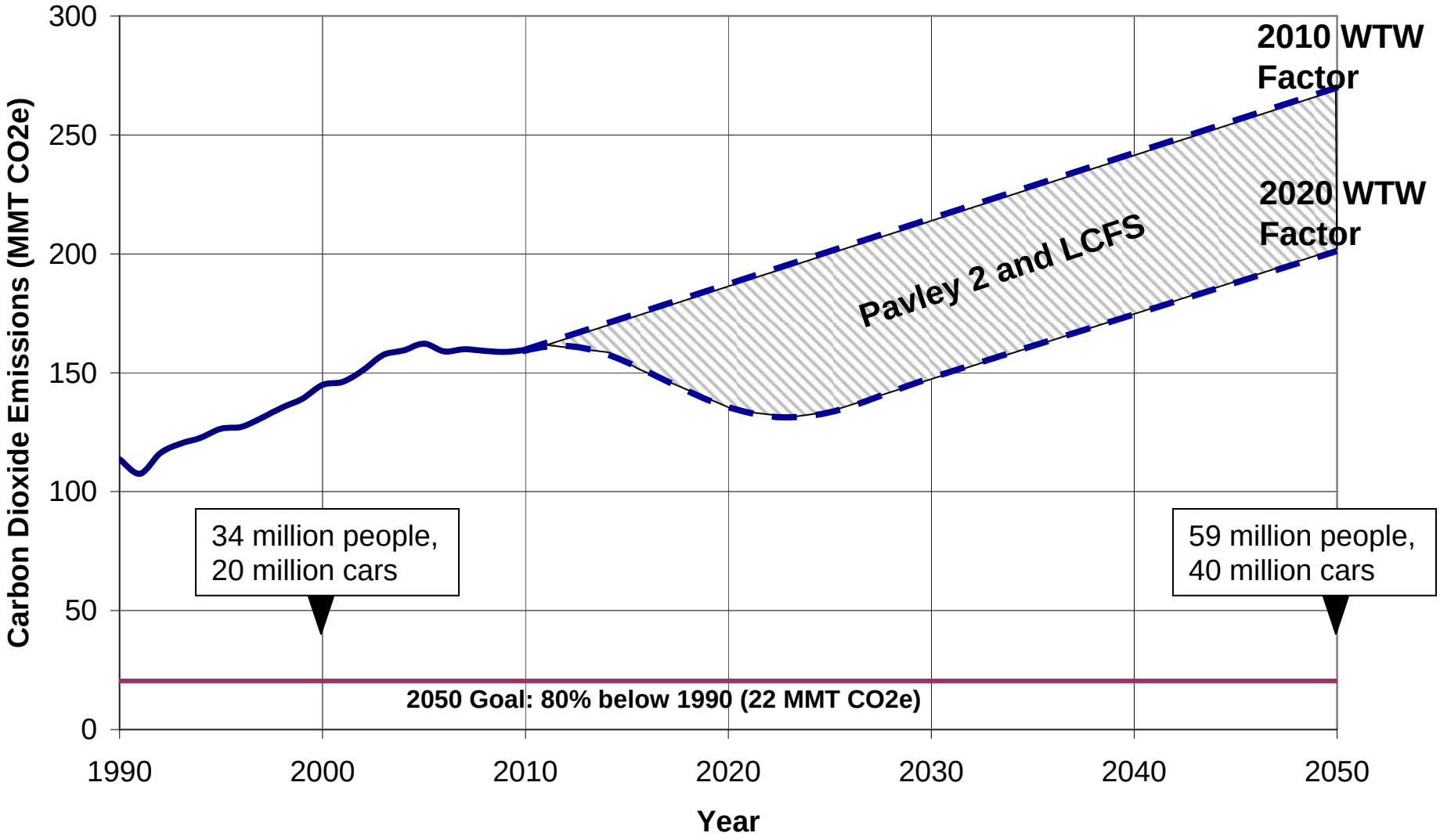
  – Assumptions for vehicle sales growth, mpg, fuel carbon intensity, population, VMT/veh, car/truck mix

