



TAFV

Analyzing the Transition to
Alternative Fuel Vehicles.

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Oak Ridge National Laboratory
and University of Maine

Project Progress Briefing
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TAFV



TAFV Project Team

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Why Study *Transition* to Alt Fuel Vehicles?

- Dual National Concerns:
 - Energy Security
 - Pollution (GHGs & Criteria)
- Limitations of Long-run Equilibrium Analysis
- Examine Policies for Technology Transitions
 - Will we meet EPCACT fuel substitution goals?
 - Effects of Fleet Mandates?
 - Other policies to get there?

Plan of Presentation

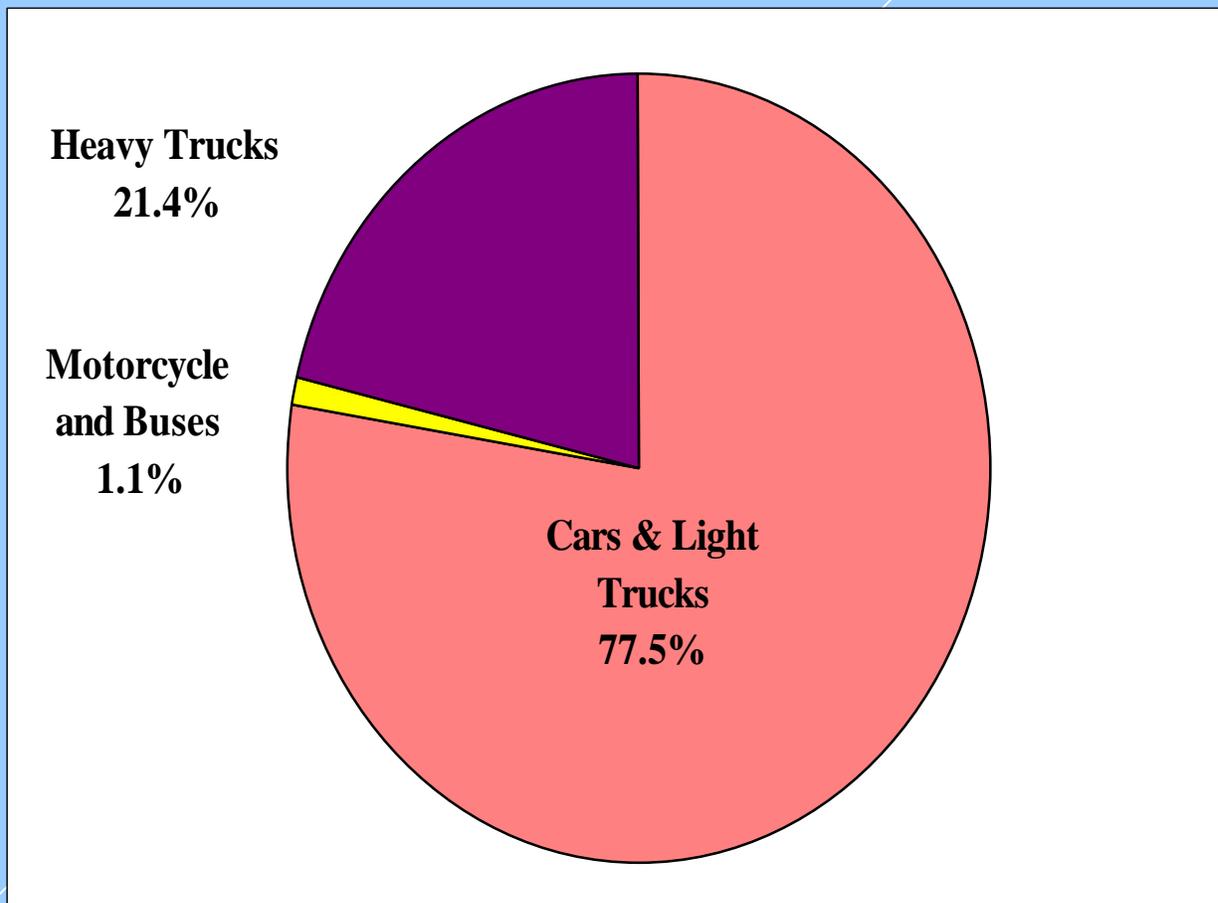
- Overview of TAFV project
- Assumptions and Data
- Focus on Ethanol Supply
- Recent Results for Fuel and Vehicle use
- Issues and Questions

1992 Energy Policy Act Goals (Sec. 502b)

- Estimate the technical and economic feasibility producing sufficient replacement fuels to replace gasoline use, on an energy equivalent basis,
 - at least 10% by year 2000; and
 - at least 30% by year 2010.

On-Road Energy Use

- In 1996 the on-road component of total transportation energy use was 76%
- 98 % from petroleum



Three Ways to Reduce Petroleum Use

- Reduce VMT
 - This reduces mobility
- Increase Vehicle Efficiency
 - (increase MPG).
- Switch fuels
 - (to non-petroleum based fuels)
 - Note: If concerned with emissions the fuels that you switch to must have lower emissions per mile

TAFV Model Focus: Switching

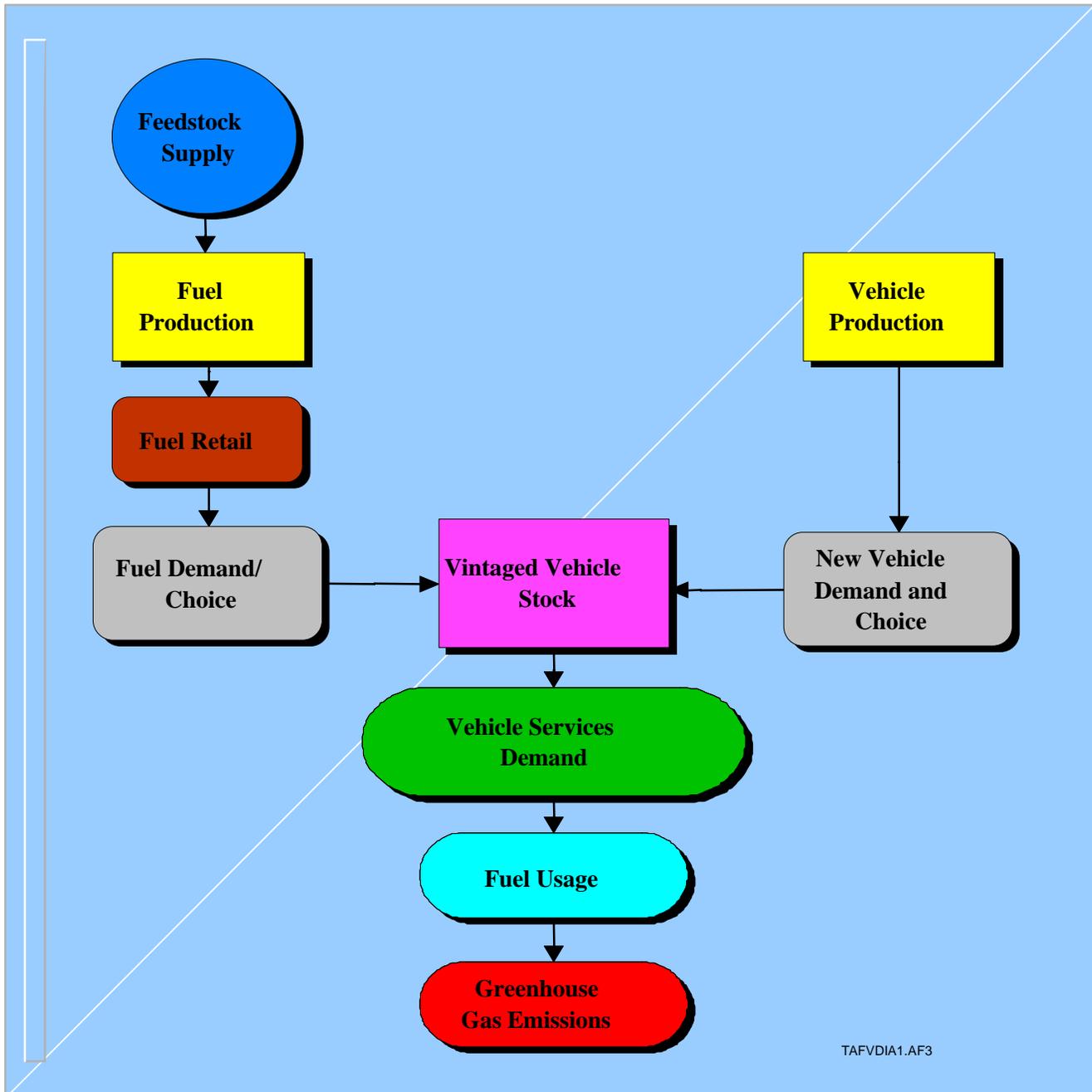
Principle Objectives of the Transition Analysis

- Explicitly model transitional fuel and vehicle time paths
- Examine barriers, as fuel and vehicle industries mature
- Model sunk investments in vehicle and fuel infrastructure
- Integrate consumer and producer behavior
- Feed-back effects from early purchase decisions
- Assess range of federal AFV incentives

Key Transitional Phenomena

- Capital stock turnover
 - vintaged vehicles
 - durable production plants
- Costs to consumers of limited retail fuel availability
- Production scale economies
- Limited vehicle model diversity
 - Costs to producers
 - Value to consumers

Conceptual Diagram of TAFV Model



TAFVDIA1.AF3

Features of the Transitional Model

- Solves yearly, 1997-2010
- US focus, urban and nonurban regions
- Endogenous feedback effects
 - Vehicle economies of scale
 - Vehicle “diversity” effects on choice
 - Retail economies of scale
 - Fuel availability costs to consumers
- Tracks GHG emissions

Important Inputs

- Fuel supply curves
- Vehicle production cost curves
- Cost of limited fuel availability
- Vehicle and fuel choice attributes

TAFV Ethanol Supply Curves

- Two Ethanol Sources:
 - Cellulosic Biomass
 - Corn
- Aggregated supply curves estimated from feedstocks.
- TAFV uses low cost combination of supply curves to satisfy ethanol demand.

Feedstock Supply Curves

- Cellulosic Biomass: Feedstocks

- Agricultural Residues
- SRWC
- Switchgrass
- Hardwoods
- Softwoods
- RDF - dropped

Feedstock Supply Curves

- Cellulosic Biomass:

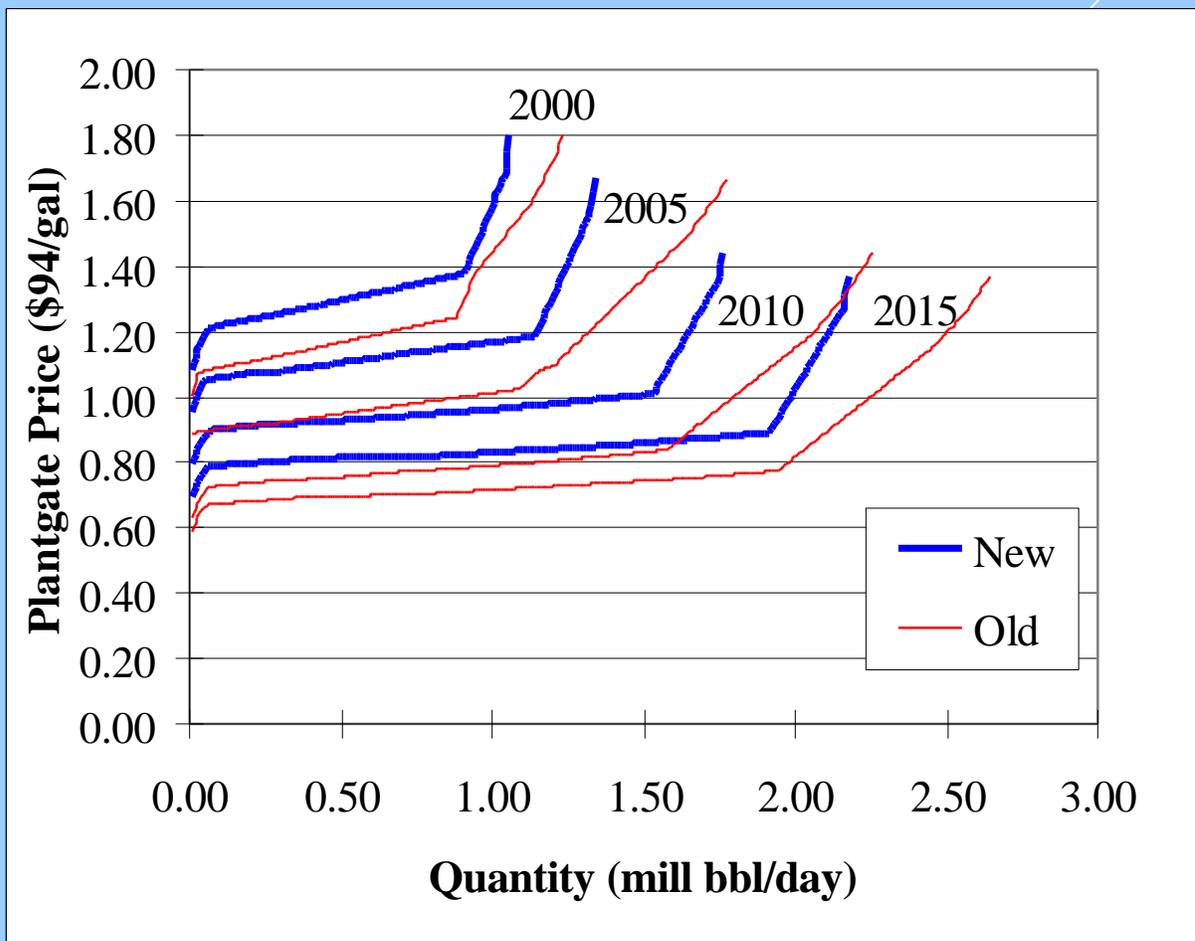
Data Sources

- Walsh, Perlack, Becker, Graham, and Turhollow (1997).
 - Intercepts
 - Slopes
 - Transportation costs
 - Max quantities
- Tien Nguyen (7/30/98).
 - New interim conversion costs

Feedstock Supply Curves - Cellulosic: Conversion Costs

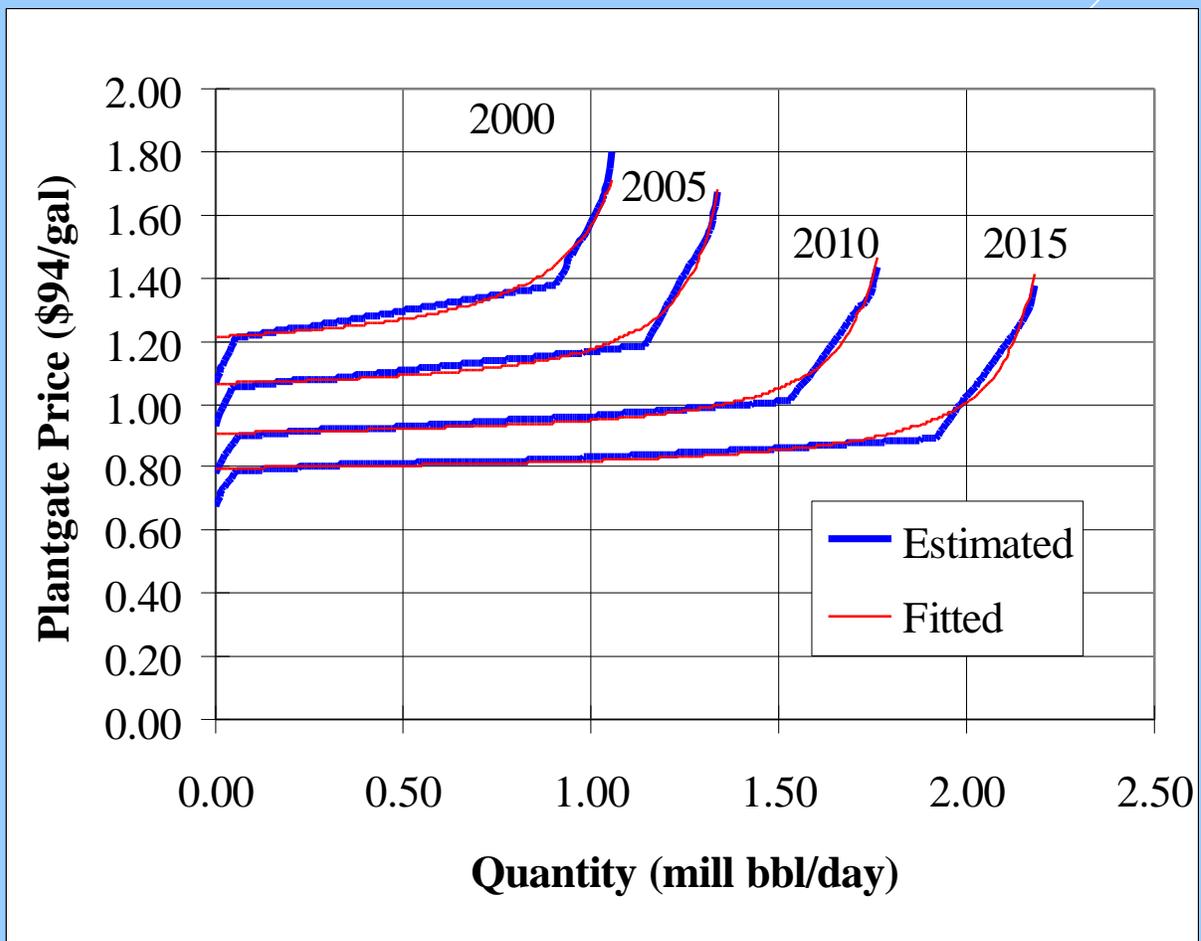
Old Conversion Costs (\$95/gal)				
	2000	2005	2010	2015
SRWC	0.765	0.643	0.405	0.352
Switchgrass	0.706	0.542	0.397	0.339
Agricultural Residues	0.706	0.542	0.397	0.339
Hardwood Wastes	0.765	0.643	0.405	0.352
Softwood Wastes	0.765	0.643	0.405	0.352
New Conversion Costs (\$95/gal)				
	2000	2005	2010	2015
All	0.843	0.709	0.575	0.46