  Task 3: Develop scenarios for reducing GHG from LDVs

  – Various advanced vehicle market scenarios

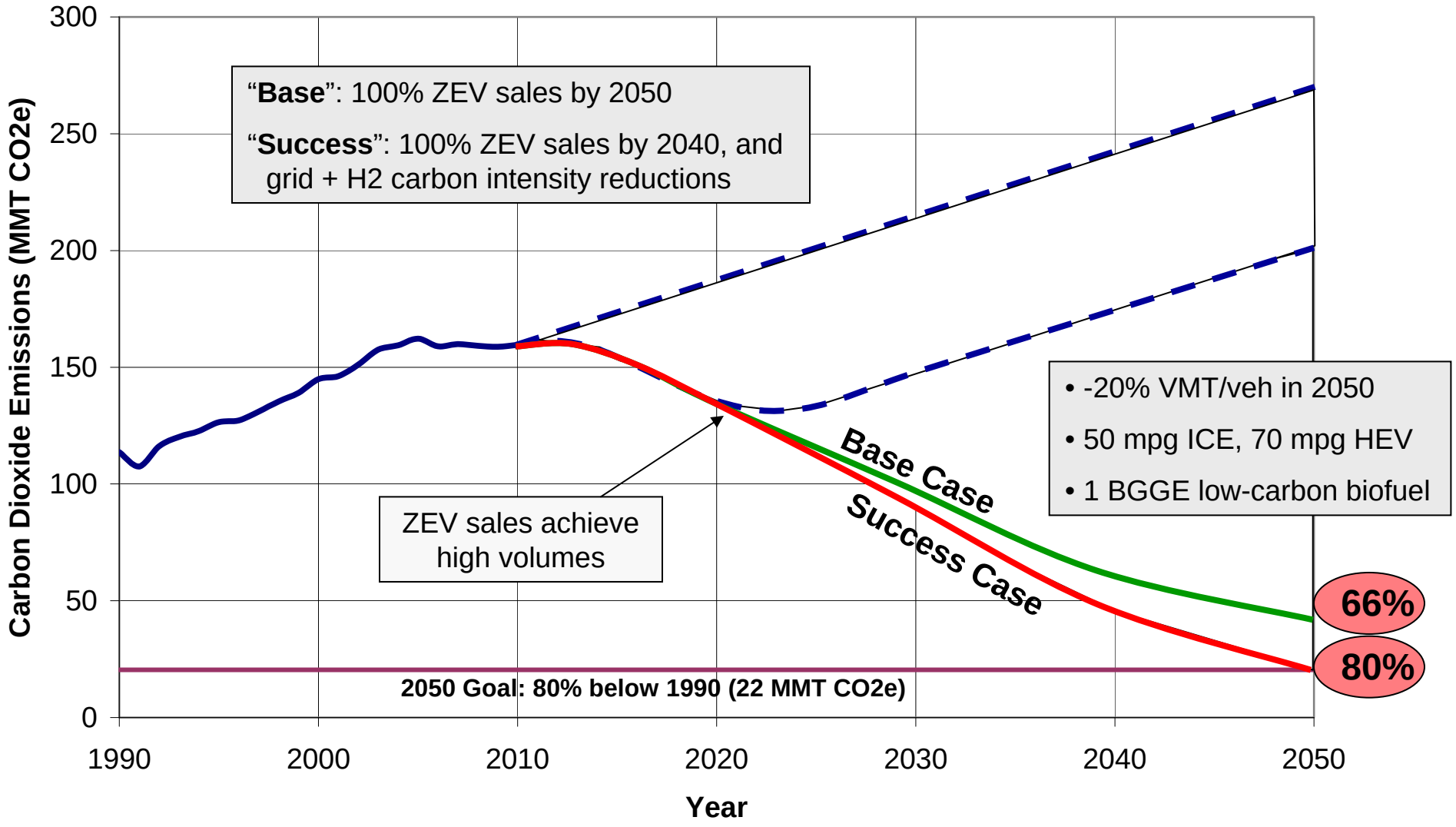
  – Various biofuel blend scenarios

Total LDV CO2 Emissions – "Business As Usual"



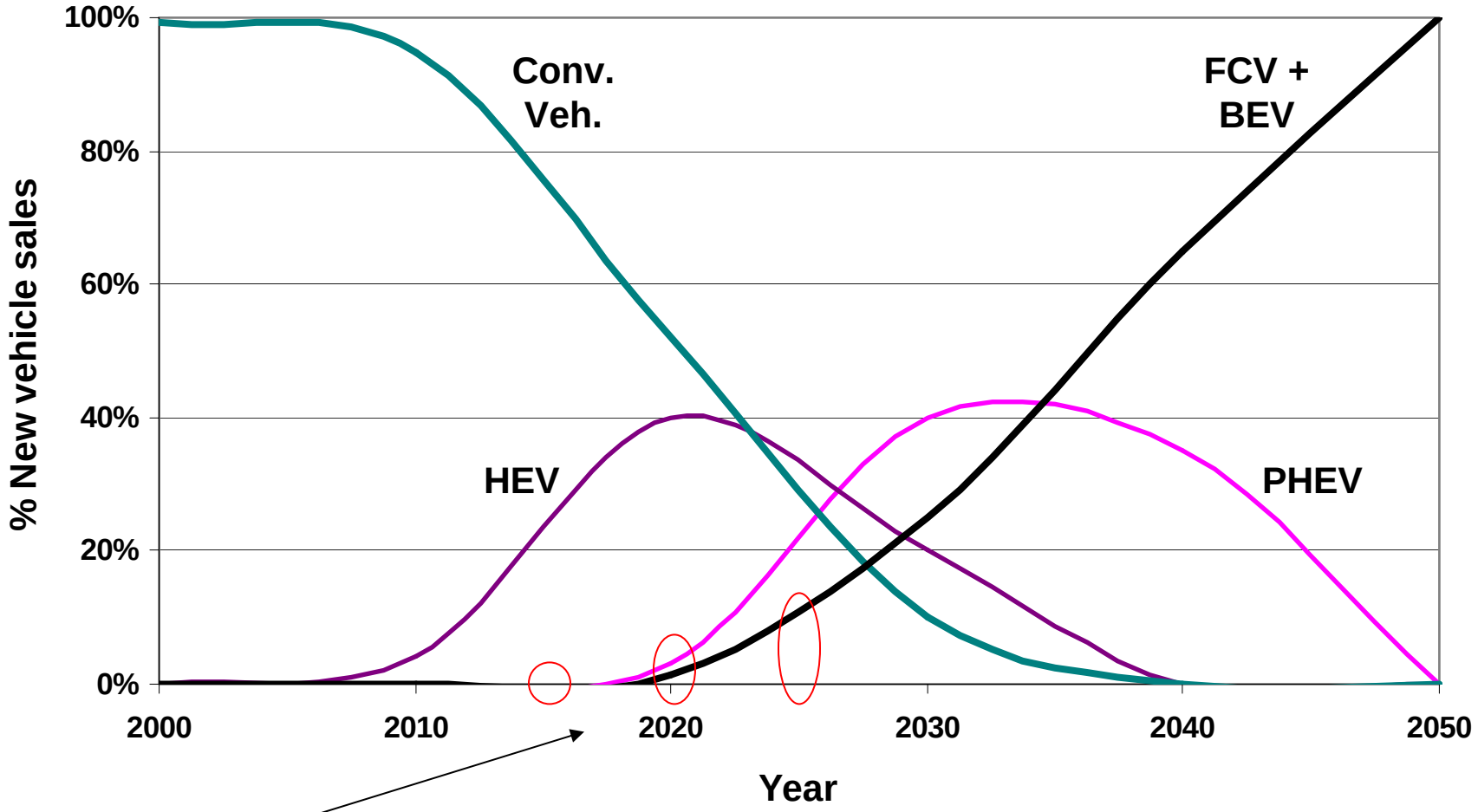
ARB Inventory for 1990 LDV emissions: 108.5 MMTCO2e (total inventory, all sectors = 427 MMTCO2e)