Cost Minimization Results - Cellulosic Biomass: New vs. Old



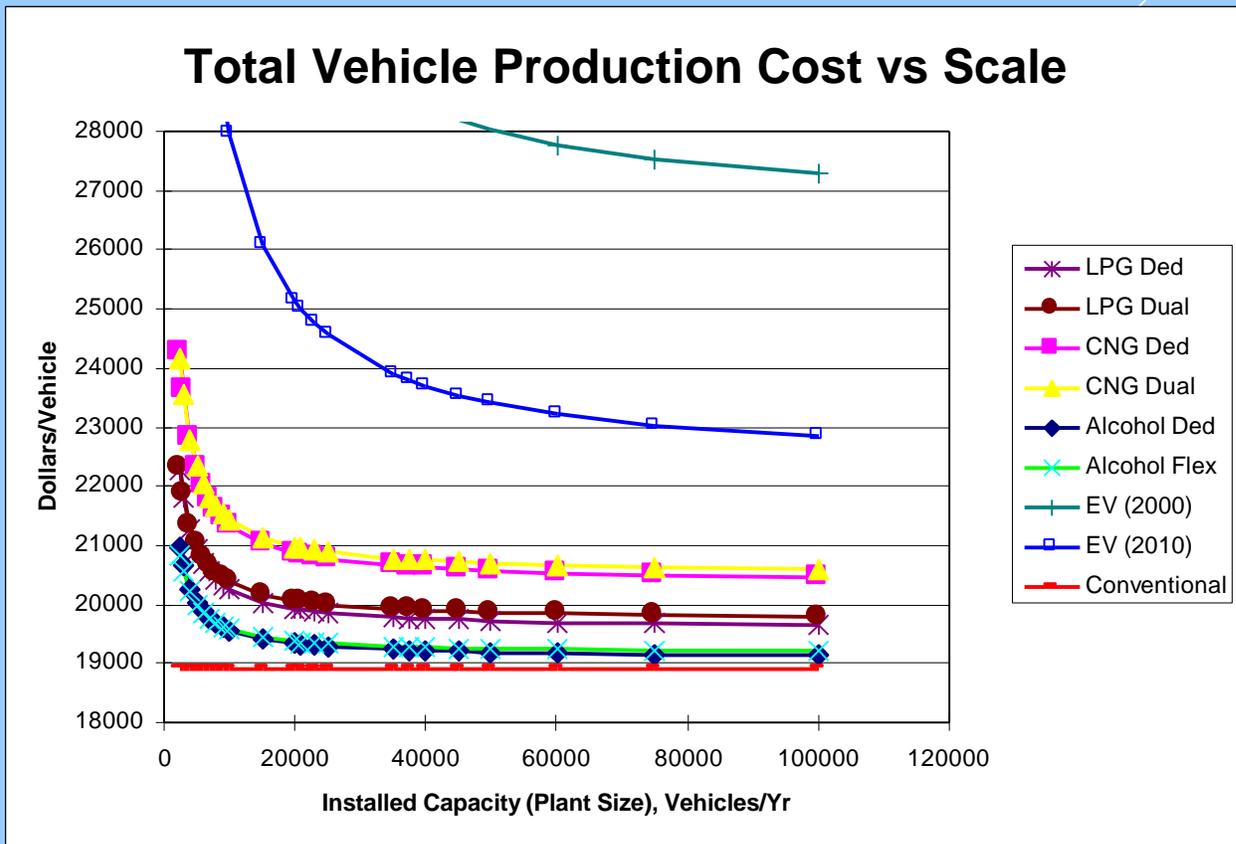
EthMCalc3.xls

Fitted TAFV Ethanol Supply Curves - Cellulosic Biomass



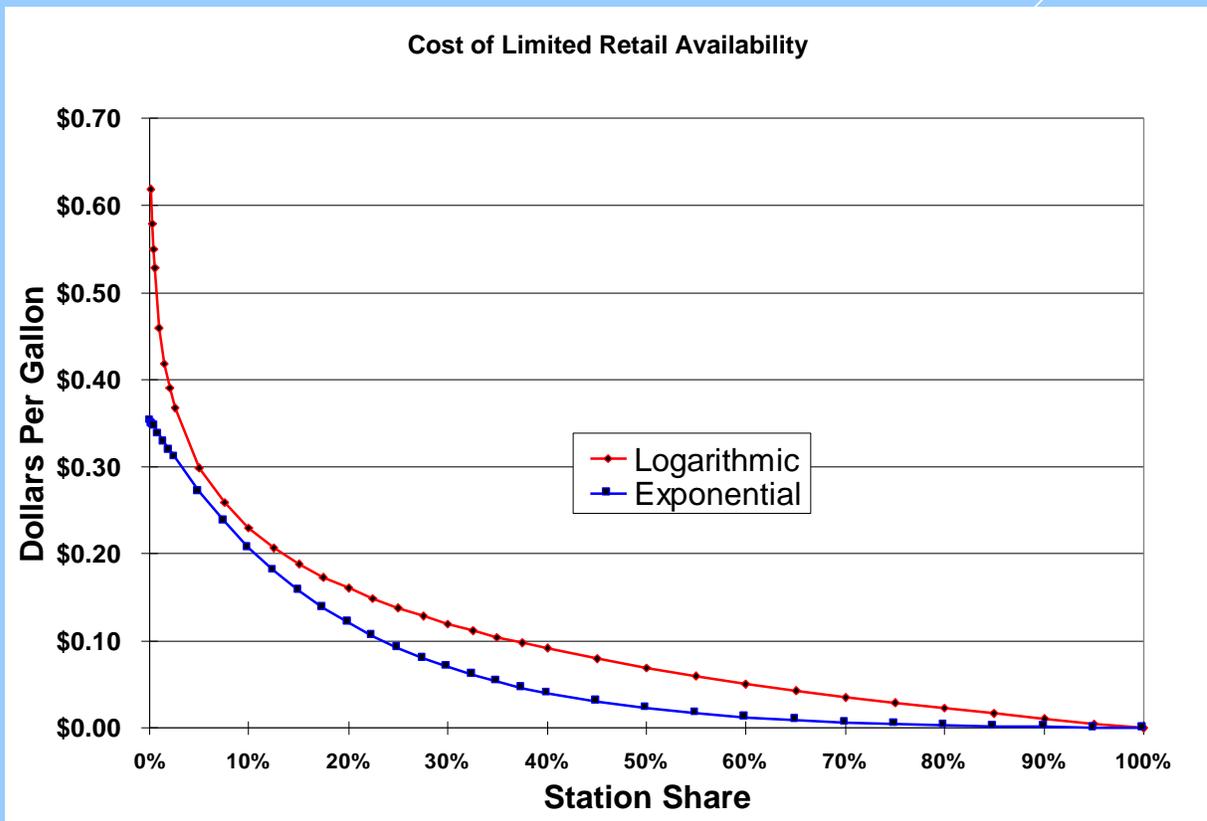
EthMCalc3.xls

Cost Data for Vehicle Production



VehPCst6, 6/20/97

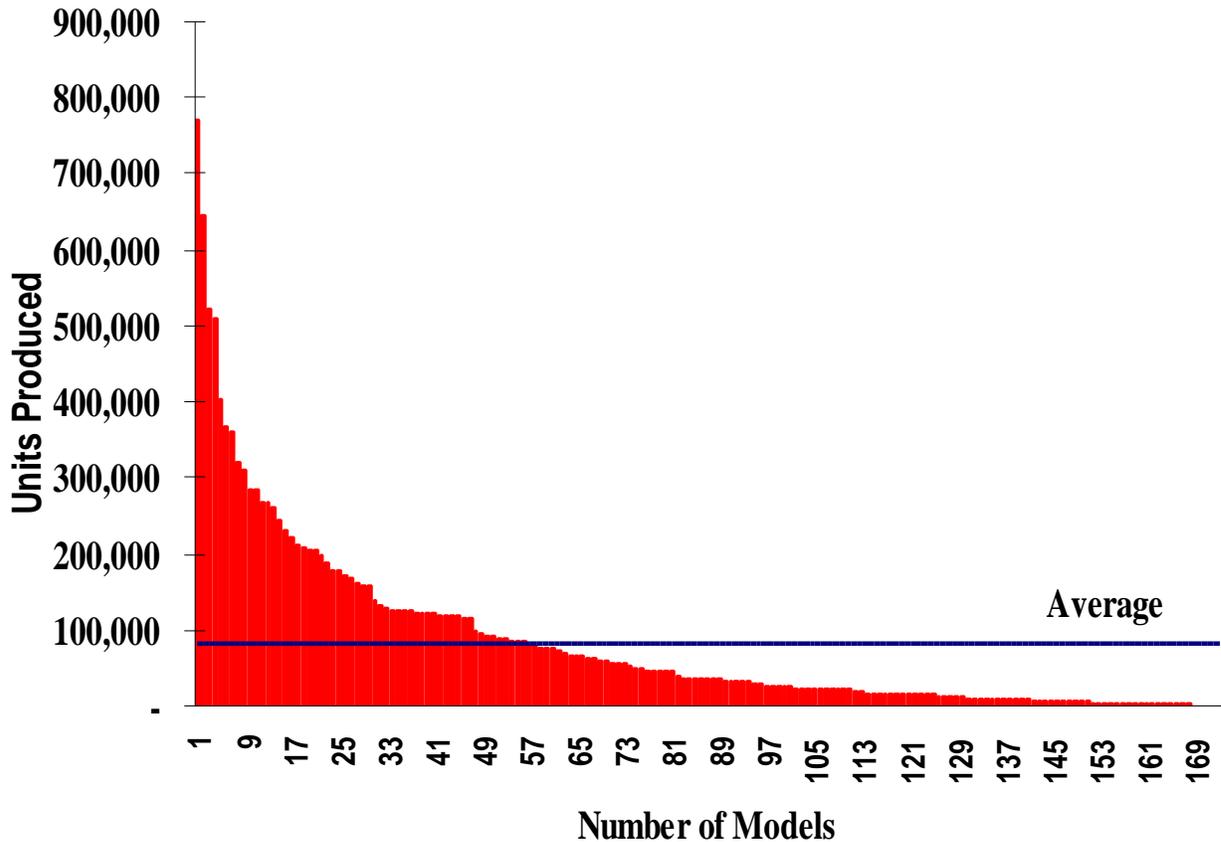
Cost of Limited Retail Availability for Fuels



FavailC4.xls 4/19/98

Variation in Vehicle Model Sales

Domestic Sales of Light Duty Vehicles for 1994



Domestic sales less than 1000 units not included.
Source: Automotive News Market Data Book 1995

vehicle0.xls

Effective Cost of Limited Vehicle-Model Diversity

- Producer's costs based on plant-level fixed costs, scale effects
- Consumer valuation based on nested multinomial logit
 - \$0/vehicle cost if diversity matches conventional vehicles
 - \$770/vehicle if fuel tech offered only on most popular model
 - \$2080/vehicle if fuel technology offered on one random vehicle

Vehicle and Fuel Choice

Factors Influencing Fuel and Vehicle Choice		
Factors considered in Fuel Choice	Endogenous	Exogenous
Fuel Price	X	
Fuel Availability (fraction stations offering fuel)	X	
Refueling Frequency (based on range)		X
Refueling Time Cost		X
Performance Using Fuel (HP: weight ratio changes)		X
Factors Considered in Vehicle Choice	Endogenous	Exogenous
Vehicle Price	X	
Fuel Cost (incl. effective cost of non-price fuel attributes)	X	
Performance (changes in HP-to-weight ratios)		X
Cargo Space (loss due to space required for fuel storage)		X
Vehicle Diversity (number of models offering AFV technology)	X	

Equal-Price Shares

Market Choice Shares			
Given Equal Prices, Fuel Availability and Vehicle Diversity			
Vehicle	Fuels	Fuel Share	Vehicle Share
Conventional	Conventional Gasoline		16.9%
Flex-Fuel	Conventional Gasoline	19.0%	
Flex-Fuel	M85	40.20%	
Flex-Fuel	E85	40.20%	16.8%
CNG Bifuel	Conventional Gasoline	90.8%	
CNG Bifuel	CNG	9.2%	7.1%
LPG Bifuel	Conventional Gasoline	76.0%	
LPG Bifuel	LPG	24.0%	13.8%
CNG Dedicated	CNG		9.7%
LPG Dedicated	LPG		15.6%
Alcohol Dedicated.	M85	50.0%	
Alcohol Dedicated	E85	50.0%	19.4%
Electric	Battery EV	0.0%	0.6%
Total			100.0%

Policy Cases Examined - 1

- **Base**
 - Current EPACT
 - CAFE credits
- **No Transitional Barriers**
- **EPACT Late Private Rule**
- **EPACT Late Private Rule *plus* 50% alt fuel use mandate**
- **Continued Ethanol Tax Credit**

Policy Cases Examined - 2

- **Ensign Bill:**
 - 50 cent AF credit thru 2004
- **Extended Ensign Bill:**
 - 25 cent AF credit thru 2009
- **Ensign Bill Plus:**
 - 50 cent AF credit and AFV Credits thru 2004
- **Extended Ensign Bill Plus:**
 - 25 cent AF credit and AFV Credits thru 2009

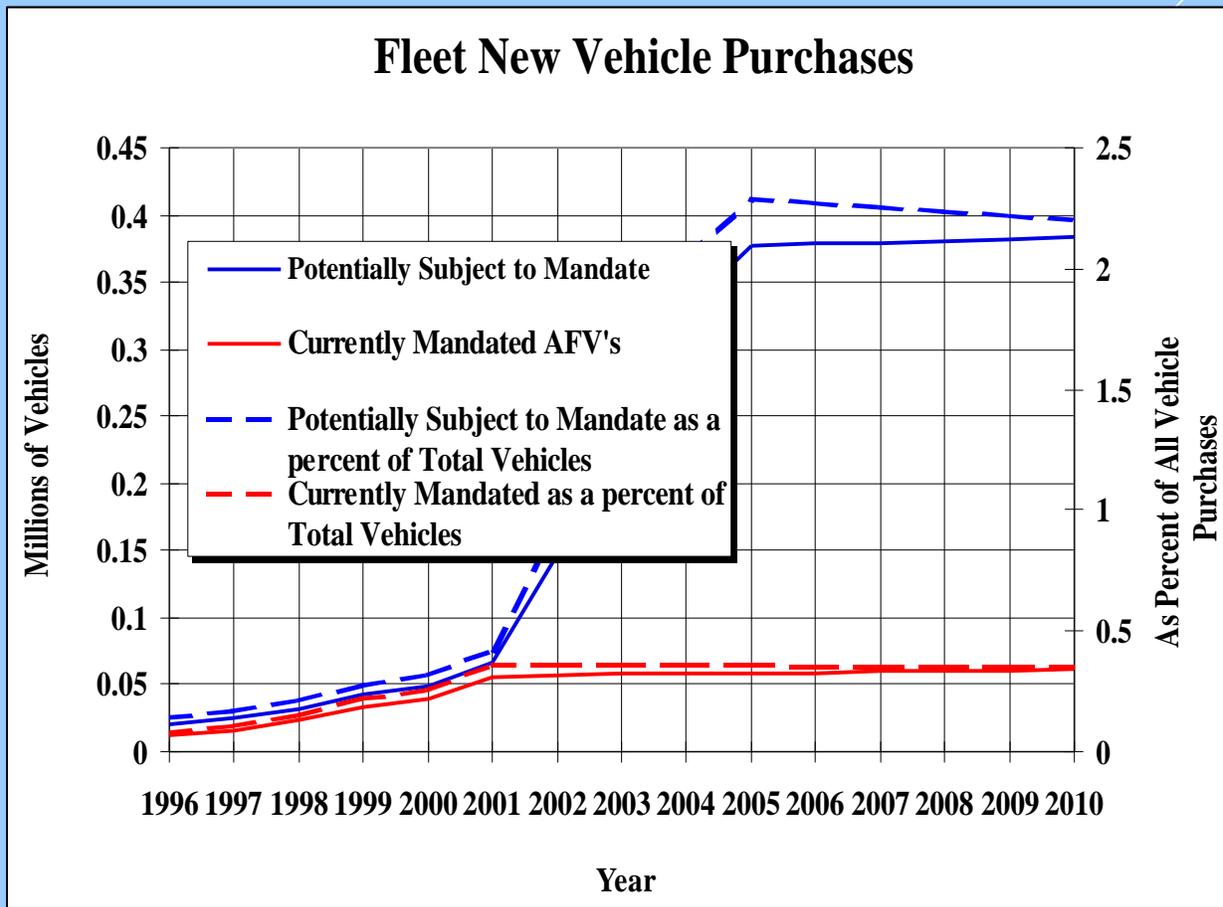
Policy Cases Examined - 3

- **Increased CAFE Standards by 1 MPG**
- **Retail AF Sales Mandate of 30% by 2010**
- **Low GHG Fuel Subsidy**

Price/Cost Scenarios

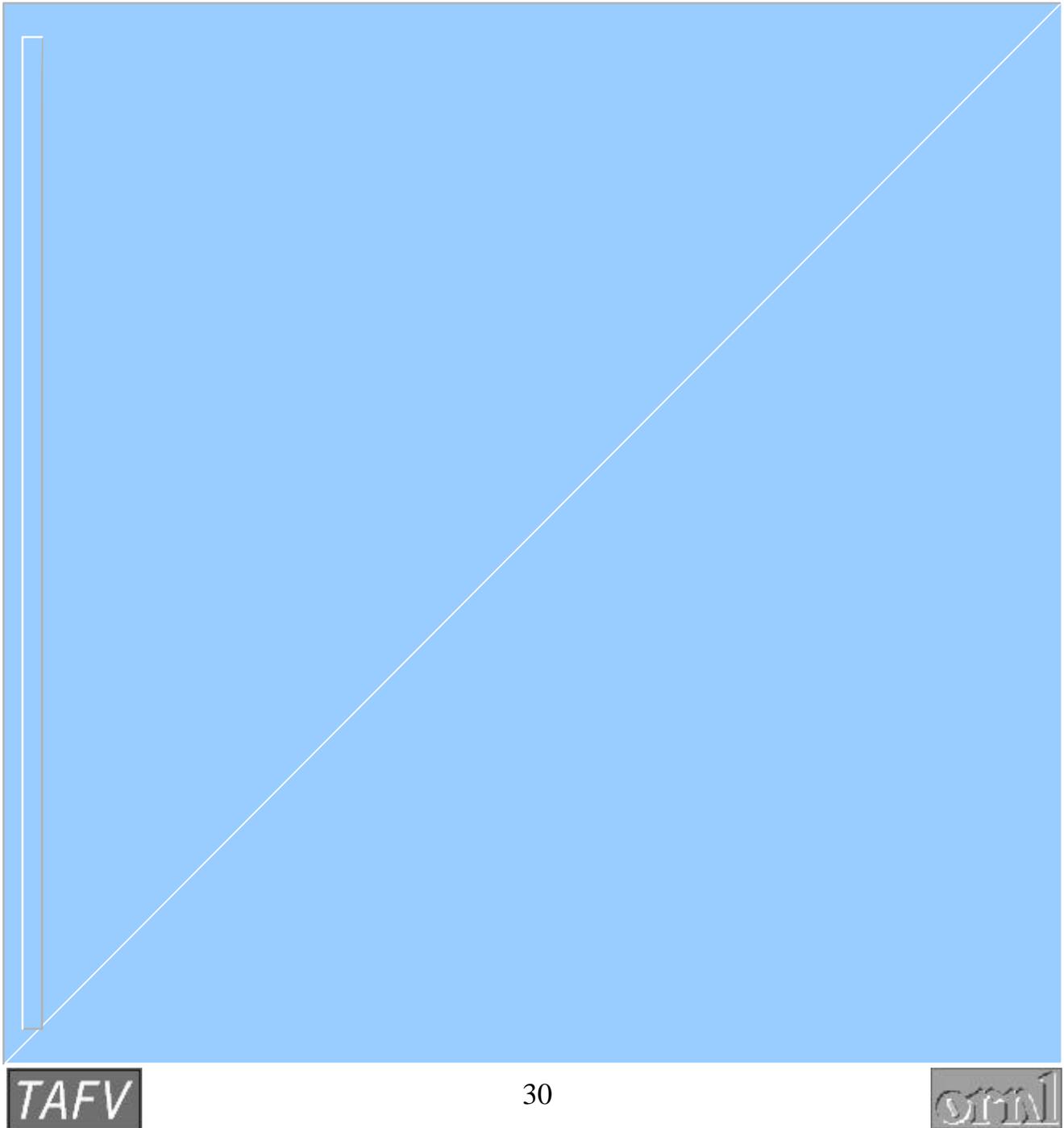
- AEO98 Base with higher LPG
- AEO98 HWOP
- AEO98 HWOP, tax credits inflation adjusted
- AEO98 HWOP, lower LPG
- AEO98 Base - oil price shock 2005
- AEO98 Base, higher LPG, tax credits inflation adjusted

EPACT AFV Mandates: Current and Late Rule

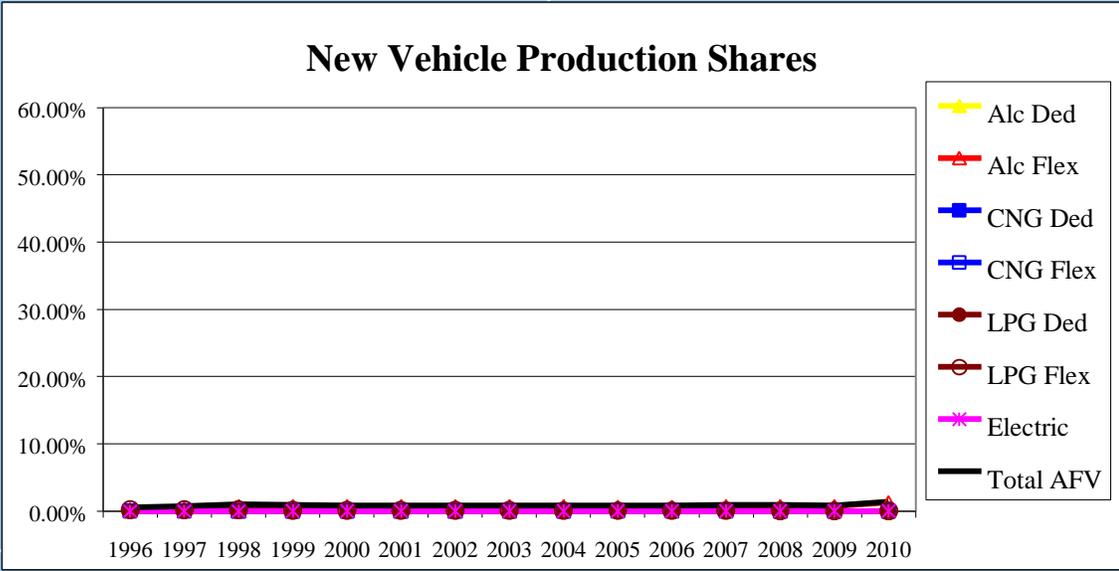
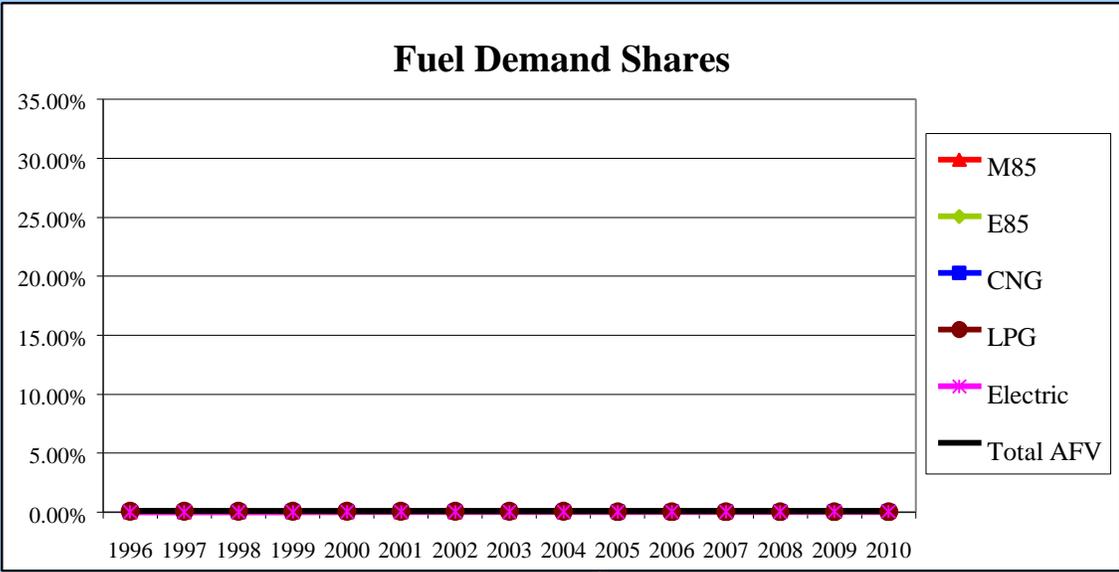


R89Rslt5V97.xls

RESULTS FROM TAFV RUNS

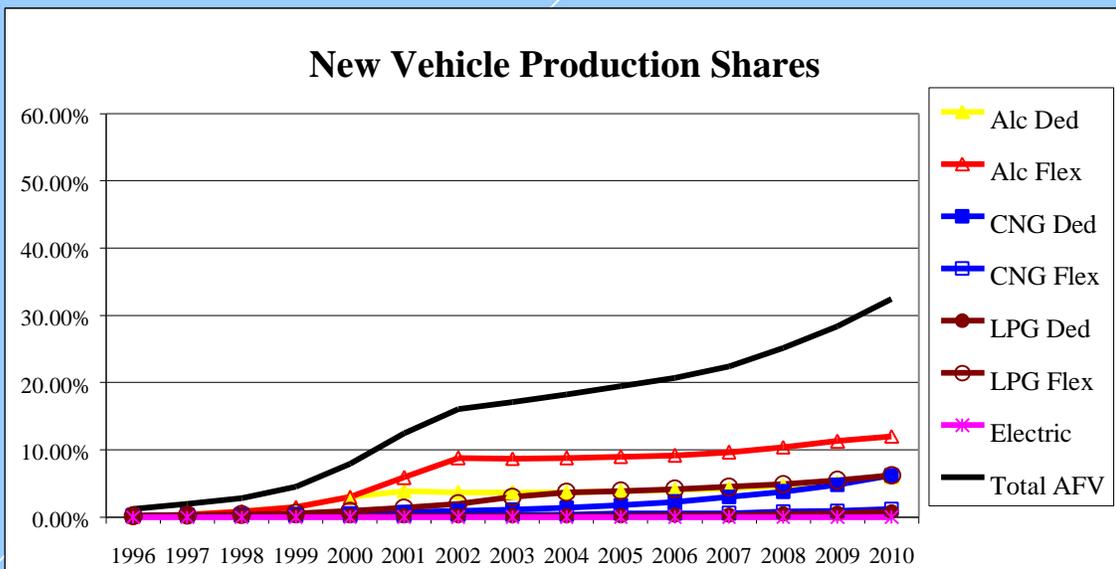
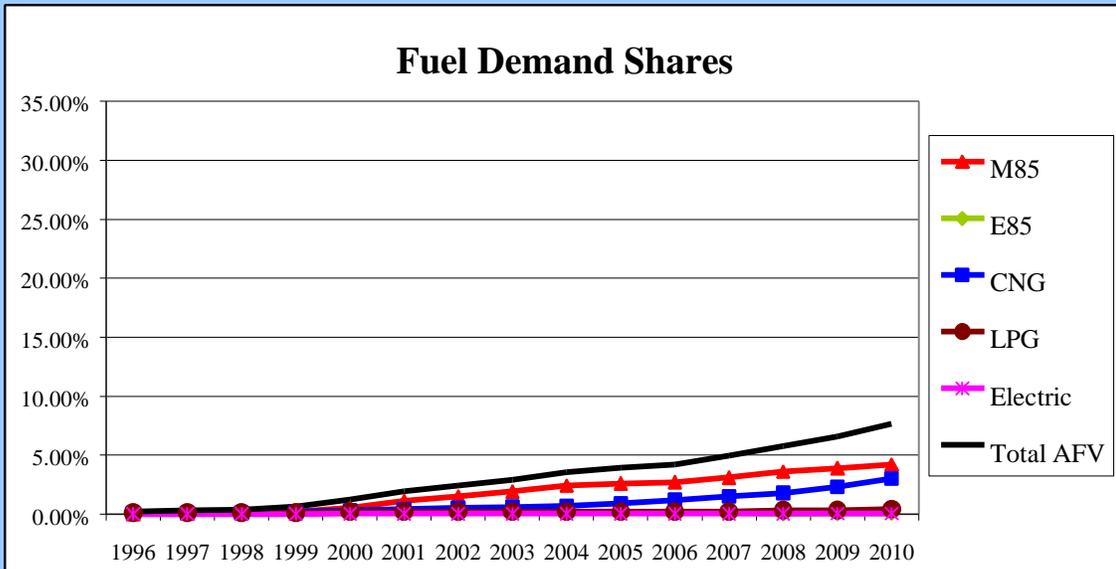


Fuel Demand and New Vehicle Production Shares Base-No New Policy Case



Case #1, R97B00RS
AEO Base, Higher LPG Cost

Fuel Demand and New Vehicle Production Shares No Transitional Barriers

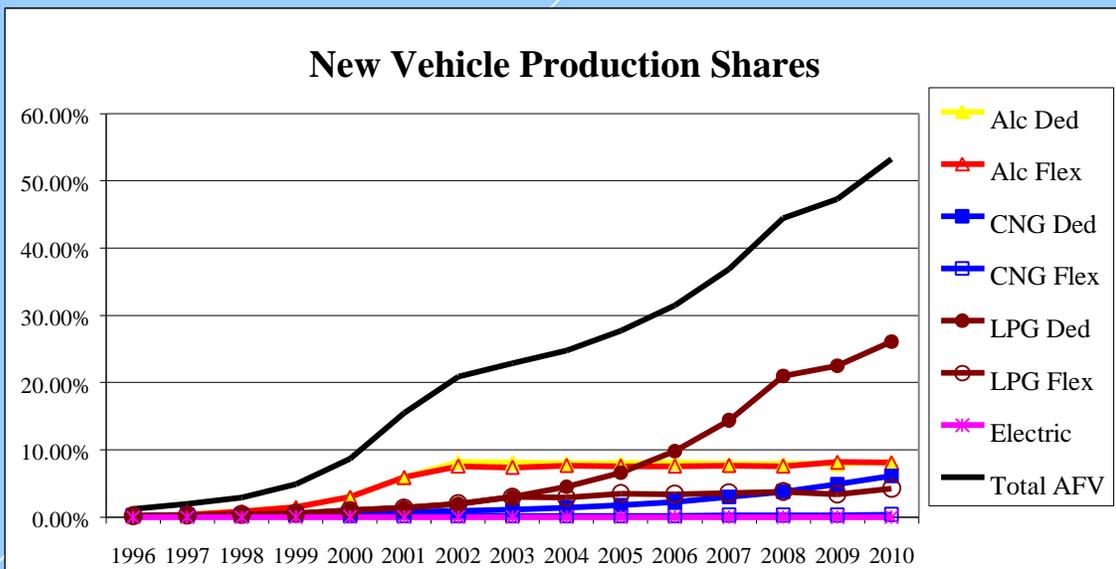
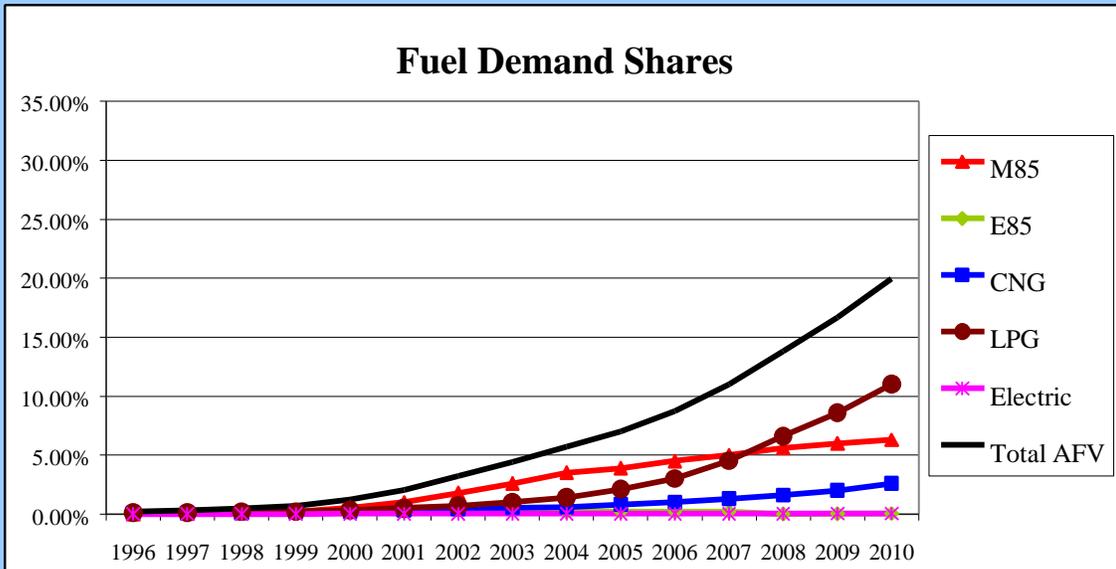


Case #12, R97BNBRS
AEO Base, Higher LPG Cost

Fuel Demand and New Vehicle Production Shares

No Transitional Barriers

Higher World Oil Price, Lower LPG Cost

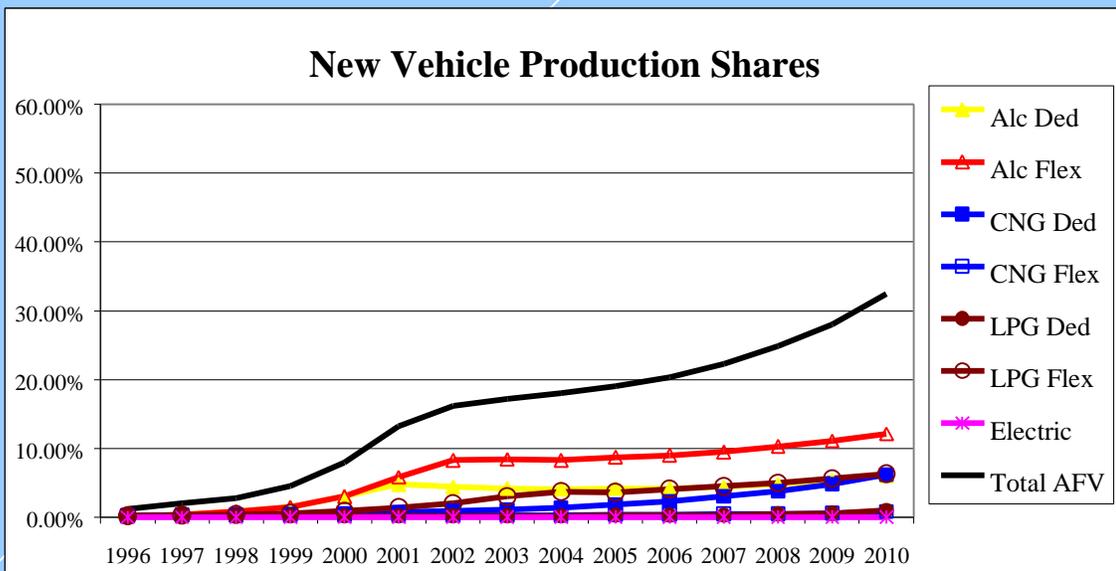
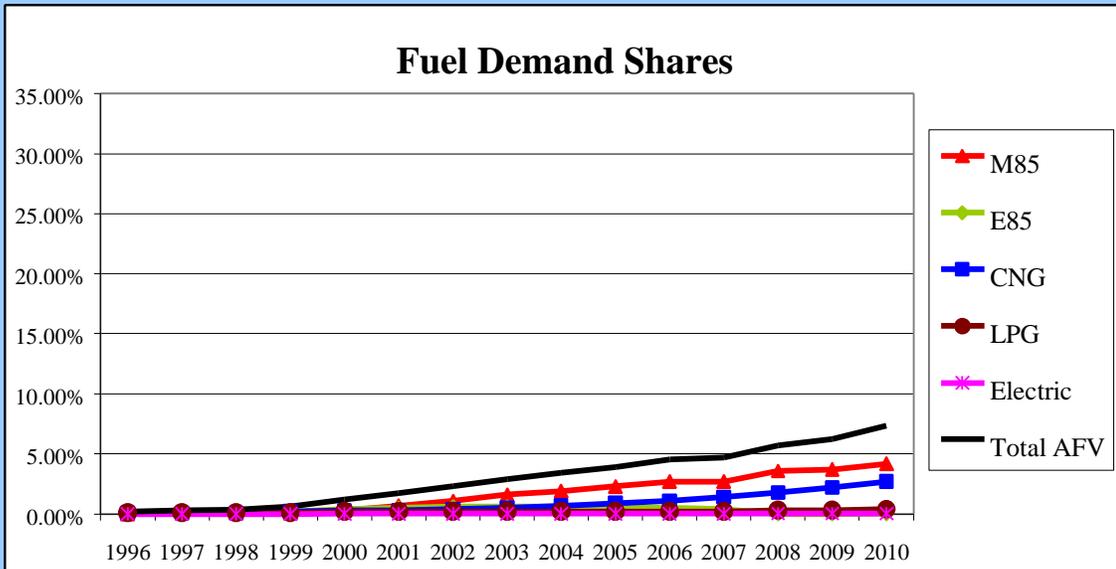


Case #48, R97BNBRS
AEO HWOP, Lower LPG Cost

Fuel Demand and New Vehicle Production Shares

No Transitional Barriers

Tax Credits Inflation Adjusted

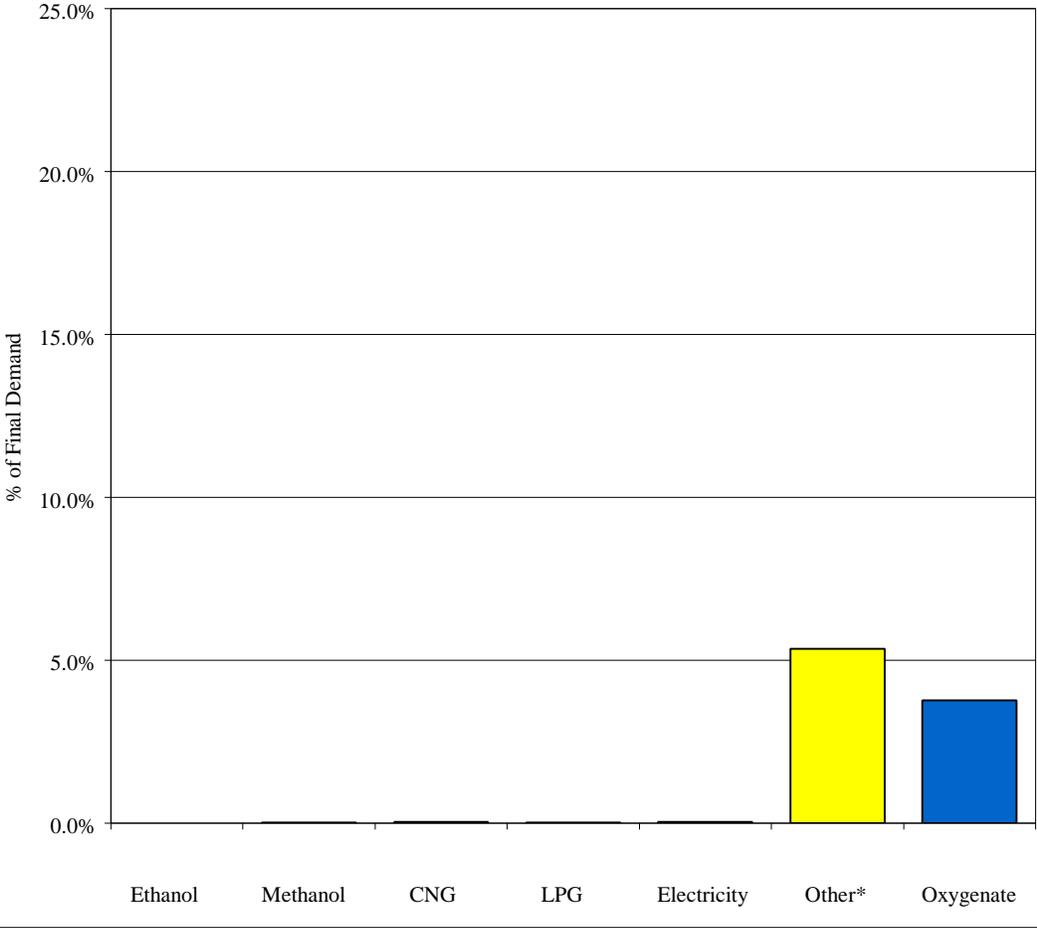


Case #72, R97BNBRS

AEO Base, Higher LPG Cost, Tax Credits Inflation Adjusted

Gasoline Displacement Base-No New Policy Case

Year 2010 Gasoline Displacement by Alternative Fuels: 9.2%



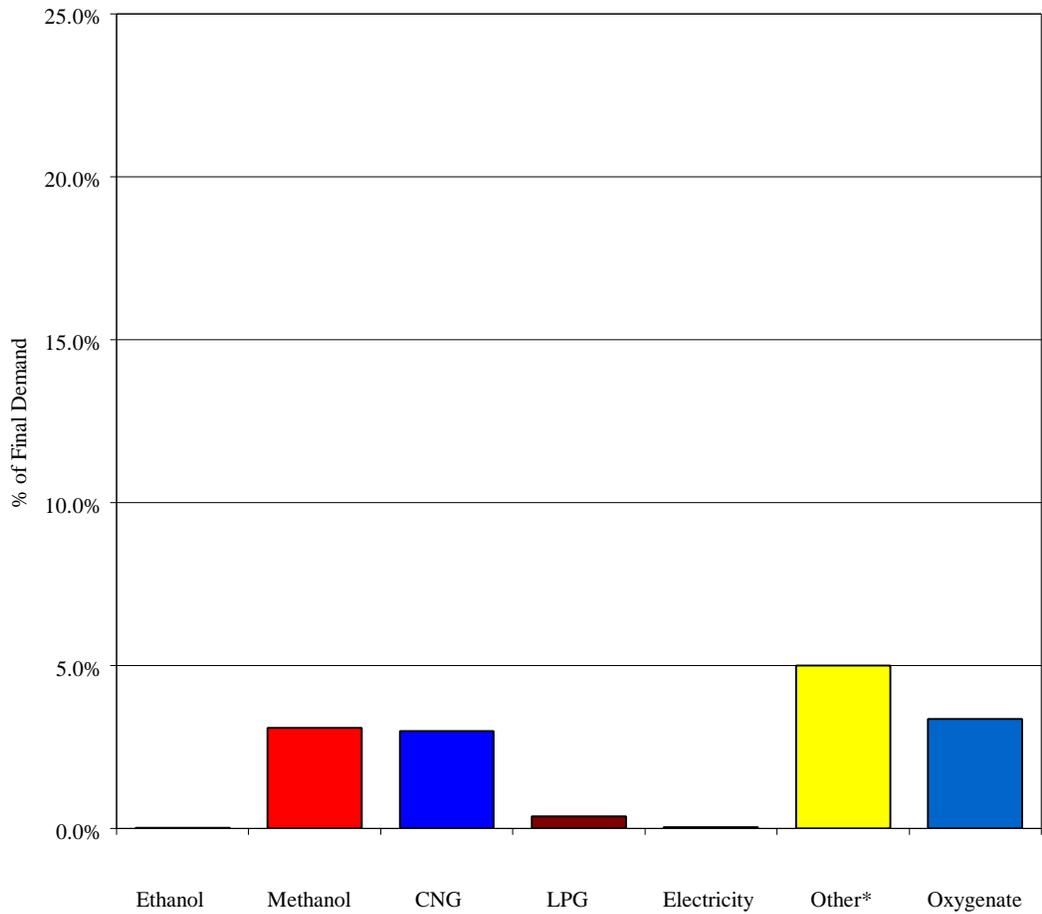
	Ethanol	Methanol	CNG	LPG	Electricity	Other*	Oxygenate
Quantity (MMBGED)	0.00	0.00	0.00	0.00	0.00	0.51	0.36
Share	0.0%	0.0%	0.0%	0.0%	0.0%	5.3%	3.8%

*Includes Natural Gas Liquids, Other Hydrocarbons, and Hydrogen

Case #1, R97B00RS
AEO Base, Higher LPG Cost

Gasoline Displacement No Transitional Barriers

Year 2010 Gasoline Displacement by Alternative Fuels: 14.9%



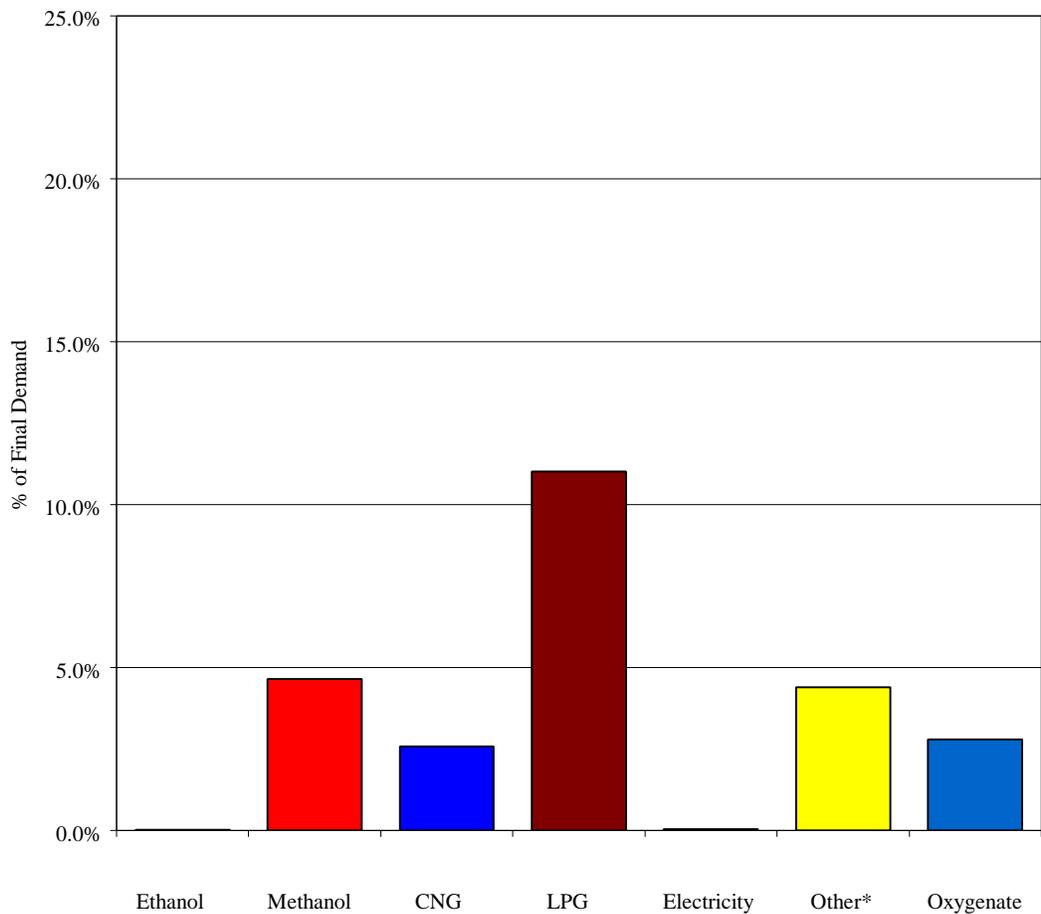
Quantity (MMBGED)	0.00	0.30	0.29	0.04	0.00	0.48	0.32
Share	0.0%	3.1%	3.0%	0.4%	0.0%	5.0%	3.4%