Total LDV CO2 Emissions – Two Scenarios



BGGE = billion gallons gasoline equivalent biofuels

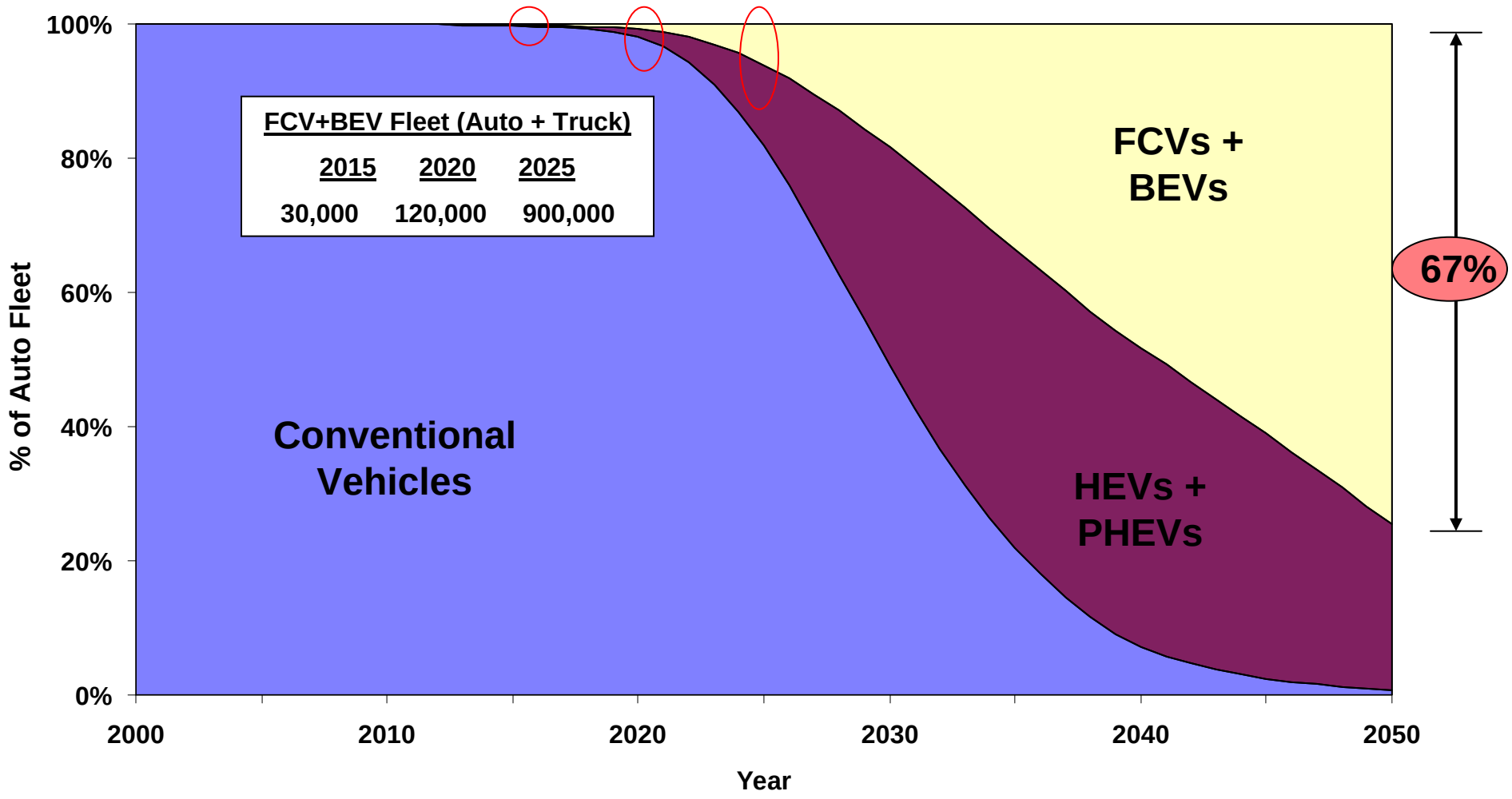
LDV New Vehicle Sales (Auto only) – Base Scenario



FCV+BEV Sales/yr (Auto + Truck)		
2015	2020	2025
7,500	25,000	230,000

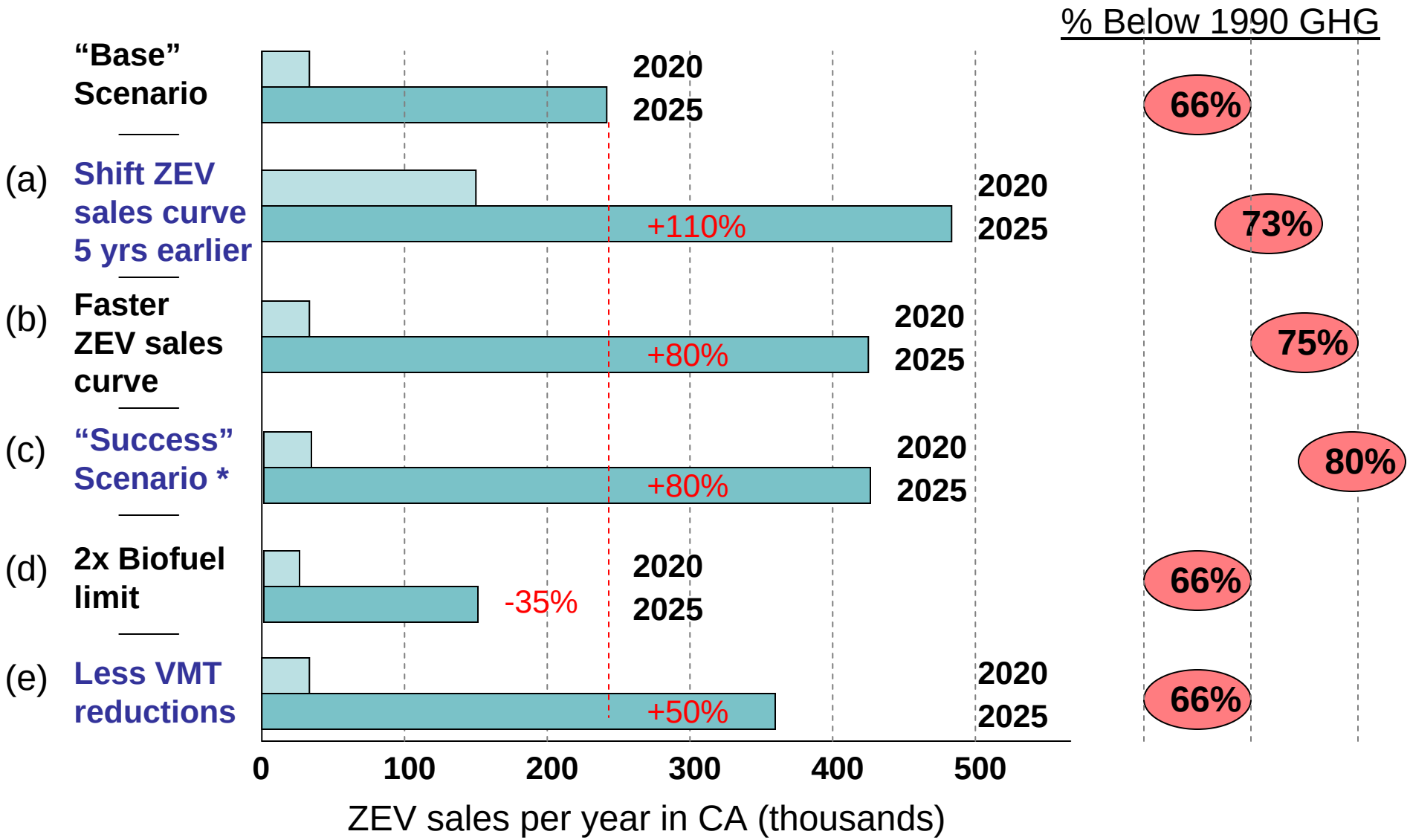
HEV	4% sales in 2010 (launch in 2000)	***10 Year Sales Growth***
PHEV	3% sales in 2020 (launch in 2010)	
BEV	1% sales in 2020 (launch in 2010)	
FCV	3% sales in 2025 (launch in 2015)	