*Includes Natural Gas Liquids, Other Hydrocarbons, and Hydrogen

Case #12, R97BNBRS
AEO Base, Higher LPG Cost

Gasoline Displacement No Transitional Barriers Higher World Oil Price, Lower LPG Cost

Year 2010 Gasoline Displacement by Alternative Fuels: 25.5%



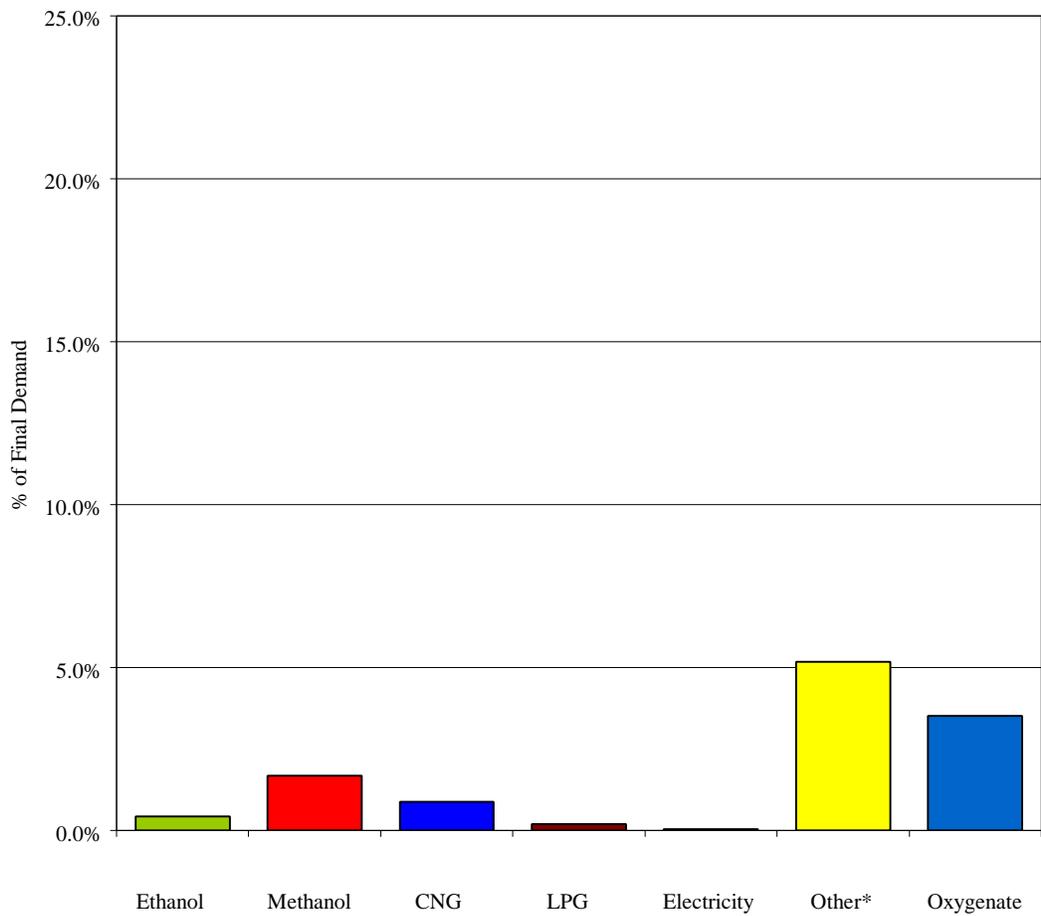
	Ethanol	Methanol	CNG	LPG	Electricity	Other*	Oxygenate
Quantity (MMBGED)	0.00	0.45	0.25	1.05	0.00	0.42	0.27
Share	0.0%	4.6%	2.6%	11.0%	0.0%	4.4%	2.8%

*Includes Natural Gas Liquids, Other Hydrocarbons, and Hydrogen

Case #48, R97BNBRS
AEO HWOP, Lower LPG Cost

Gasoline Displacement No Transitional Barriers Tax Credits Inflation Adjusted

Year 2005 Gasoline Displacement by Alternative Fuels: 11.9%



Quantity (MMBGED)	0.04	0.15	0.08	0.02	0.00	0.46	0.31
Share	0.4%	1.7%	0.9%	0.2%	0.0%	5.2%	3.5%

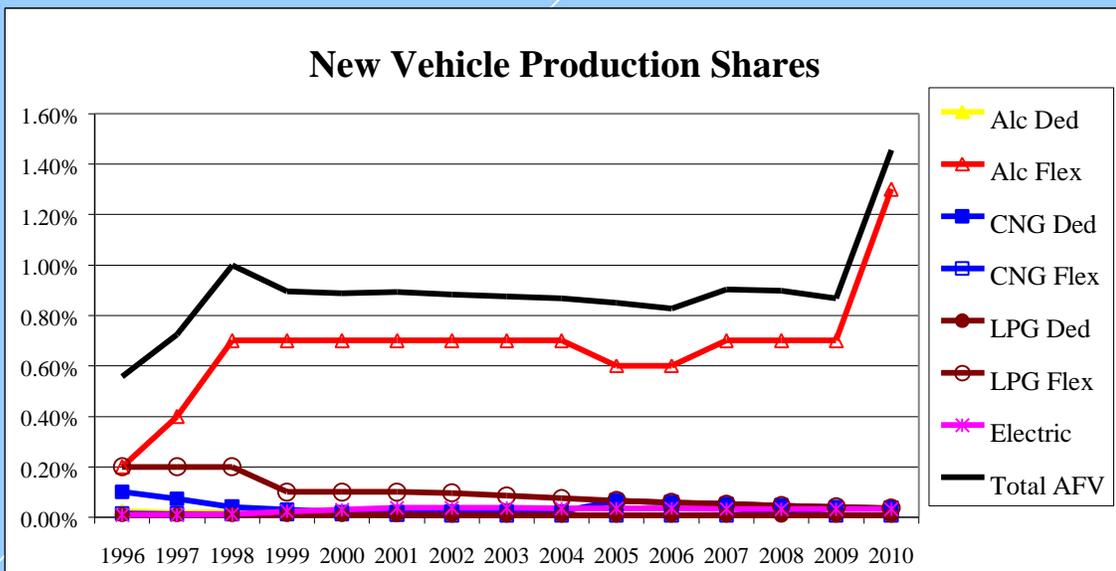
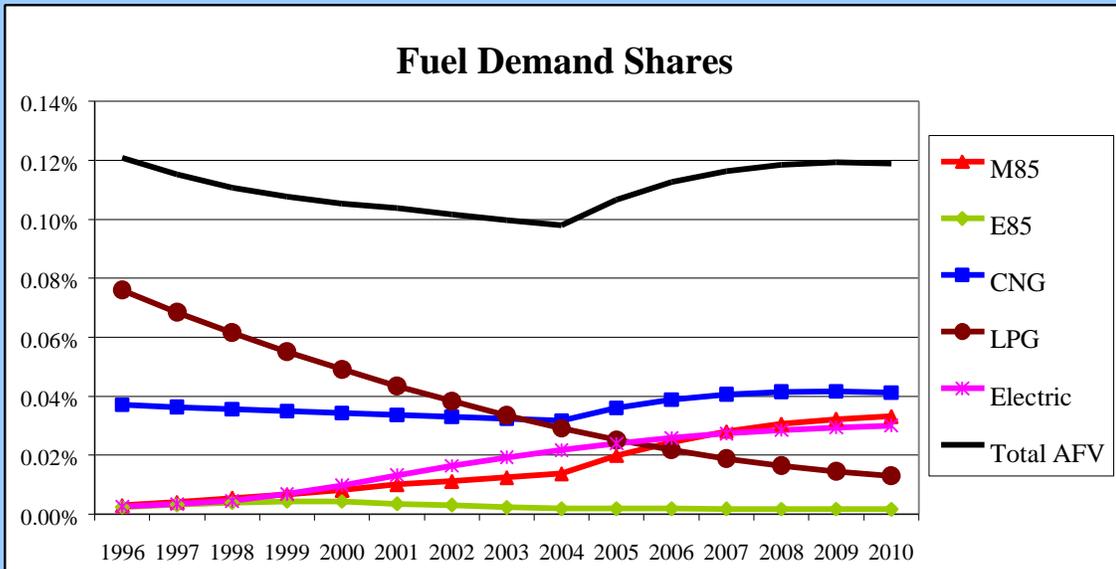
*Includes Natural Gas Liquids, Other Hydrocarbons, and Hydrogen

Case #72, R97BNBRS

AEO Base, Higher LPG Cost, Tax Credits Inflation Adjusted

Fuel Demand and New Vehicle Production Shares Base-No New Policy Case

(Enhanced Scale)



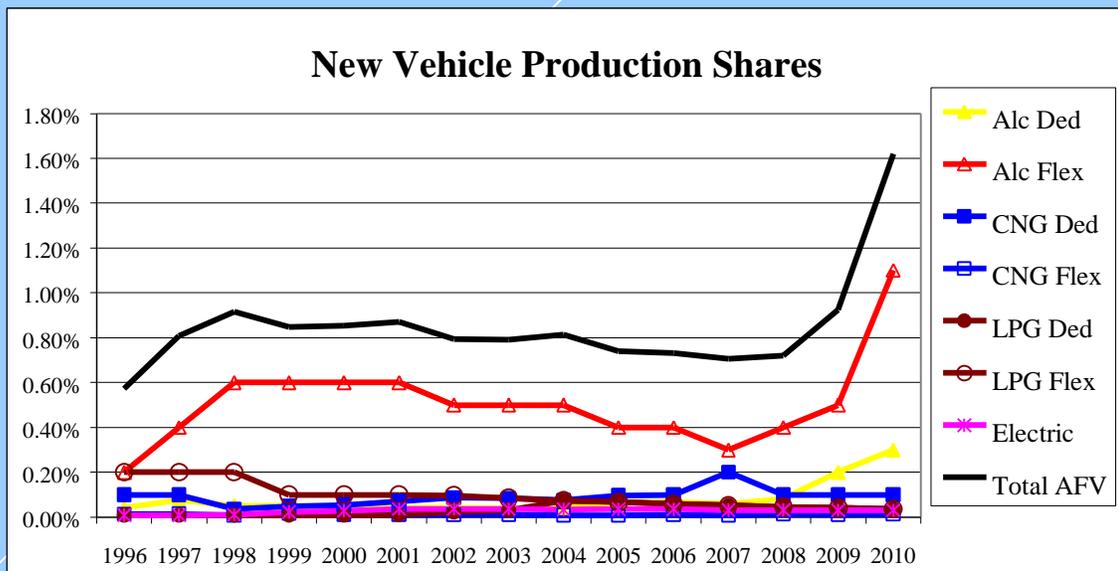
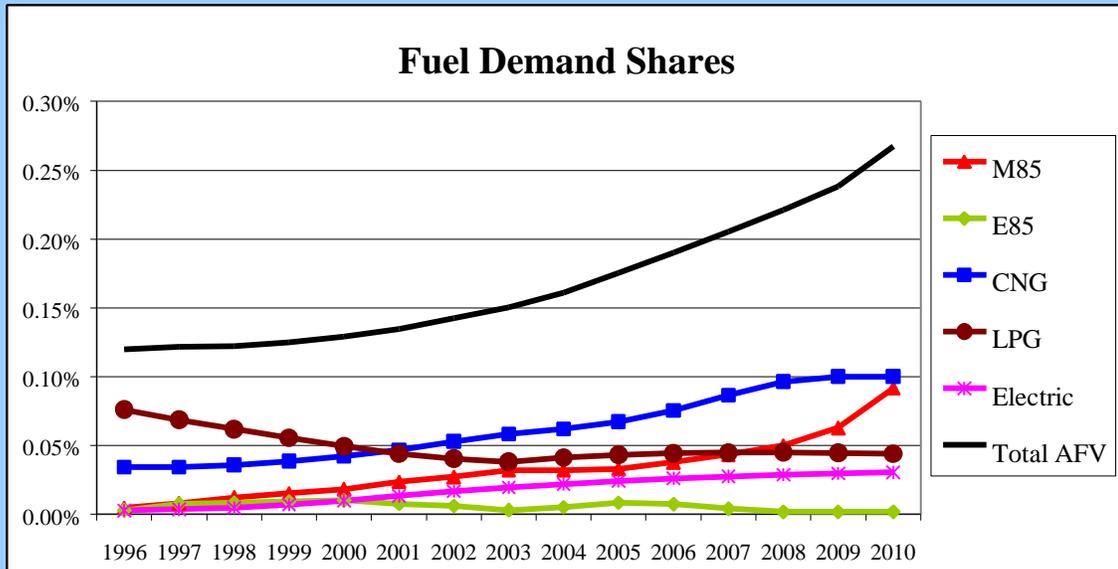
Case #1, R97B00RS
AEO Base, Higher LPG Cost

Fuel Demand and New Vehicle Production Shares

Base-No New Policy Case

Higher World Oil Price, Lower LPG Cost

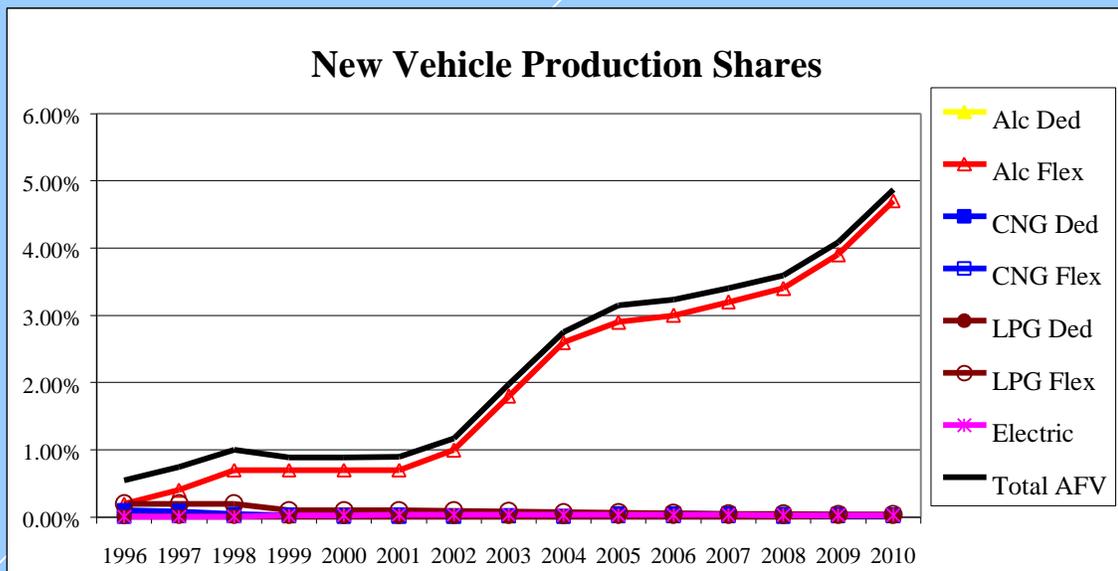
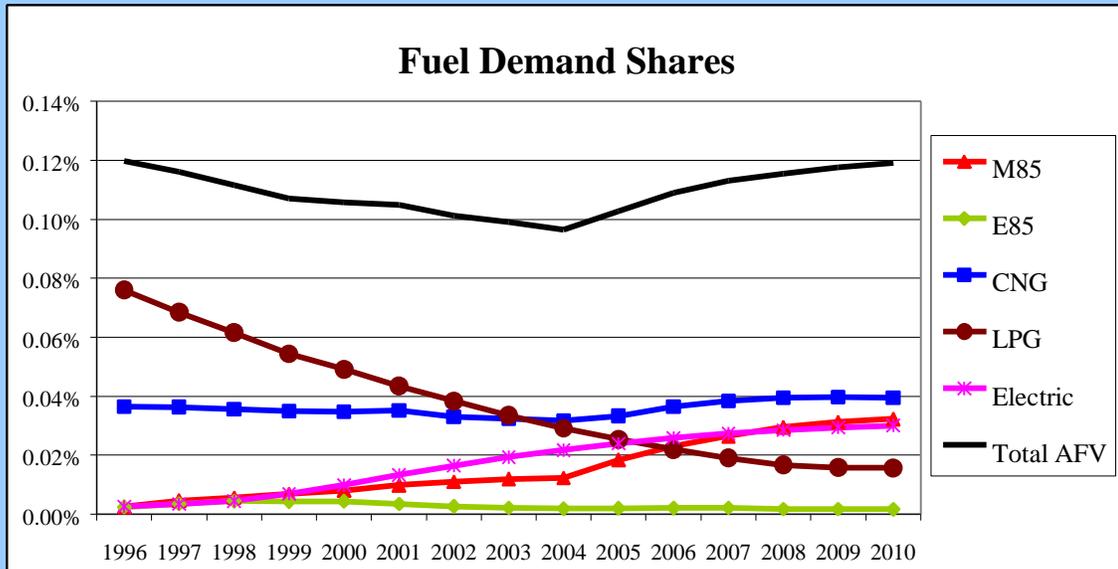
(Enhanced Scale)



Case #37, R97B00RS
AEO HWOP, Lower LPG Cost

Fuel Demand and New Vehicle Production Shares Late Private Rule

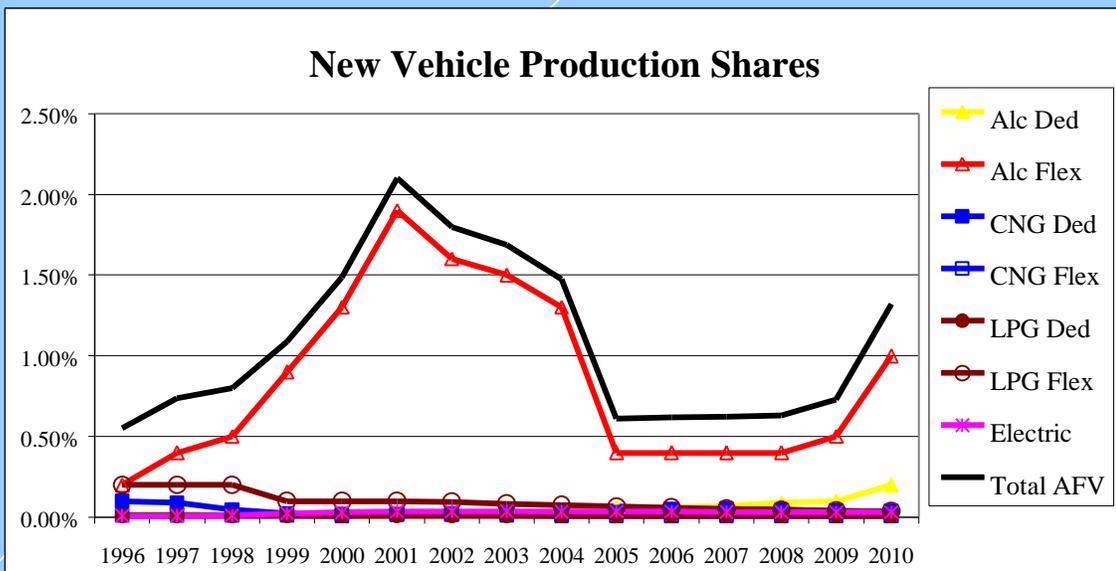
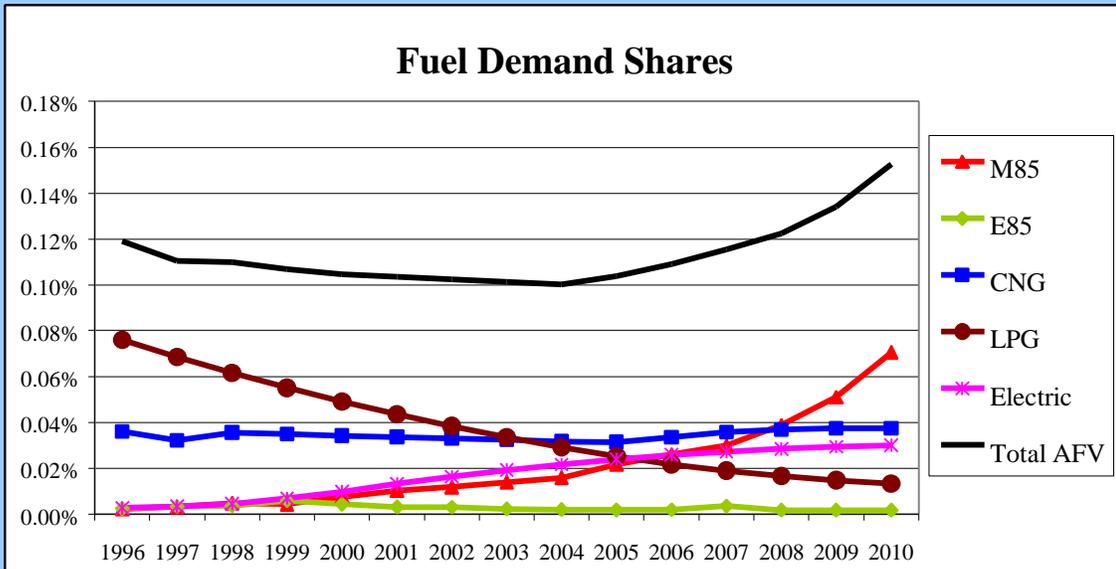
(Enhanced Scale)