LDV On-Road Fleet (Auto only) – Base Scenario



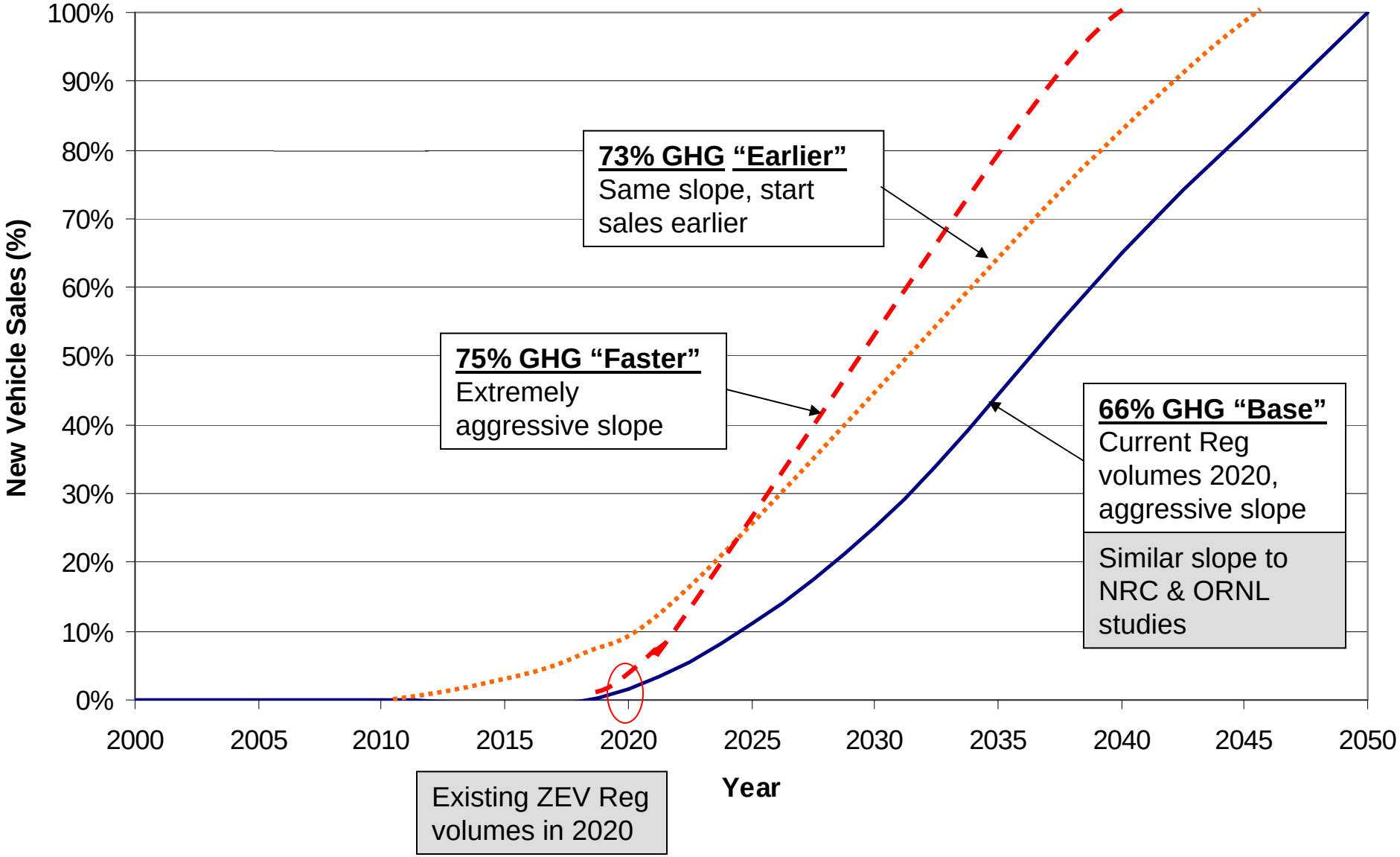
- Accounts for vehicle stock turn-over & population growth
- ~ 10 year delay between ZEV sales % and ZEV fleet %
- CA's vehicle population nearly doubles from 2000 to 2050 (40 million veh)

Sensitivity Study – A Focus on ZEV Sales



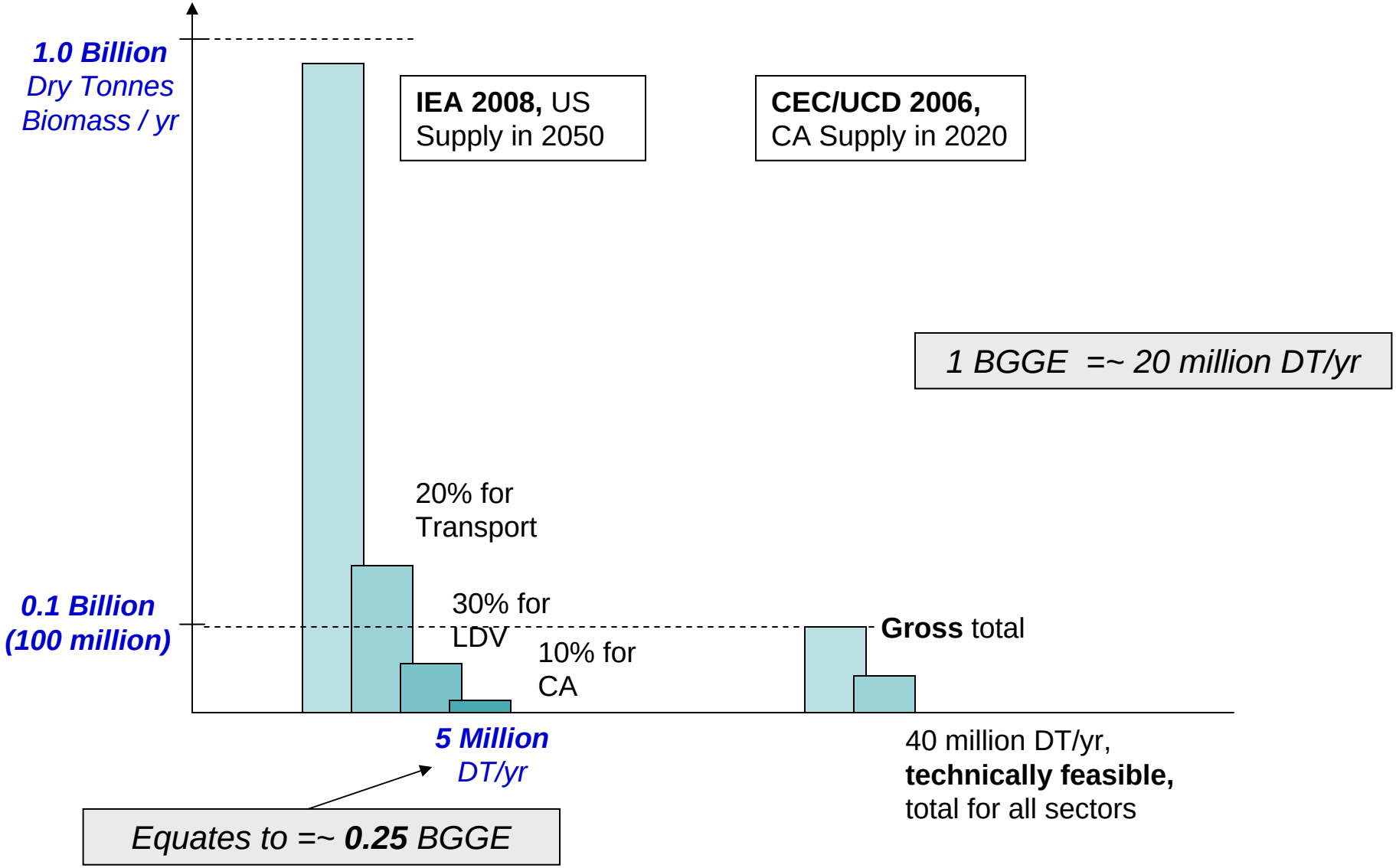
** Includes grid and electricity carbon intensity improvements as well*

LDV New Vehicle Sales (Auto only) – 3 ZEV Sales Scenarios

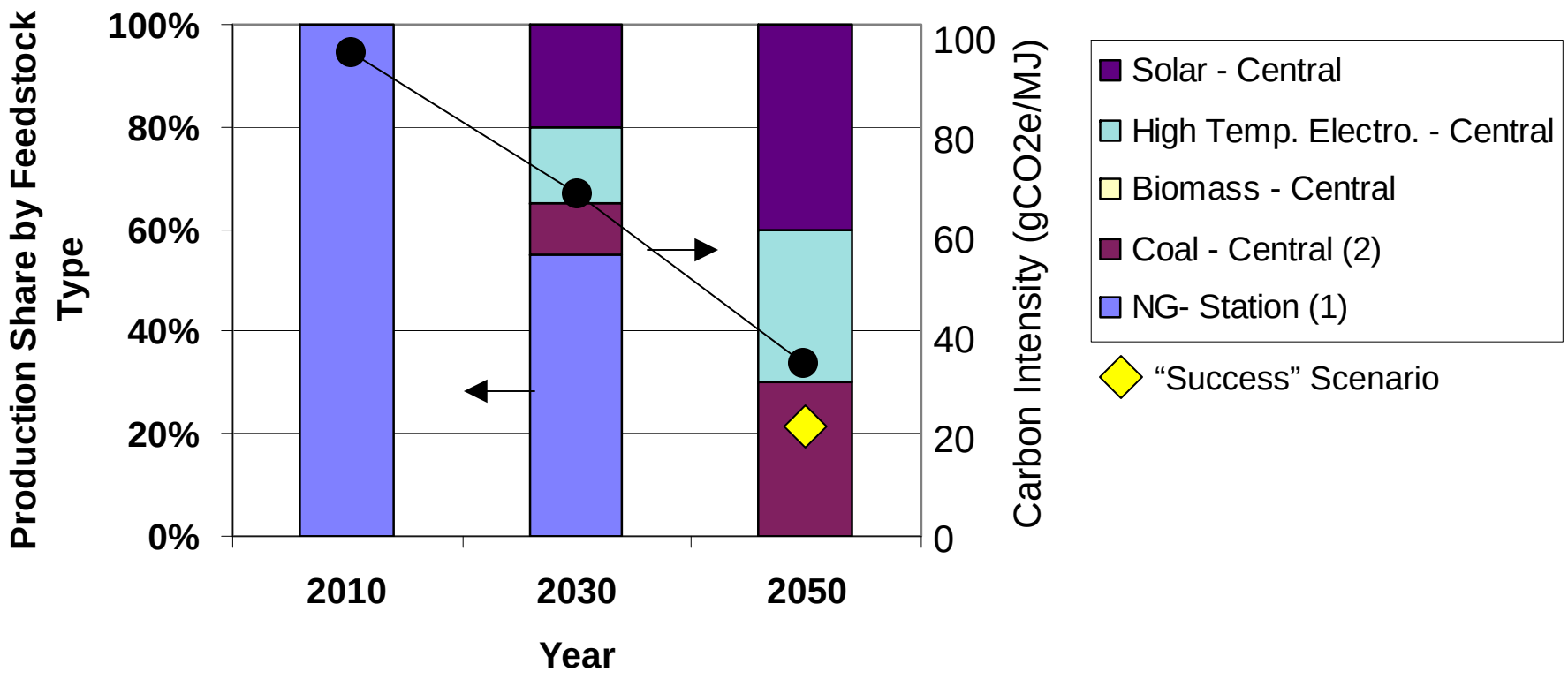


Biomass Supply Limit Assumptions

Further research needed on this assumption

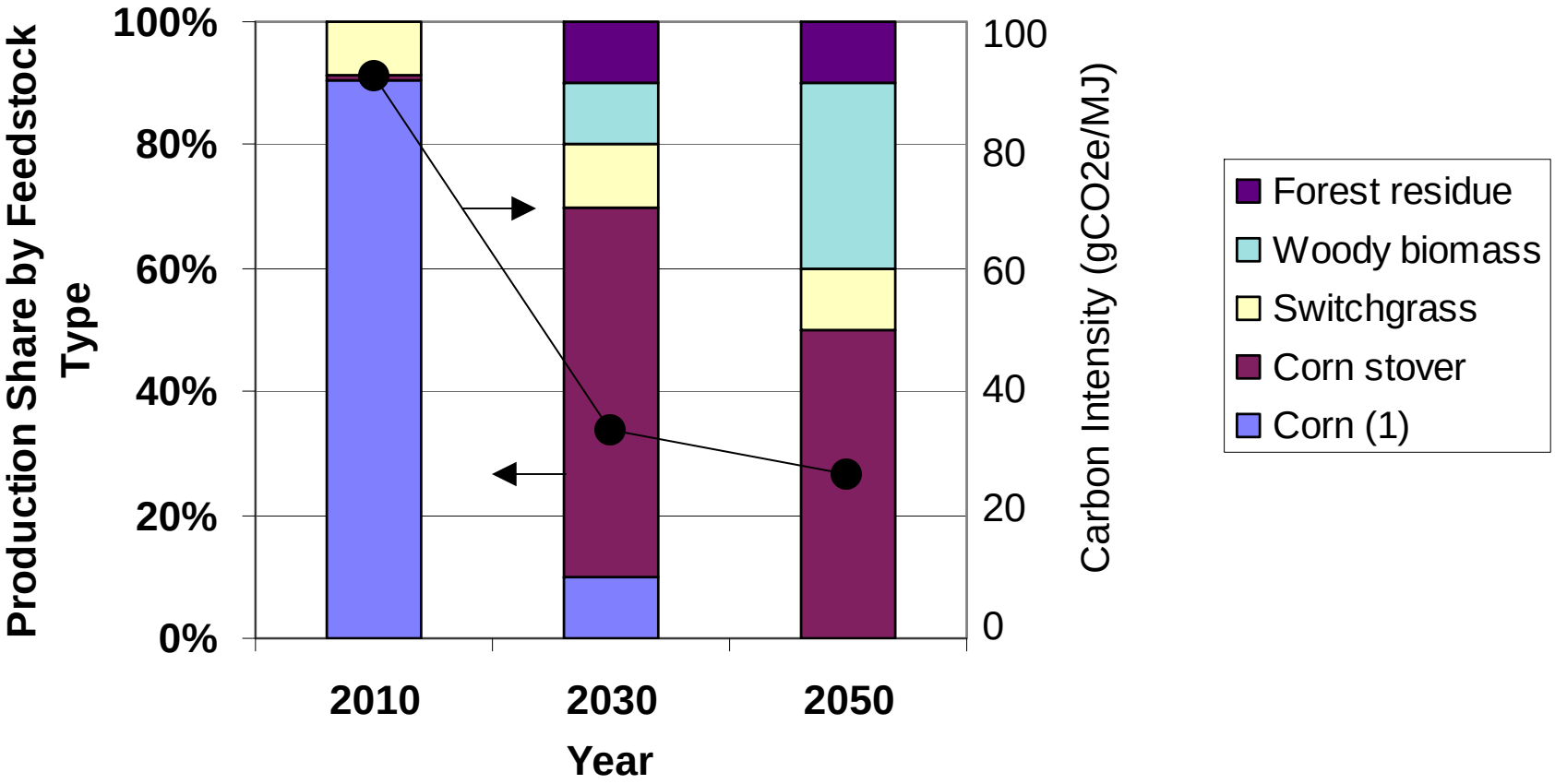