Case #2, R97P00RS
AEO Base, Higher LPG Cost

Fuel Demand and New Vehicle Production Shares Increased CAFE Standards

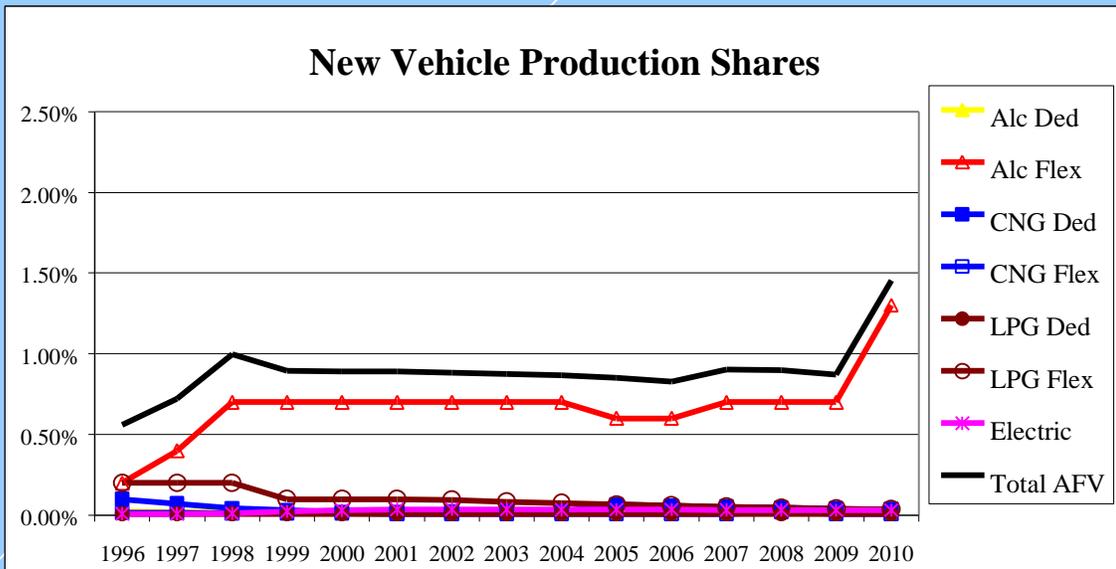
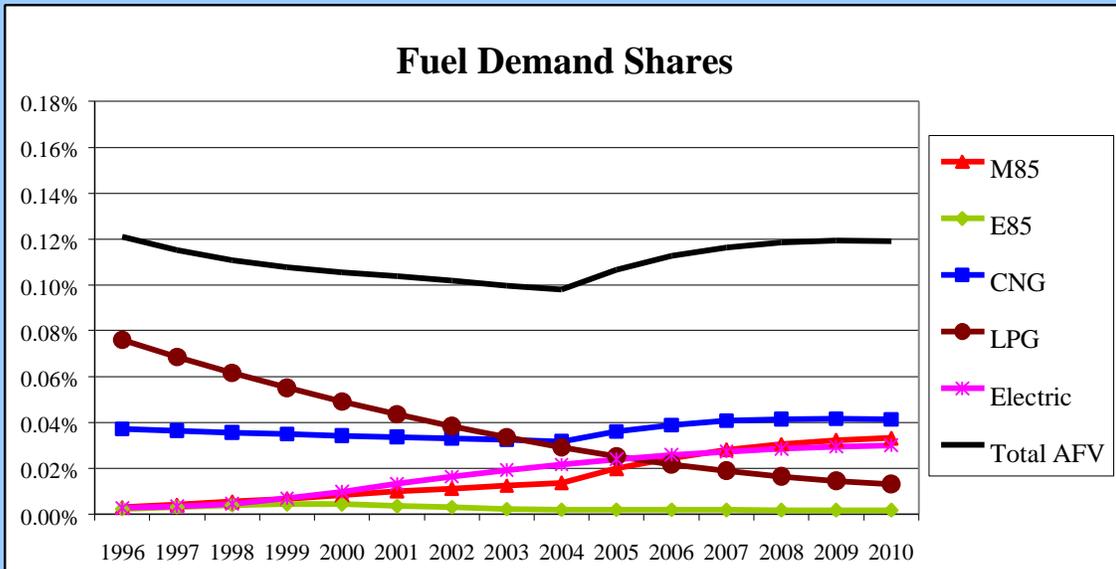
(Enhanced Scale)



Case #6, R97CA0RS
AEO Base, Higher LPG Cost

Fuel Demand and New Vehicle Production Shares Base-No New Policy Case

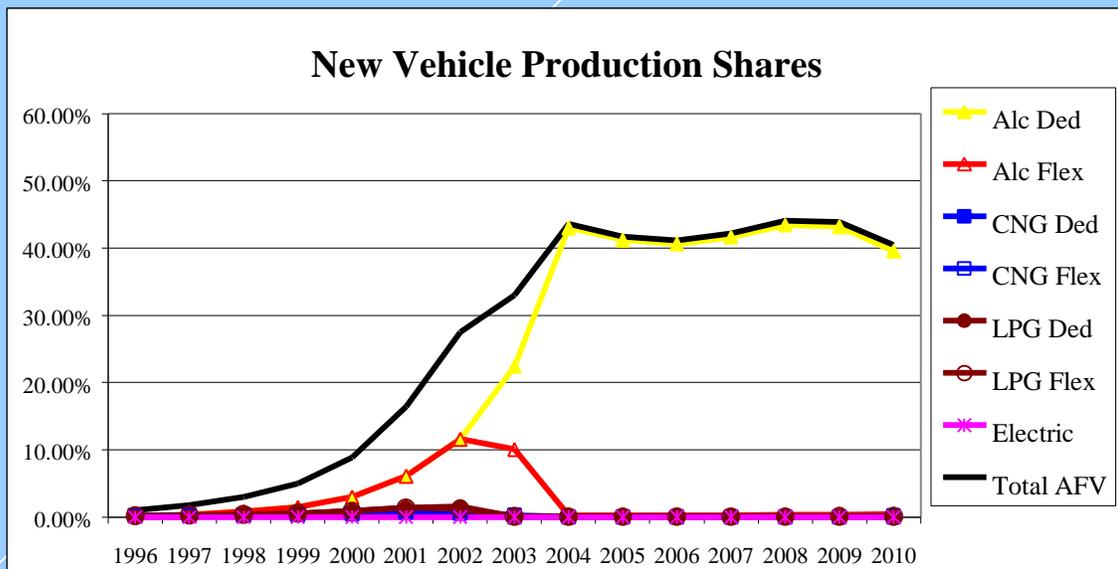
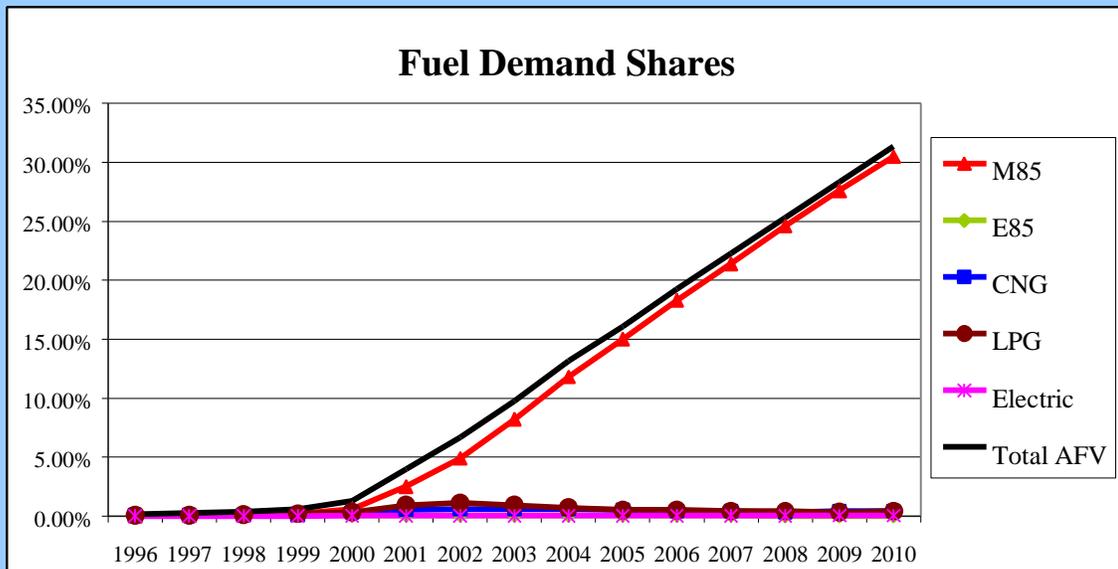
(Scale Matches Increased CAFE Standard)



Case #1, R97B00RS
AEO Base, Higher LPG Cost

Fuel Demand and New Vehicle Production Shares

Retail Alternative Fuel Sales Mandate

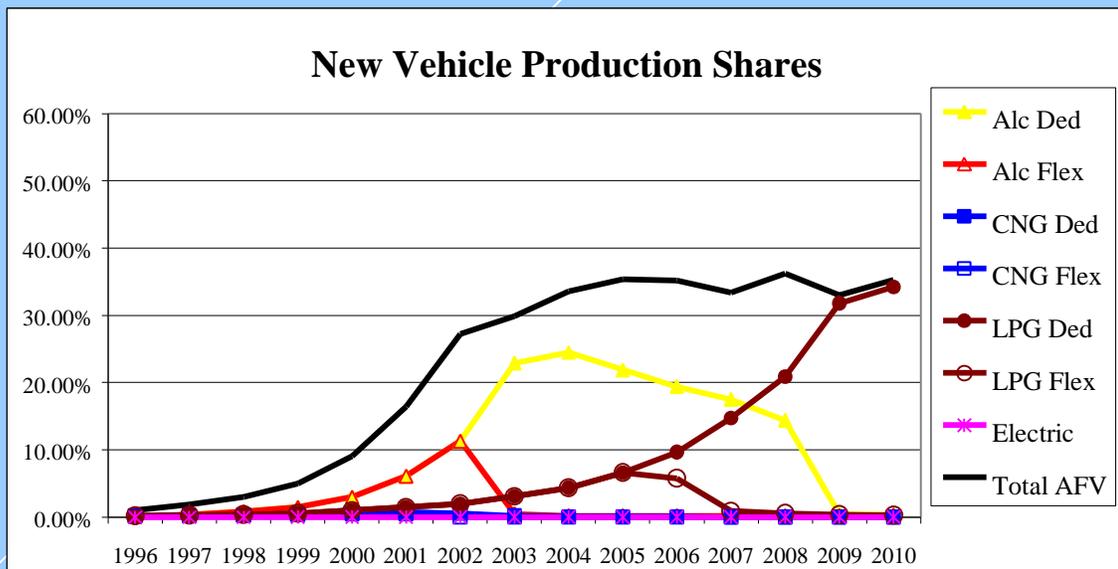
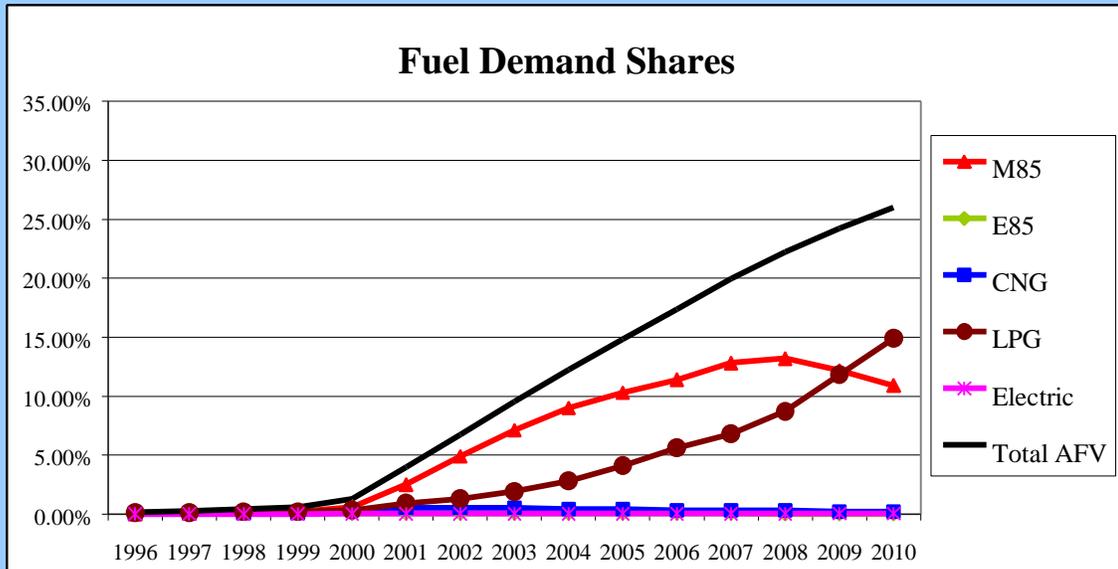


Case #7, R97FM0RS
AEO Base, Higher LPG Cost

Fuel Demand and New Vehicle Production Shares

Retail Alternative Fuel Sales Mandate

Higher World Oil Price, Lower LPG Cost

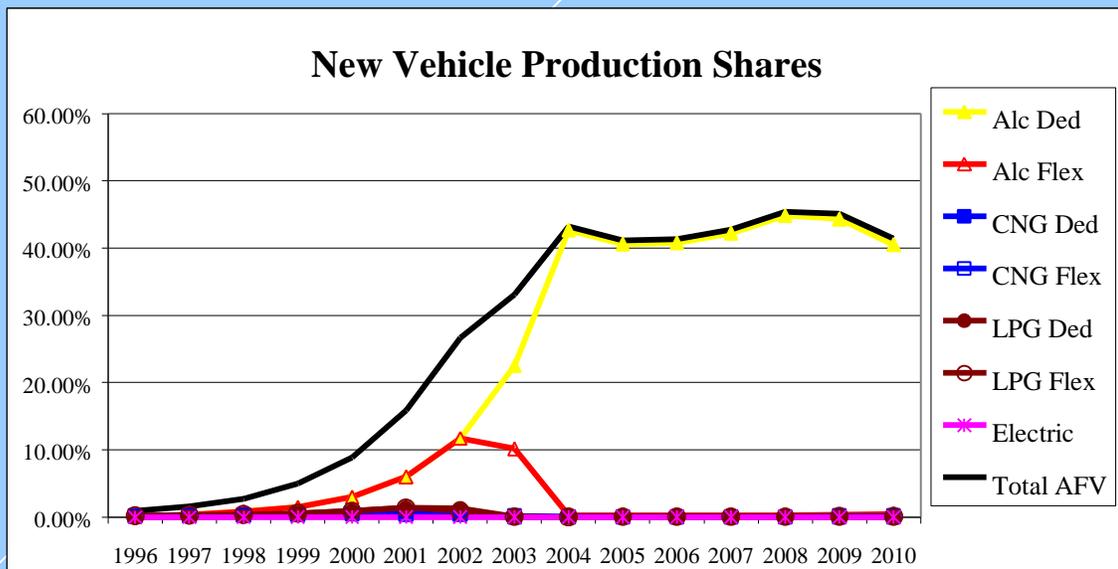
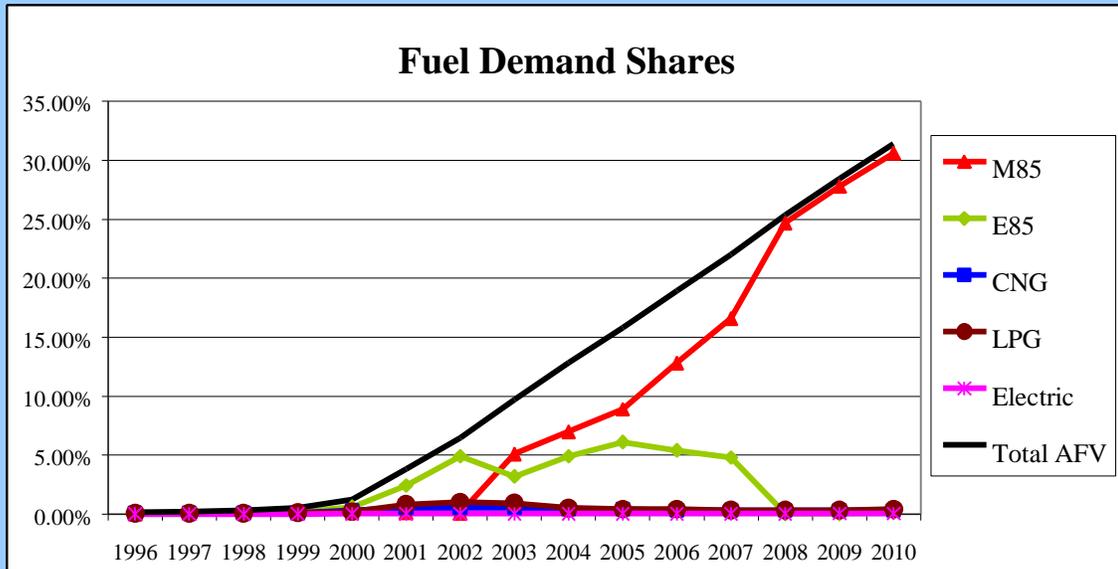


Case #43, R97FM0RS
AEO HWOP, Lower LPG Cost

Fuel Demand and New Vehicle Production Shares

Retail Alternative Fuel Sales Mandate

Tax Credits Inflation Adjusted

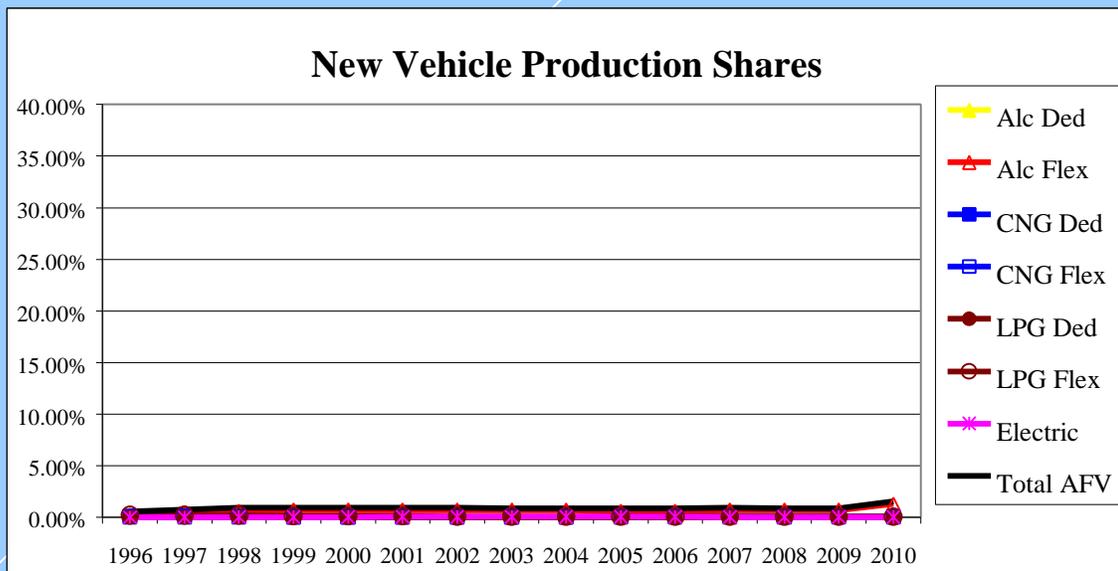
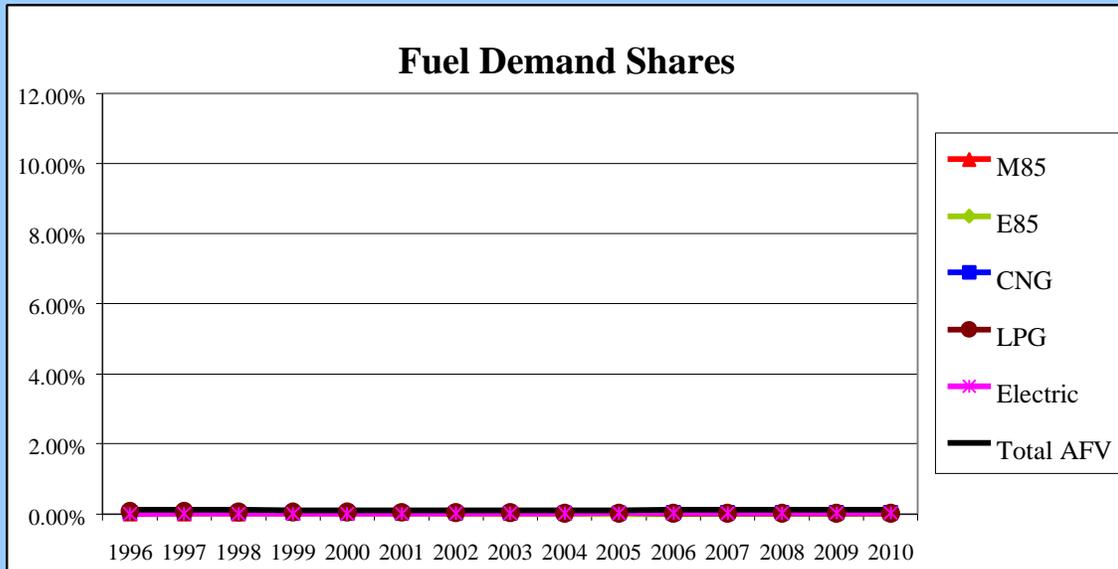


Case #67, R97FM0RS

AEO Base, Higher LPG Cost, Tax Credits Inflation Adjusted

Fuel Demand and New Vehicle Production Shares Continued Ethanol Tax Credit

(Scale Matches Higher World Oil Price, Tax Credits
Inflation Adjusted)