Hydrogen Production & Carbon Intensity – "Base" Scenario



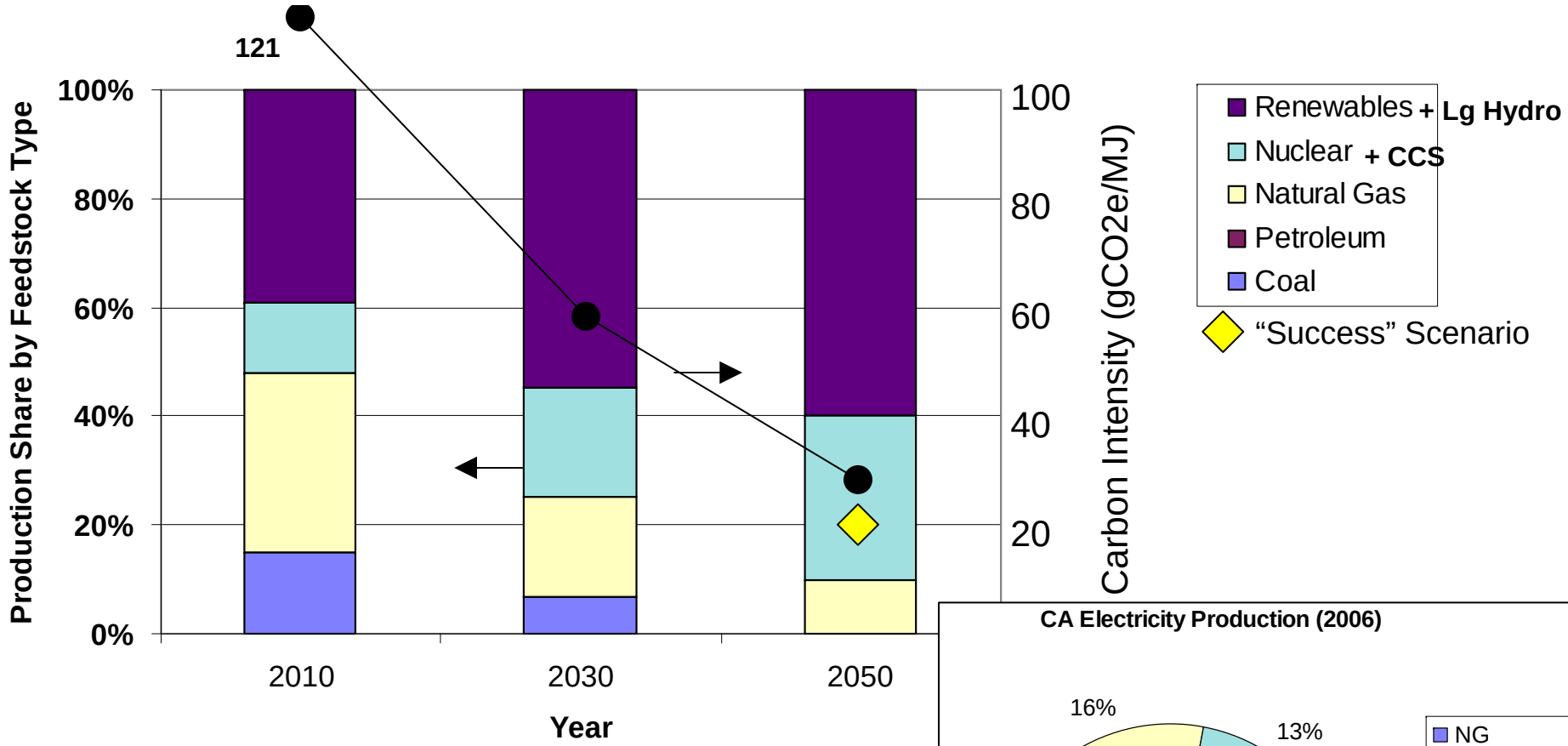
- No biomass available due to LDV biomass limitation
- Central coal includes CCS