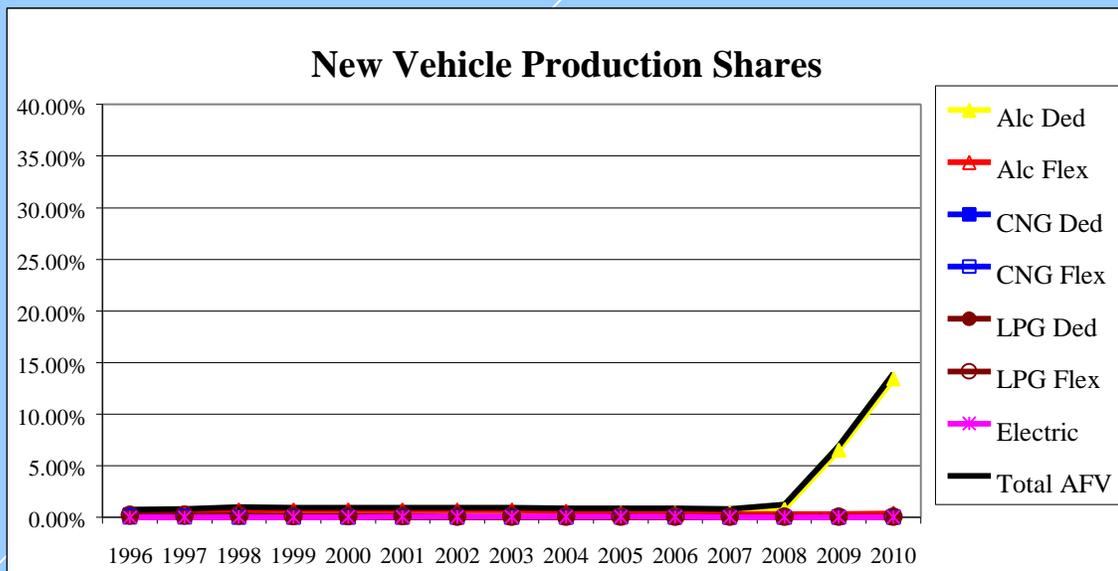
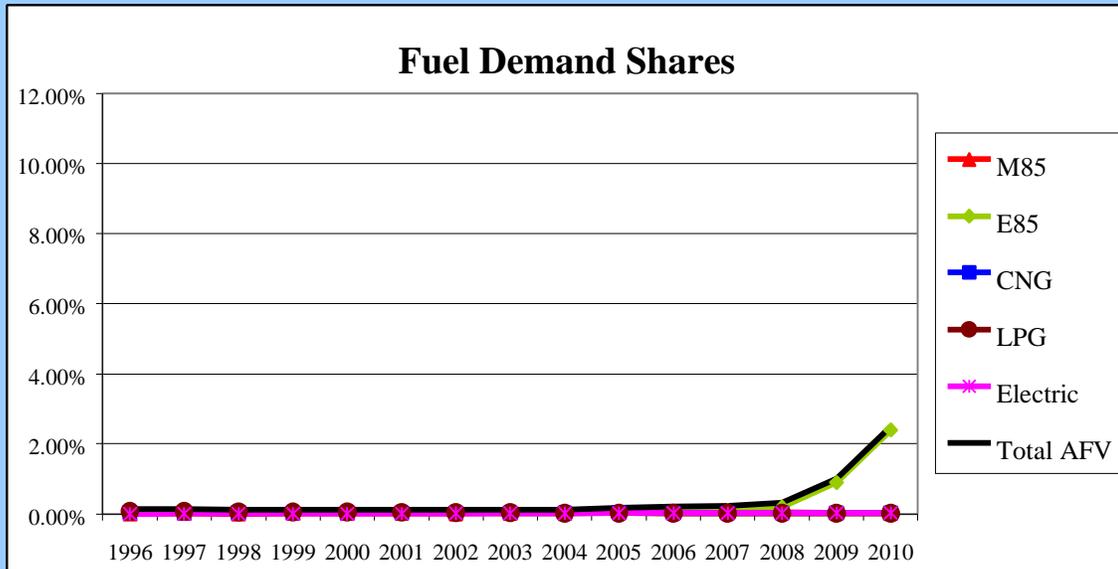


Case #4, R97TC0RS
AEO Base, Higher LPG Cost

Fuel Demand and New Vehicle Production Shares

Continued Ethanol Tax Credit

Tax Credits Inflation Adjusted
(Scale Matches Higher World Oil Price, Tax Credits Inflation Adjusted)



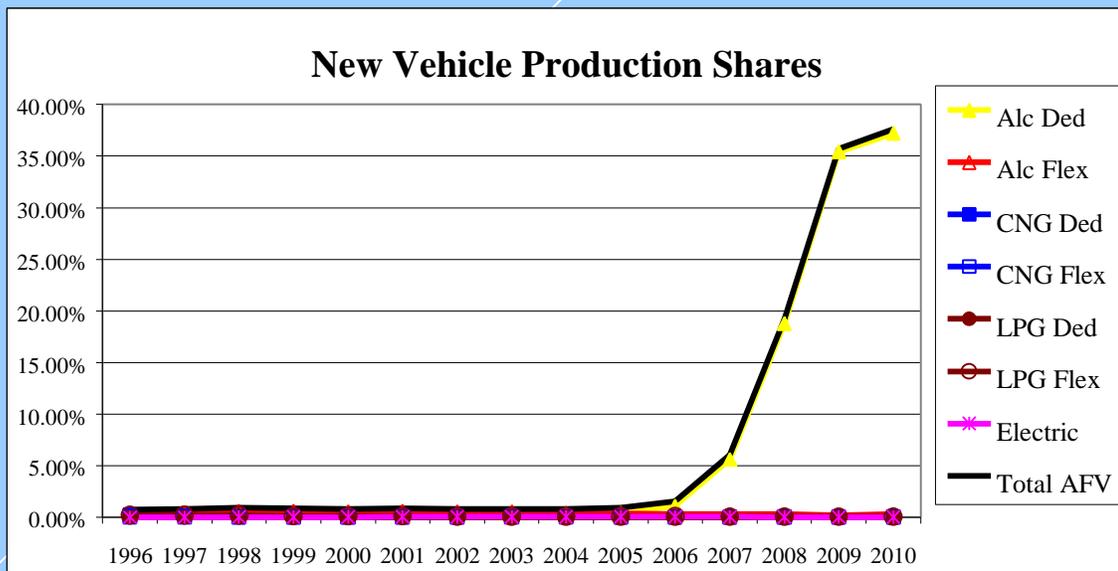
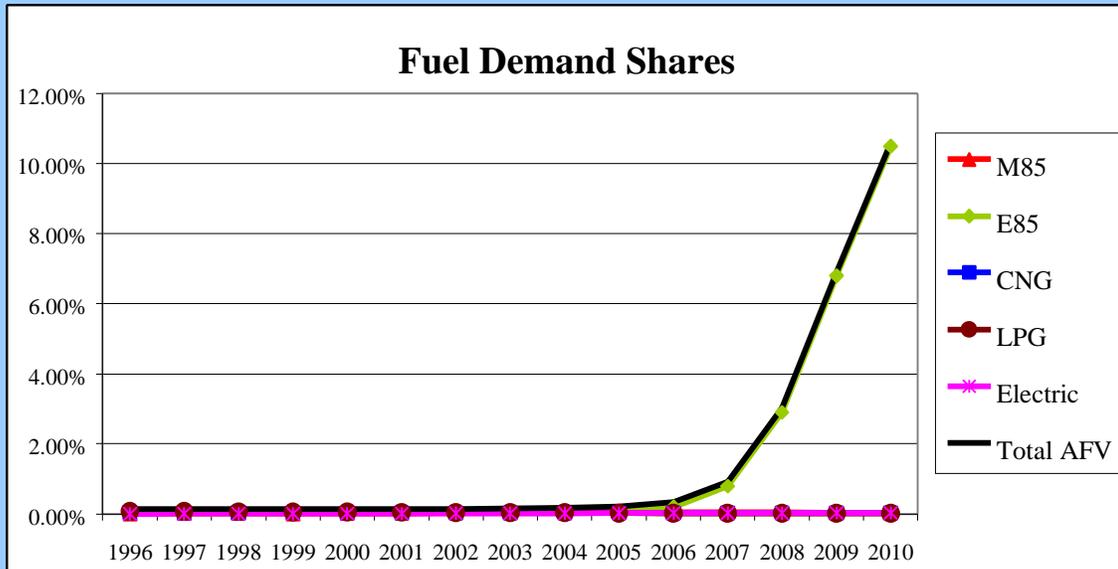
Case #64, R97TCORS

AEO Base, Higher LPG Cost, Tax Credits Inflation Adjusted

Fuel Demand and New Vehicle Production Shares

Continued Ethanol Tax Credit

Higher World Oil Price, Tax Credits Inflation Adjusted
(Enhanced Scale)



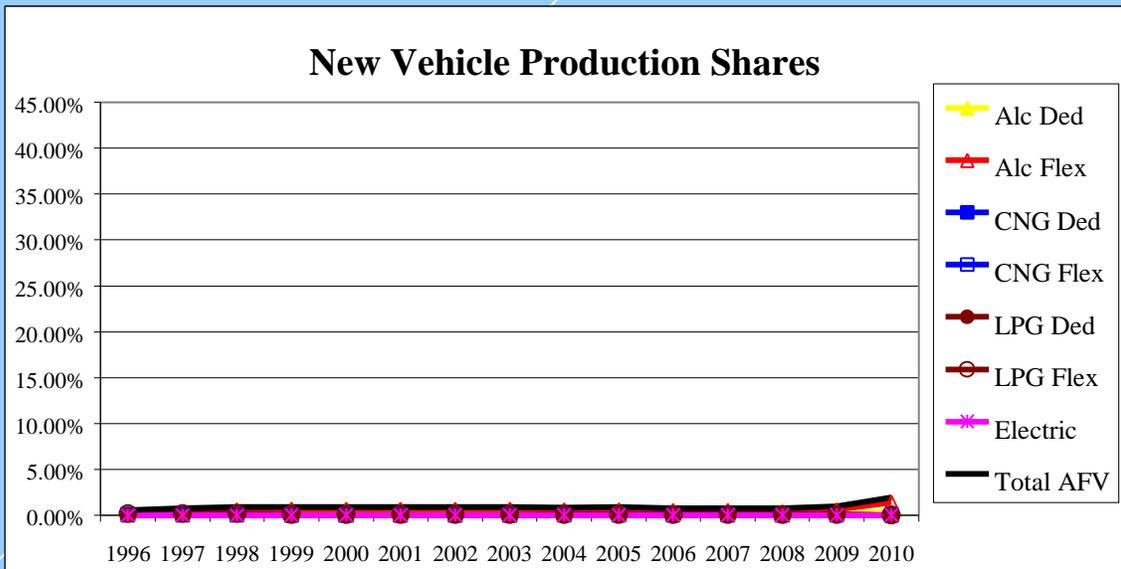
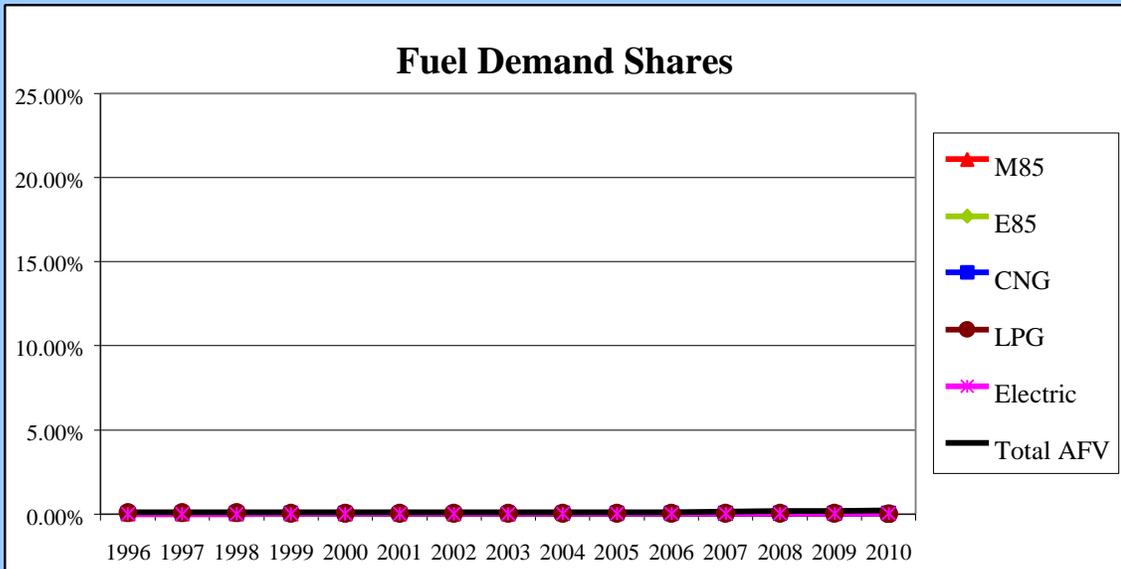
Case #28, R97TCORS

AEO HWOP, Higher LPG Cost, Tax Credits Inflation Adjusted

Fuel Demand and New Vehicle Production Shares

Low-GHG Fuel Subsidy

(Scale Matches Higher World Oil Price, Tax Credits Inflation Adjusted)

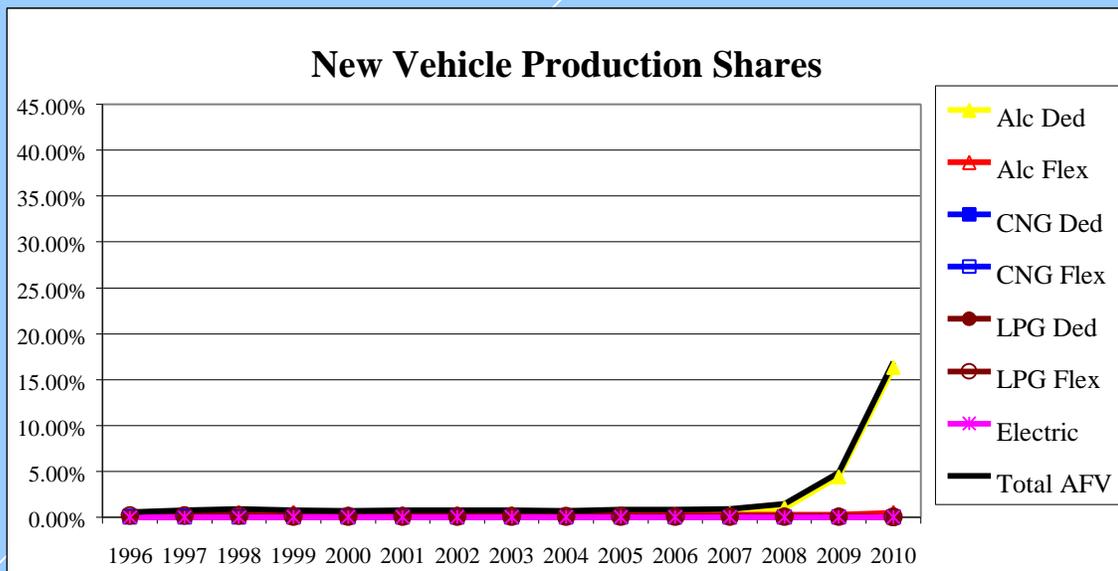
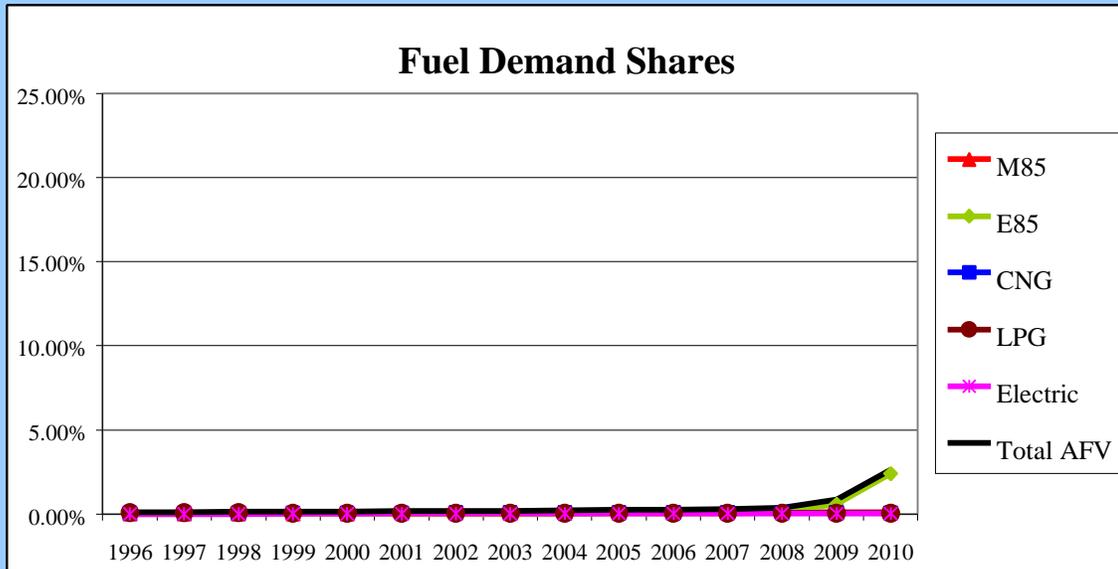


Case #5, R97GH0RS
AEO Base, Higher LPG Cost

Fuel Demand and New Vehicle Production Shares

Low-GHG Fuel Subsidy

Higher World Oil Price, Lower LPG Cost
 (Scale Matches Higher World Oil Price, Tax Credits
 Inflation Adjusted)

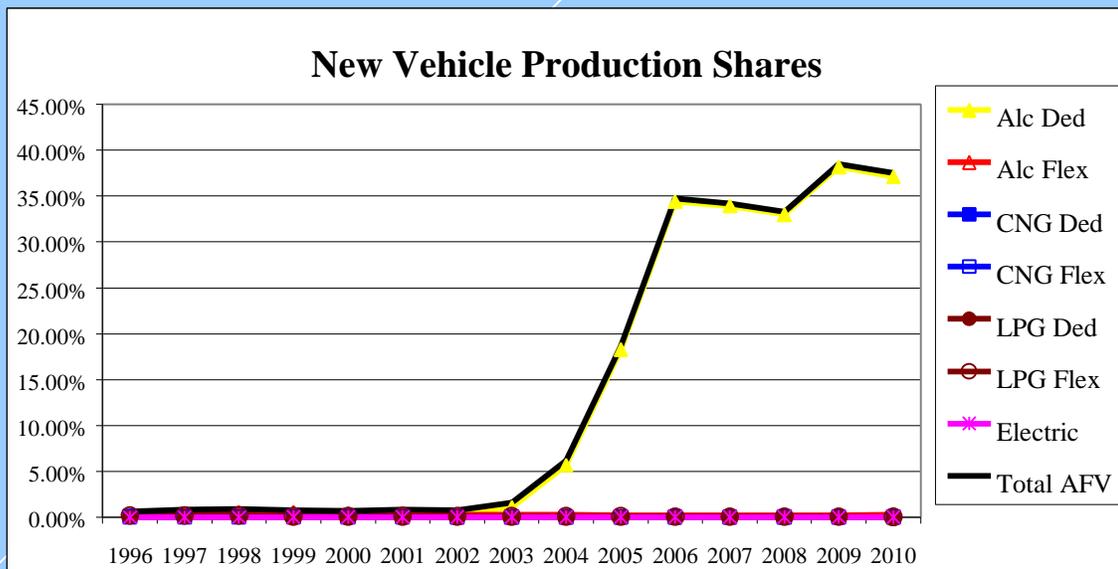
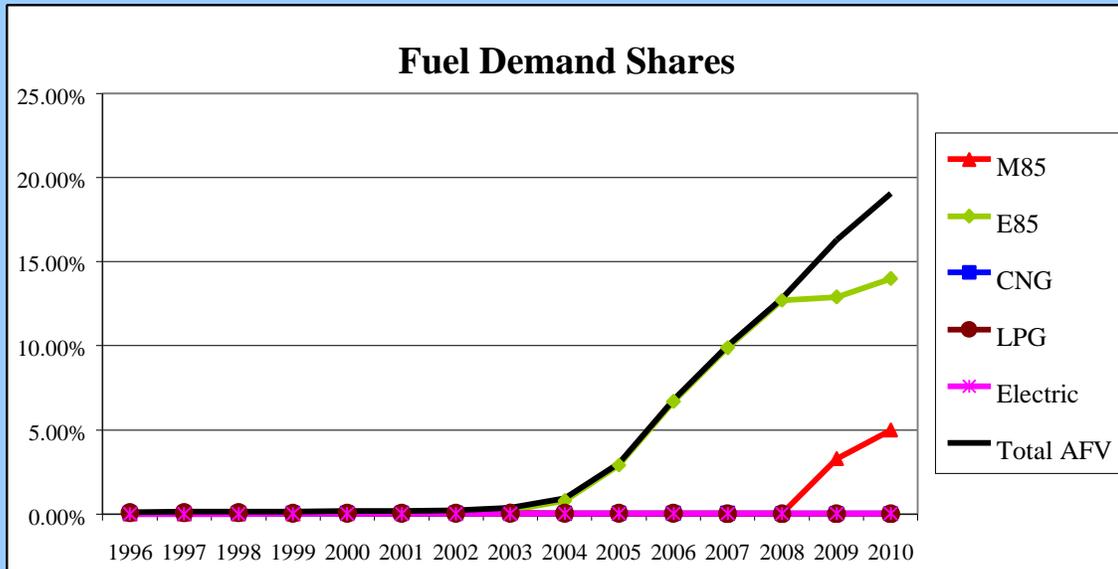