Bio-Hydrocarbon Production & Carbon Intensity – "Base" Scenario

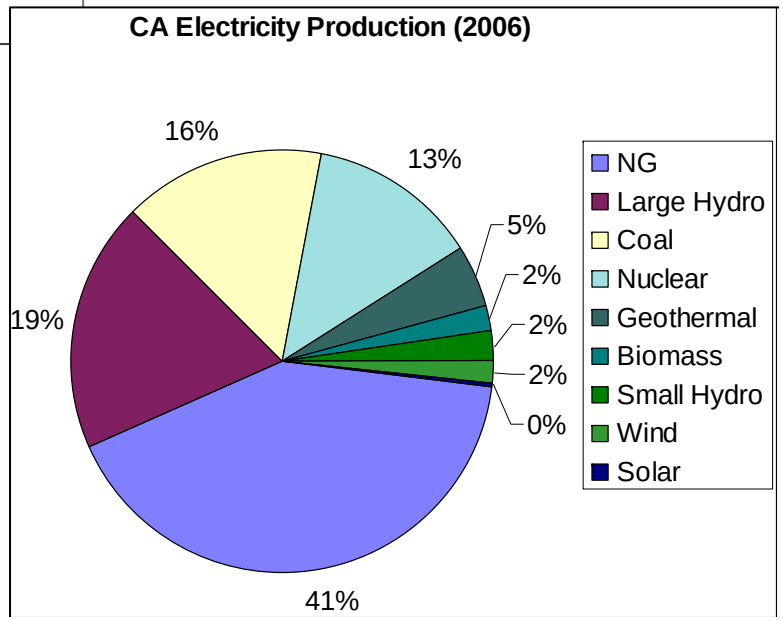


- Drop in carbon intensity by 2030 reflects LCFS compliance
- Assume a bio-hydrocarbon fuel replaces ethanol post 2025

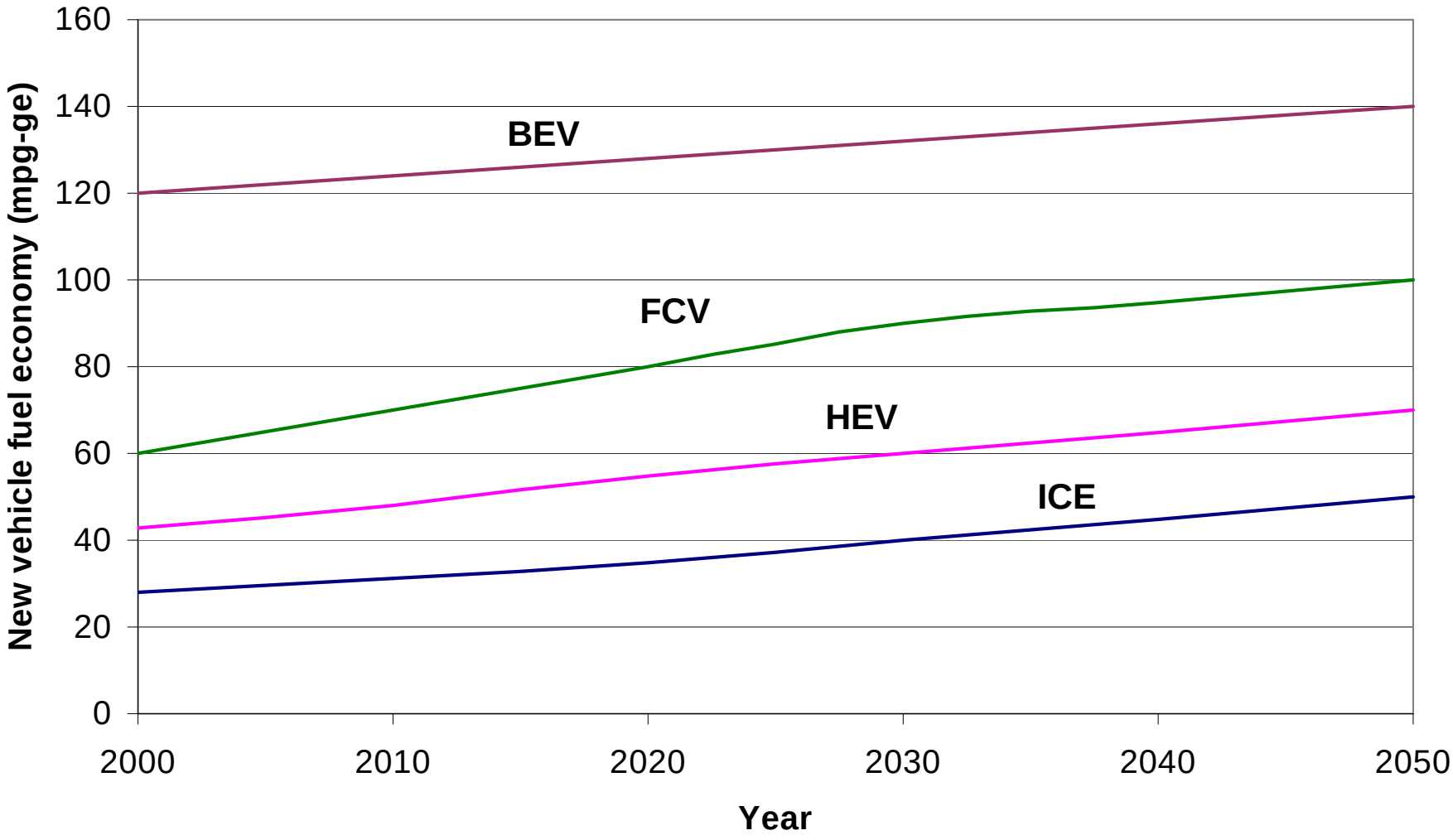
Electricity Production & Carbon Intensity – "Base" Scenario



- 33% renewables in 2020 (<u>not</u> including large hydro)
- 45% renewables in 2050
- Reliance on carbon capture & storage (CCS) and/or nuclear growth