Case #41, R97GH0RS
 AEO HWOP, Lower LPG Cost

Fuel Demand and New Vehicle Production Shares

Low-GHG Fuel Subsidy

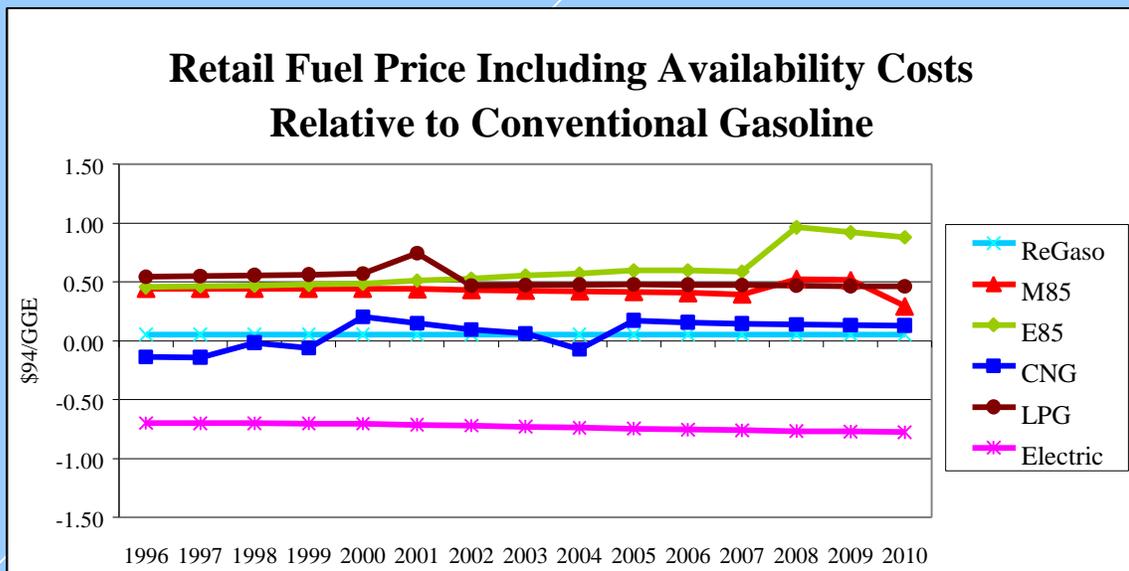
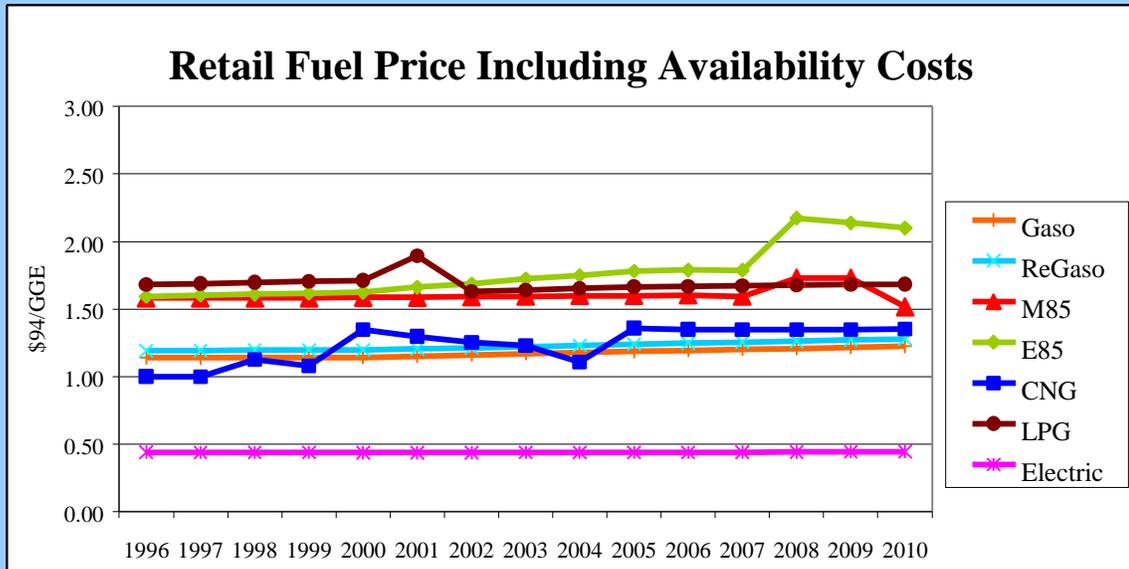
Higher World Oil Price, Tax Credits Inflation Adjusted
(Enhanced Scale)



Case #29, R97GH0RS

AEO HWOP, Higher LPG Cost, Tax Credits Inflation Adjusted

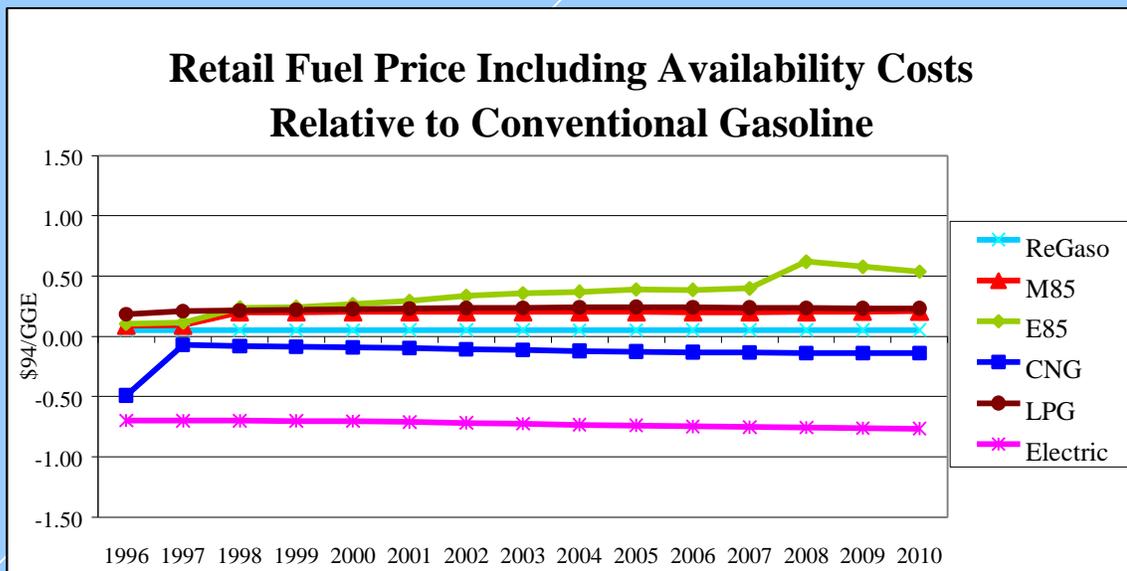
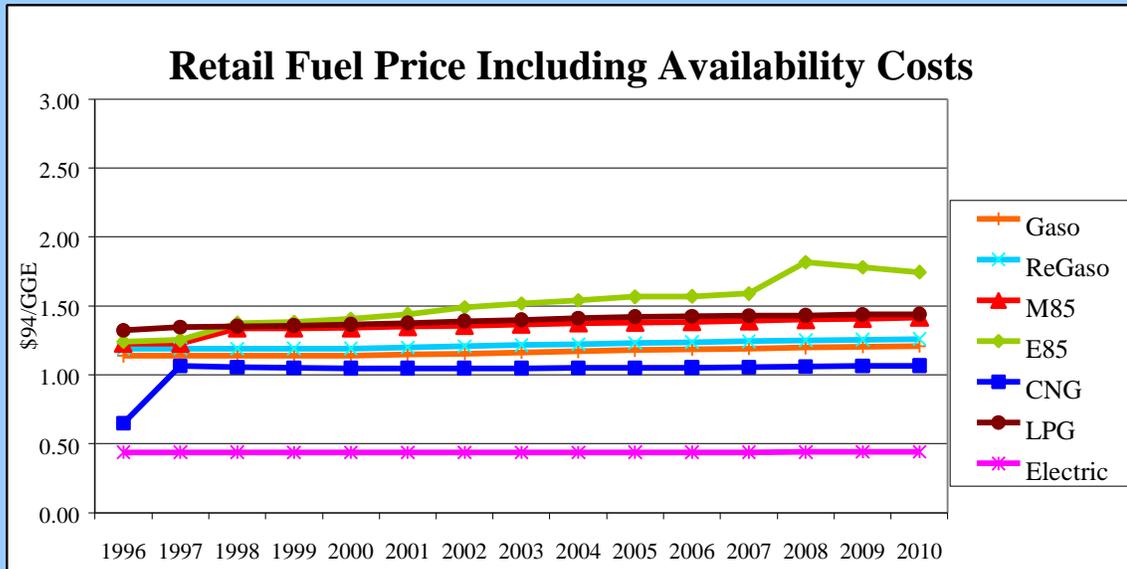
Retail Fuel Prices Including Tax and Availability Cost Base-No New Policy Case



Case #1, R97B00RS
AEO Base, Higher LPG Cost

Retail Fuel Prices Including Tax and Availability Cost

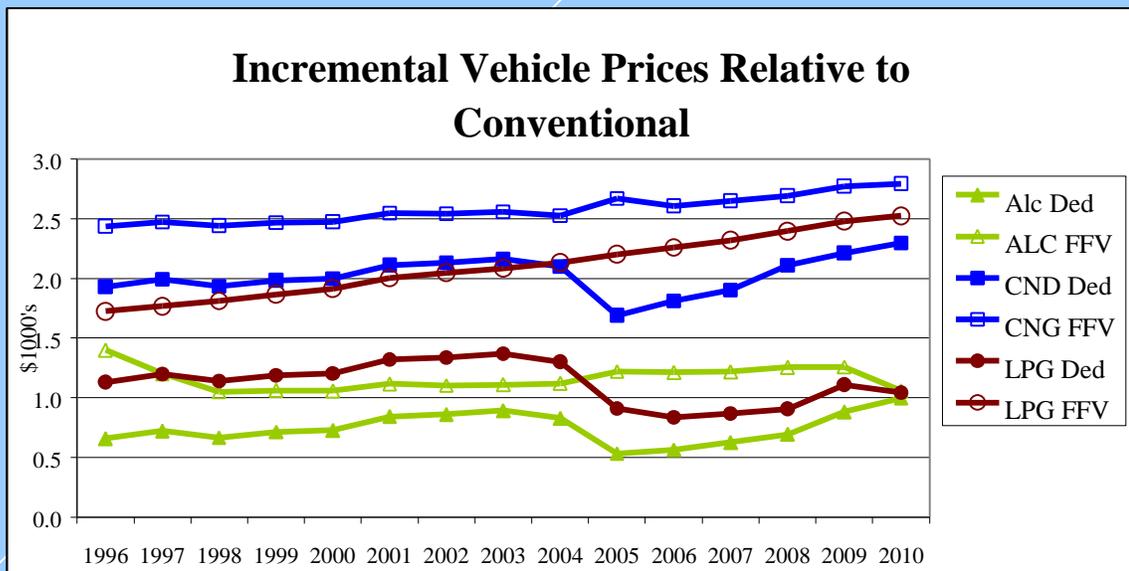
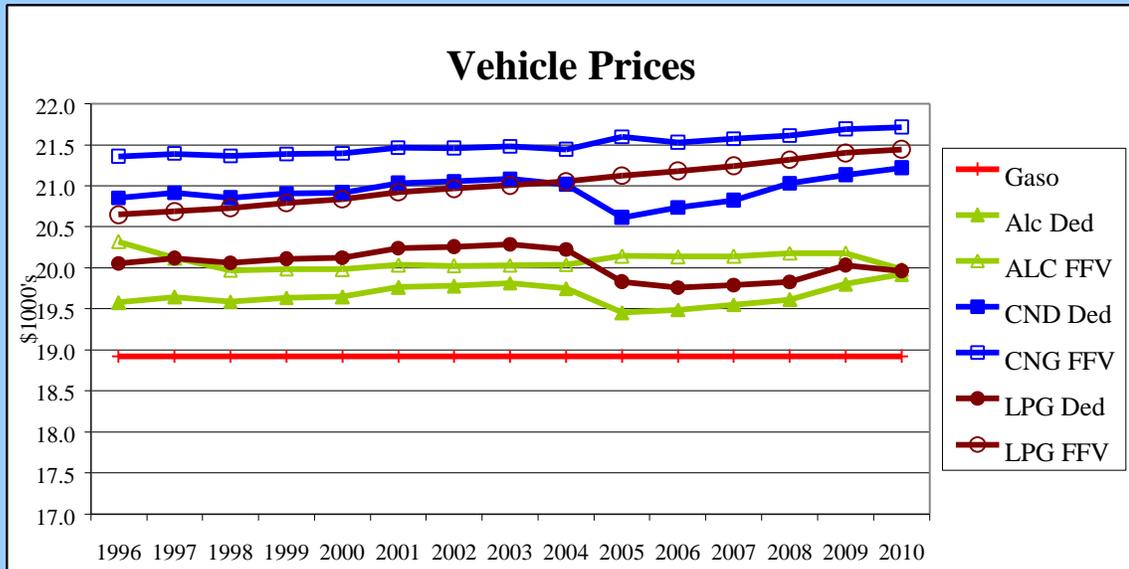
No Transitional Barriers (Availability Cost is Zero)



Case #12, R97BNBRS
AEO Base, Higher LPG Cost

Vehicle Prices Base-No New Policy Case

Enhanced Scale



Case #1, R97B00RS

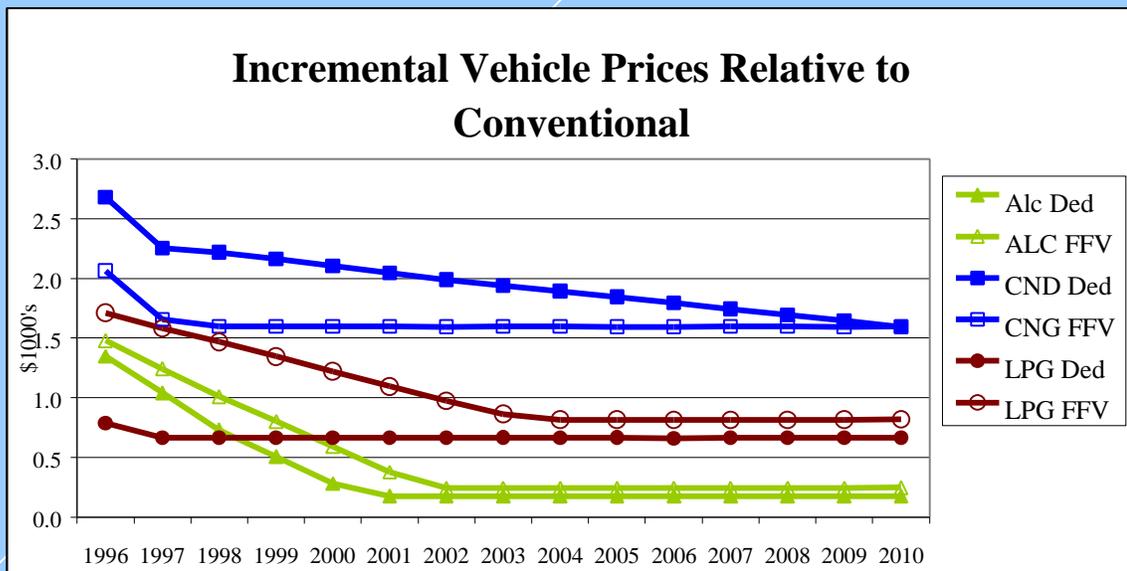
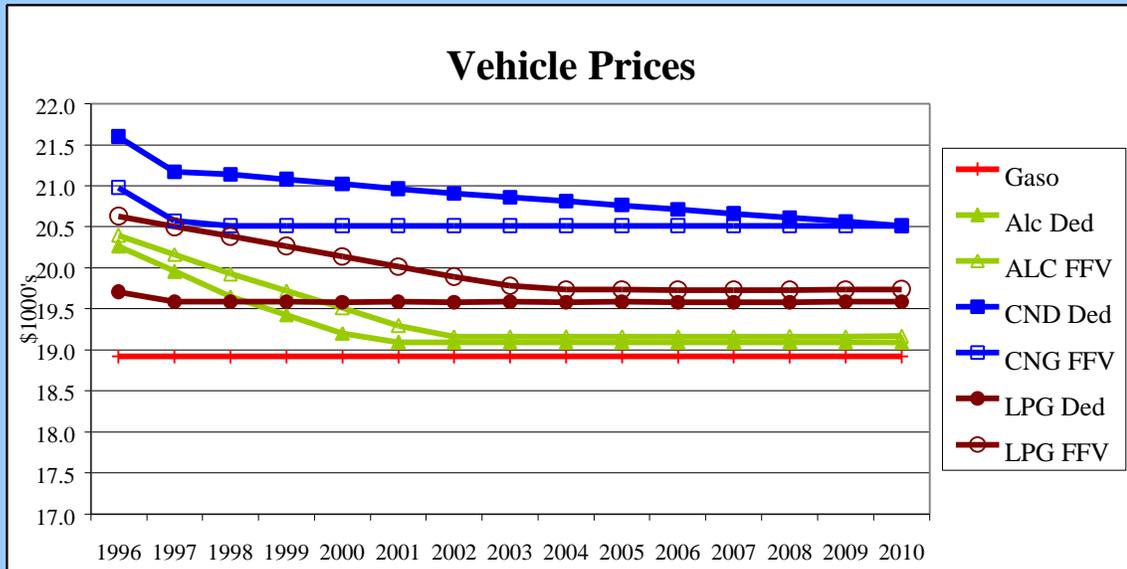
AEO Base, Higher LPG Cost

Vehicle Prices

No Transitional Barriers

(Large Scale Production, No Diversity Costs)

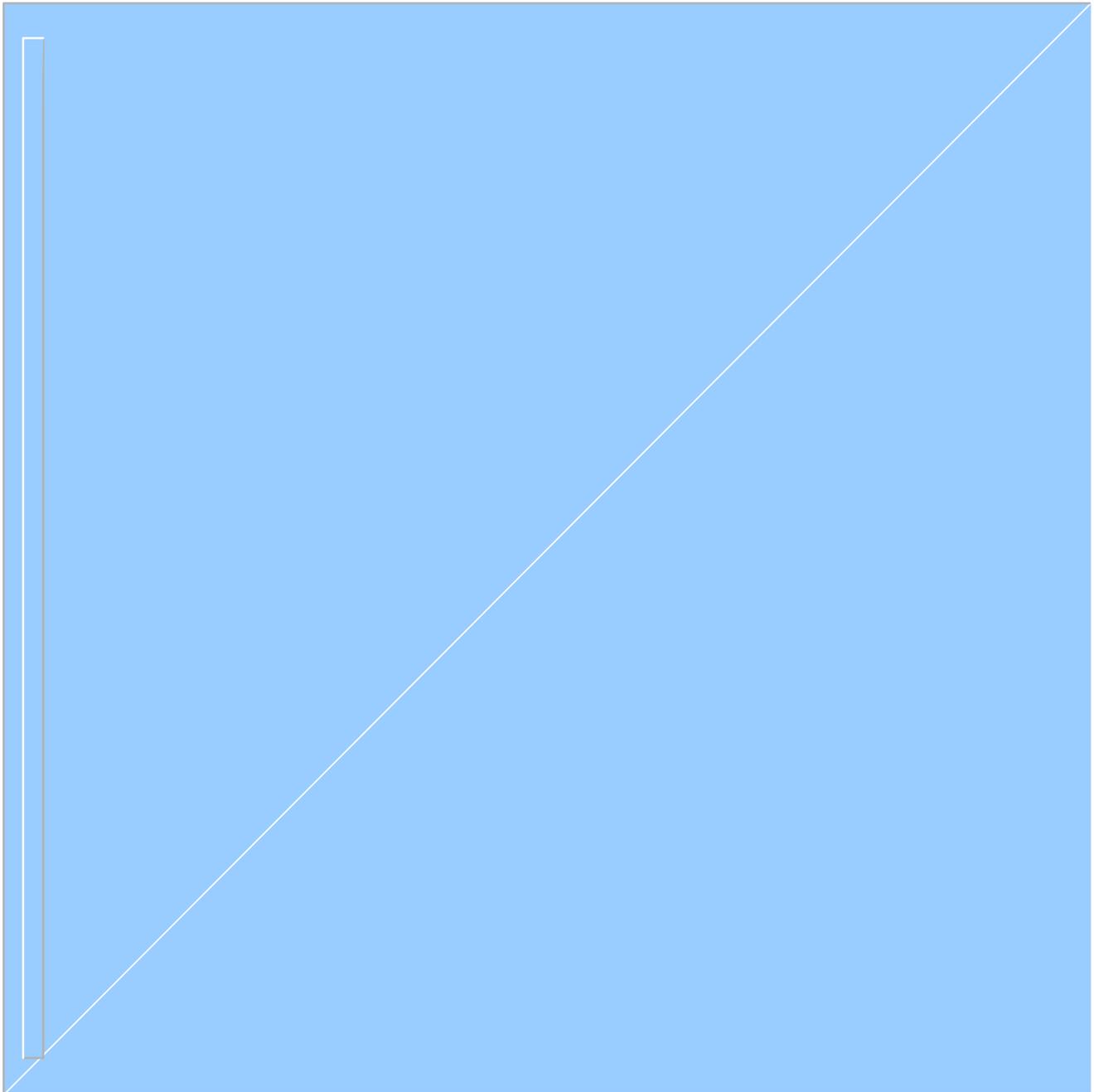
(Scale Matches Base-No Policy Case)