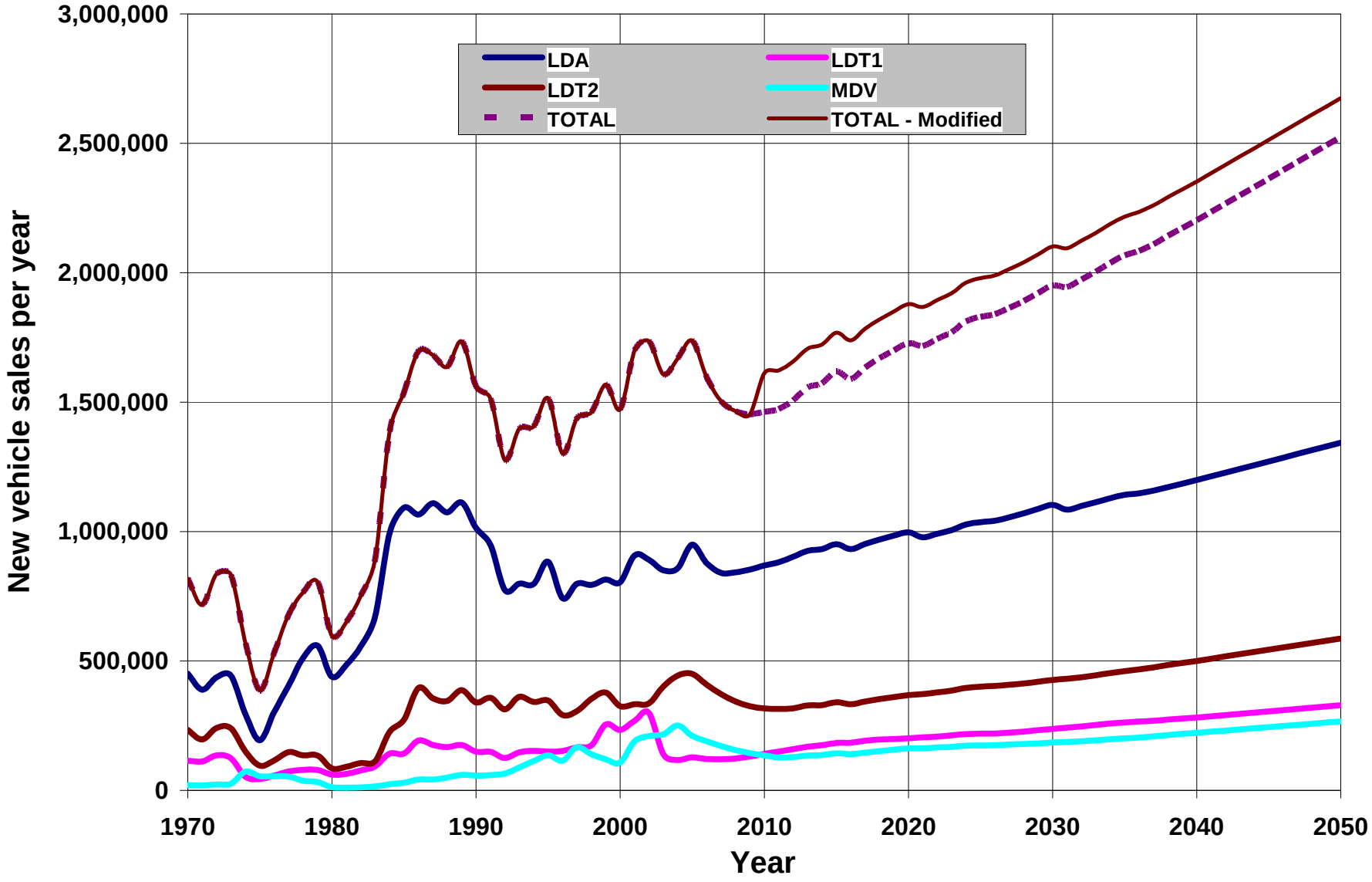


Fuel Economy (On-Road) – LDV Autos



- Fuel economy improves for PHEVs also - not shown here.
- Same for all scenarios

ARB EMFAC Dataset *



EMFAC projections to 2040, extrapolation to 2050

Summary of Major Assumptions

- CA population doubles from 1990 – 59 million people
- All fuels and electricity achieve very low carbon intensity
  - *Electricity – 60% renewables + large hydro, coal with CCS, nuclear*
  - *Hydrogen – Renewables, CCS, natural gas*
  - *Biofuels – waste feedstocks, forest, cellulosic energy crops*
- Biofuel supplies will be restricted, particularly for LDVs
  - *Sustainably grown biofuels needed for aviation, HDV, rail, etc*
  - *1 Billion gallons gasoline equivalent (BGGE) for LDV segment*
- Passenger mode shift required
  - *Reduced annual VMT/veh – 20% below 2050 projections*
    - *9,500 miles/yr/veh*
    - *Mass transit, compact cities, car sharing,*
  - *LDV segment shift – 70% cars, 30% trucks*

Modeling Conclusions (1)

1. All scenarios require multiple adv. vehicle technologies
   - *Only 1 scenario achieves full 80% goal*
   - *Too risky to eliminate vehicle alternatives today*
2. Multiple decades required for ZEV fleet growth, high volume sales need to be established by 2020
3. Base scenario – 66% below 1990 GHG levels
   - *On-Road cumulative ZEV fleet: 100,000 (2020); 900,000 (2025)*
   - *Annual ZEV sales: 25,000 (2020); 230,000 (2025)*
4. Success scenario – 80% below 1990 GHG levels
   - *Annual ZEV sales: 25,000 (2020);* ***450,000*** *(2025) **
   - *Grid & H2 carbon intensity further improved **
   - *** both of these assumptions exceed external expert references*

Modeling Conclusions (2)

5. A few sensitive parameters need further study
   - *Biofuel supply limit for LDVs: increasing to 2 BGGE vs. 1 reduces ZEV sales req. to 150,000 (2025), 35% reduction*
   - *VMT/veh: If only 10% reduction achieved vs. 20%, ZEV sales req. increases to 360,000 (2025), 50% increase*
   - *Carbon intensity of biofuels, hydrogen, and electricity; considering California specific feedstocks*

6. High risk assumptions include:
   - *CCS is commercialized by ~2025*
   - *Bio-hydrocarbon is commercialized by 2025, replaces ethanol*
   - *Hydrogen infrastructure emerges for early fleets ~2015*
   - *Growth in grid renewables (traditional, not including large hydro)*

Discussion Questions

Discussion Questions

1. Considering all three vehicle alternatives (FCVs, BEVs, PHEVs) have varying challenges (cost, durability, range, infrastructure access), **which alternatives are more appropriate for specific market segments** (e.g. urban vs. rural ownership, compact vehicle vs. light-truck, etc)?
2. Is long-term market success for advanced vehicles more feasible if aggressive sales begin by 2015 (to provide more time for markets to grow) or by 2020 (to allow technology innovation to progress further)?

Discussion Questions

3. What is the appropriate mix of long-term production feedstocks for electricity and hydrogen that result in a very low average carbon intensity?

4. Are there certain resource supply restrictions that are particularly important to evaluate? For example, long-term biomass supply may be limited for use in the LDV sub-segment given demand in other transportation sub-sectors (aviation, heavy-duty trucks, marine, etc).

Discussion Questions

5. Does the LDV sub-sector need to achieve it's "fair share" of 80% below 1990 levels?
   - If the power sector exceeds 80%, the full transportation sector likely could achieve a lower level.
   - However, within the transportation sector, aviation, HDV, and marine are not expected to achieve their "fair share".

Contact Information

- ARB welcomes feedback on this material. All written comments may be directed towards:

  Joshua Cunningham, jcunning@arb.ca.gov, 916-324-2553

- Additional information can be found on the program website:

  http://www.arb.ca.gov/msprog/zevprog/2009zevreview/2009zevreview.htm