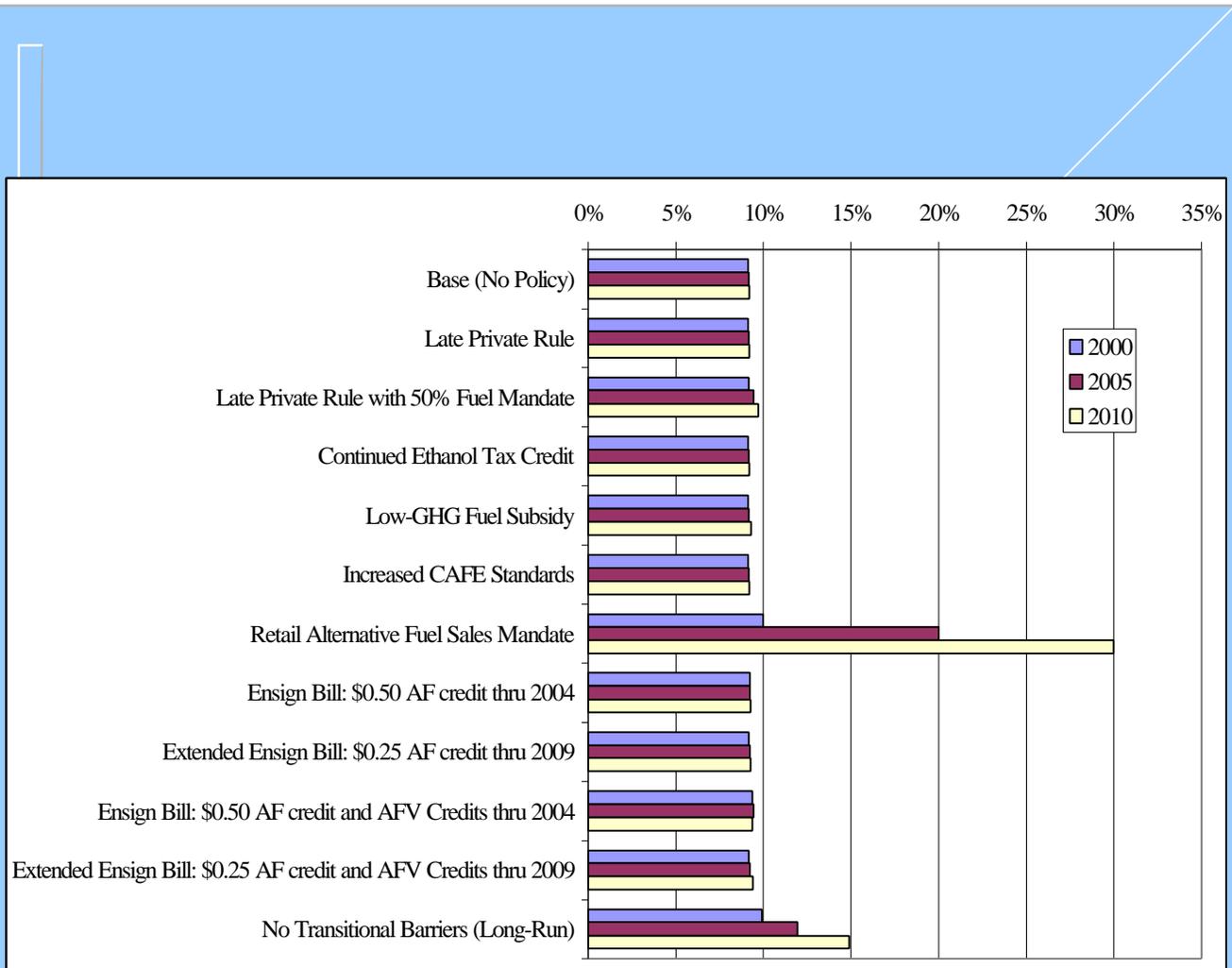
Case #12, R97BNBRS

AEO Base, Higher LPG Cost

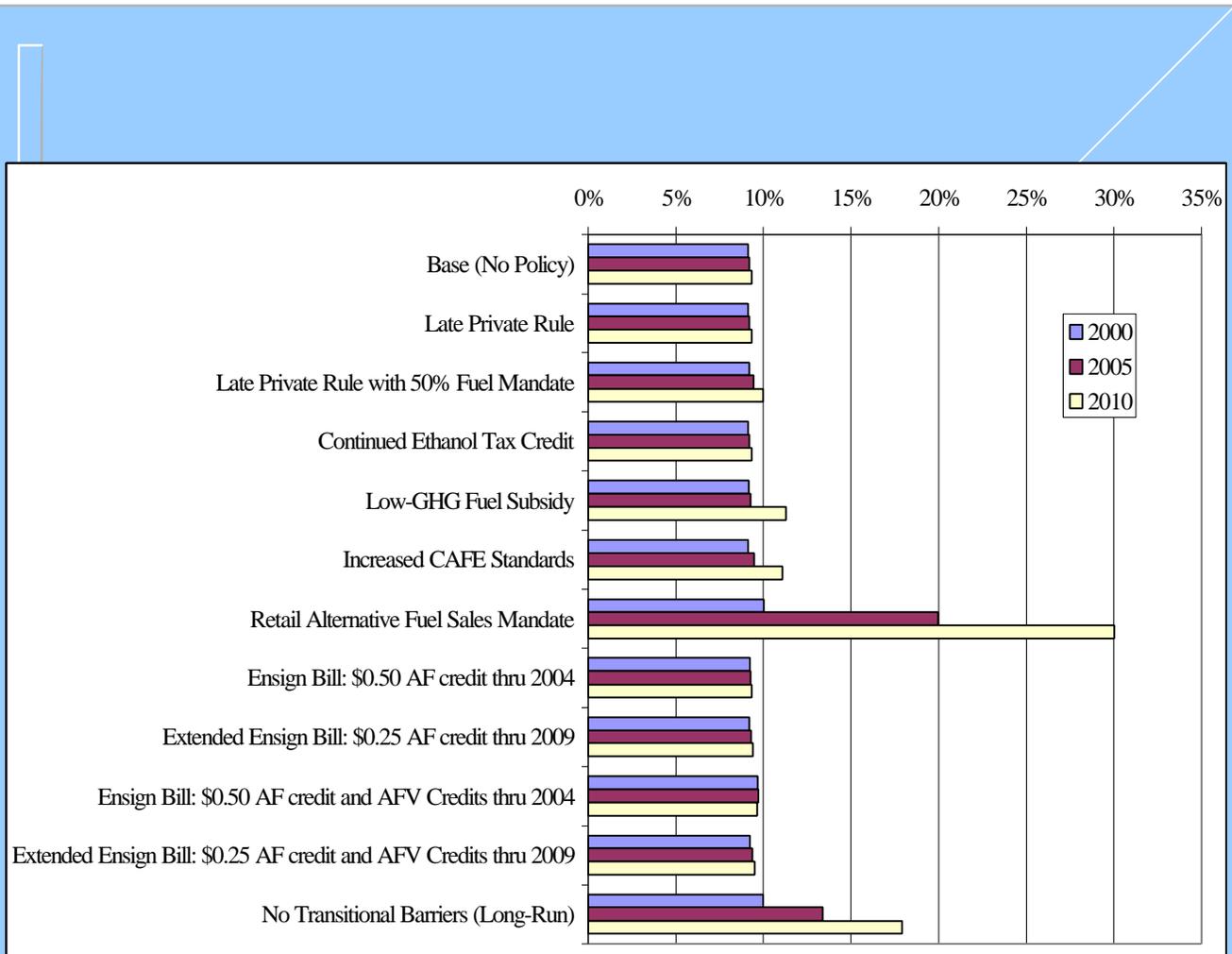
SUMMARY GRAPHS (MULTICASE COMPARISONS)



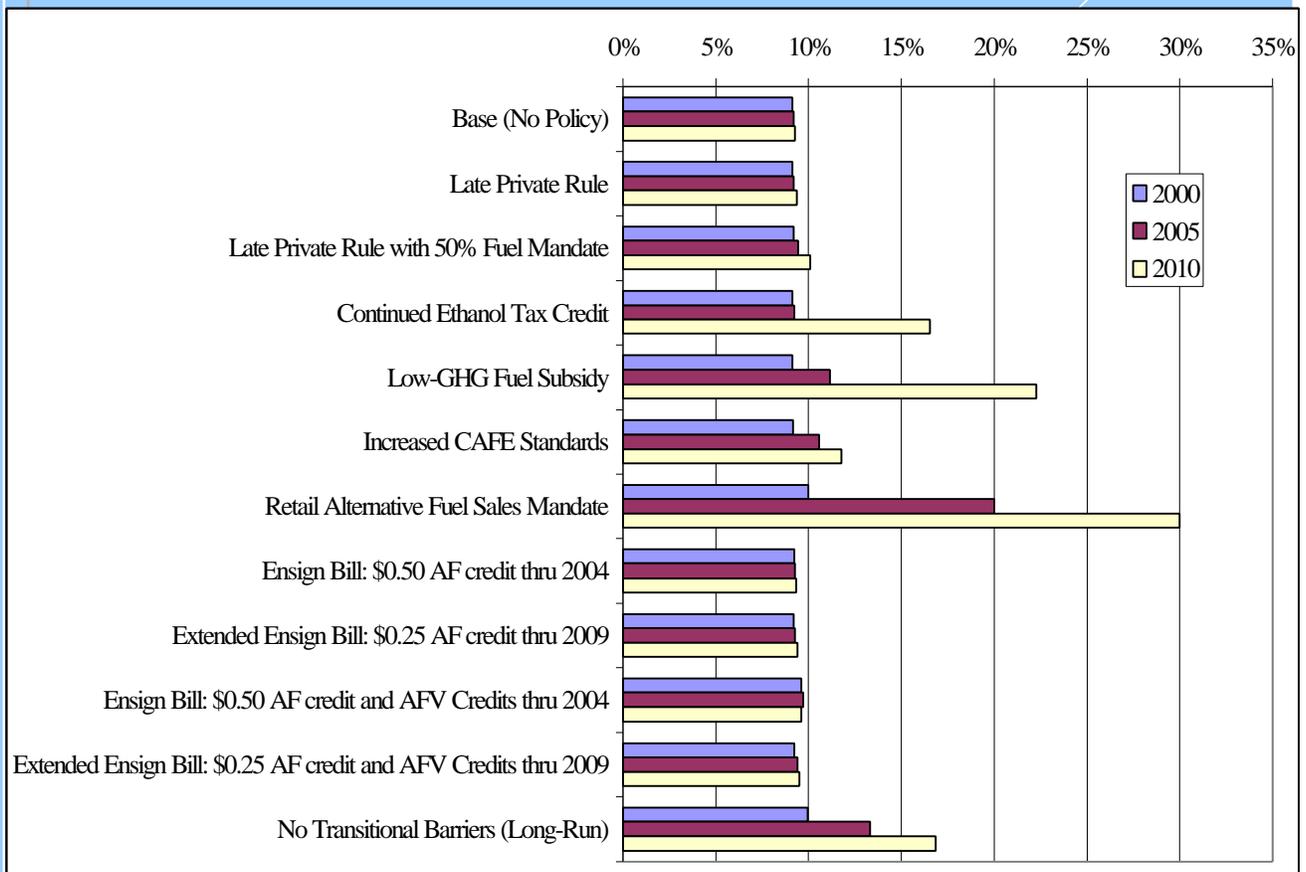
Gasoline Displacement by Alternative Fuels: AEO Base, Higher LPG Cost



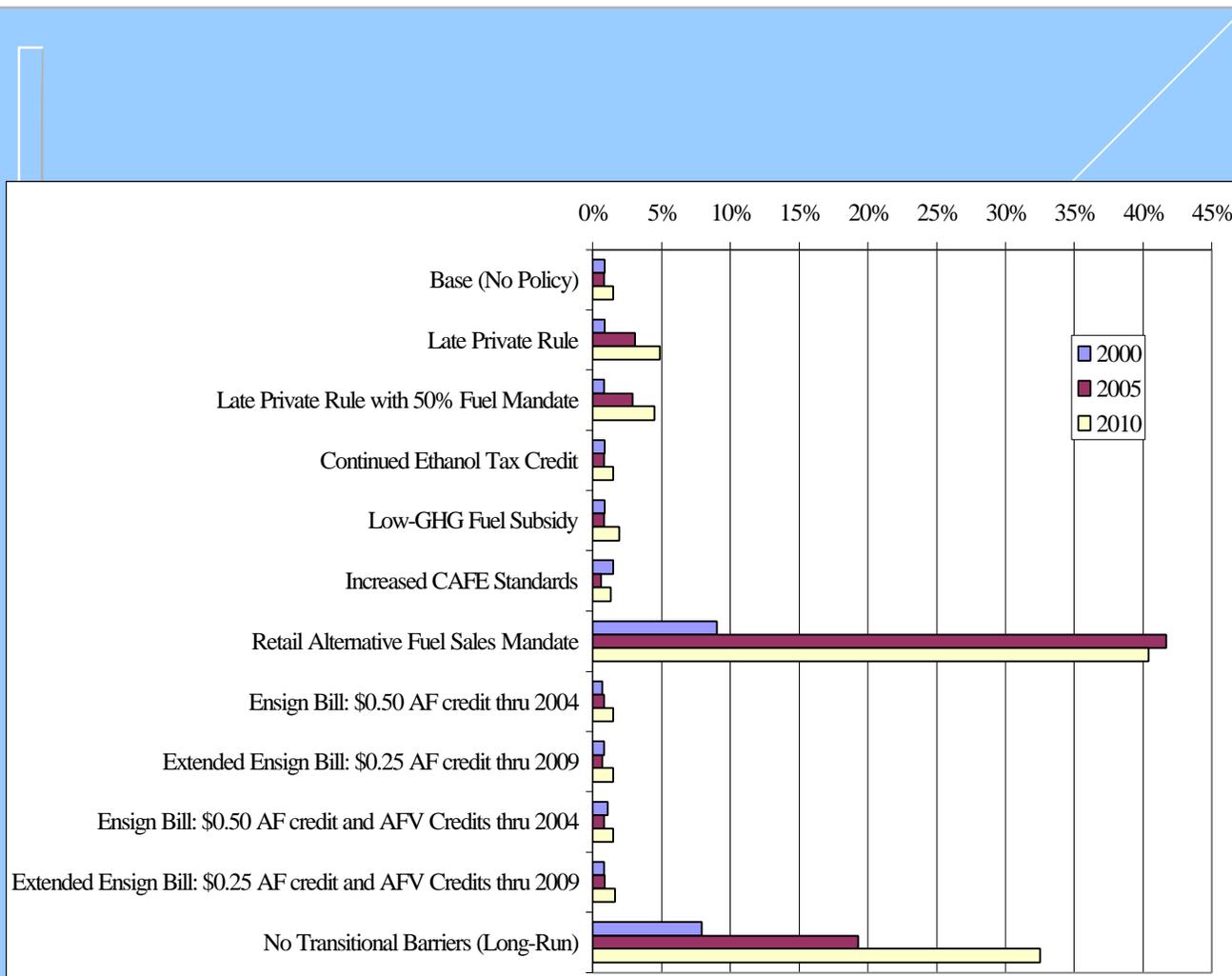
Gasoline Displacement by Alternative Fuels: AEO HWOP, Higher LPG Cost



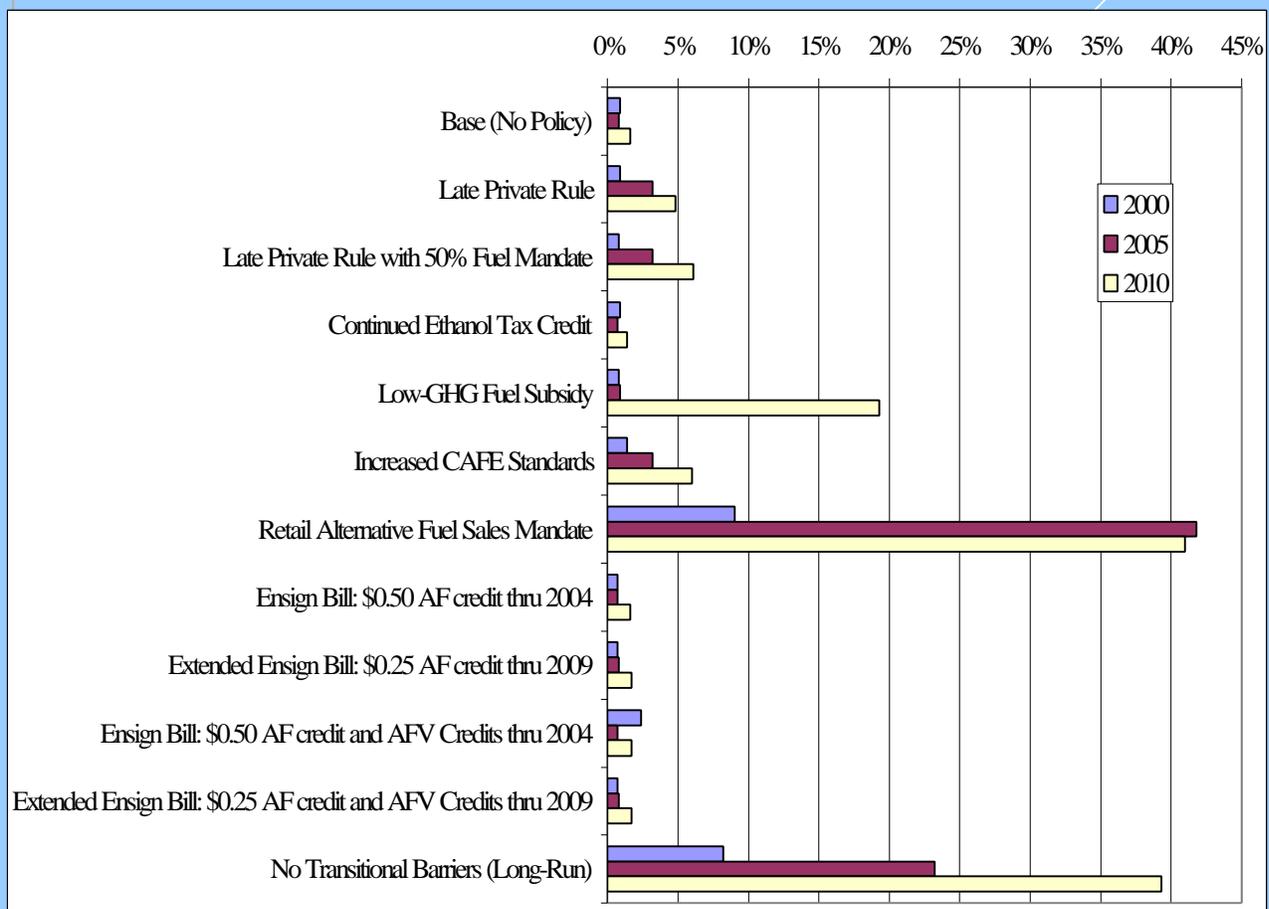
Gasoline Displacement by Alternative Fuels: AEO HWOP, Higher LPG Cost, Tax Credits Inflation Adjusted



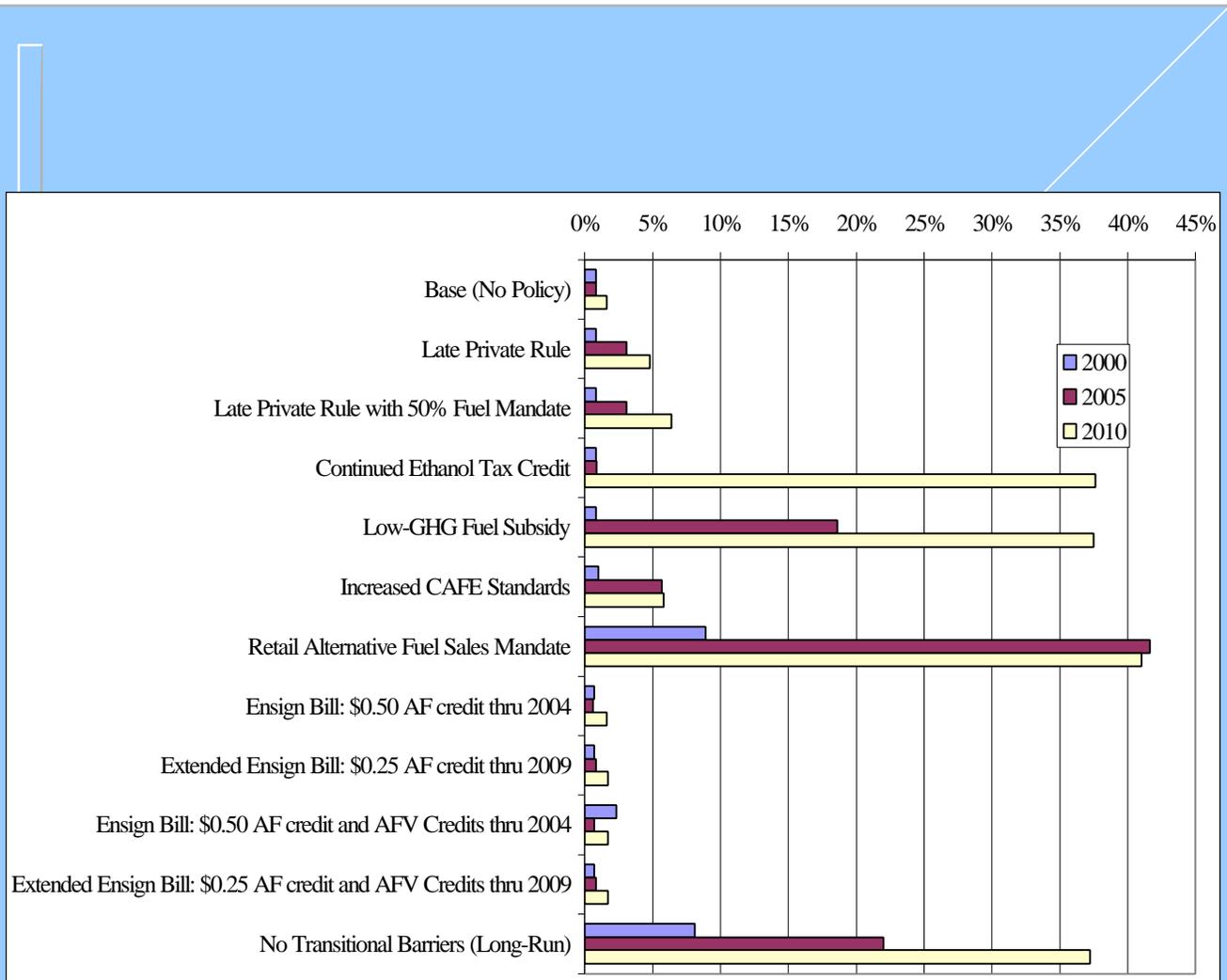
New AFV Demand Share: AEO Base, Higher LPG Cost



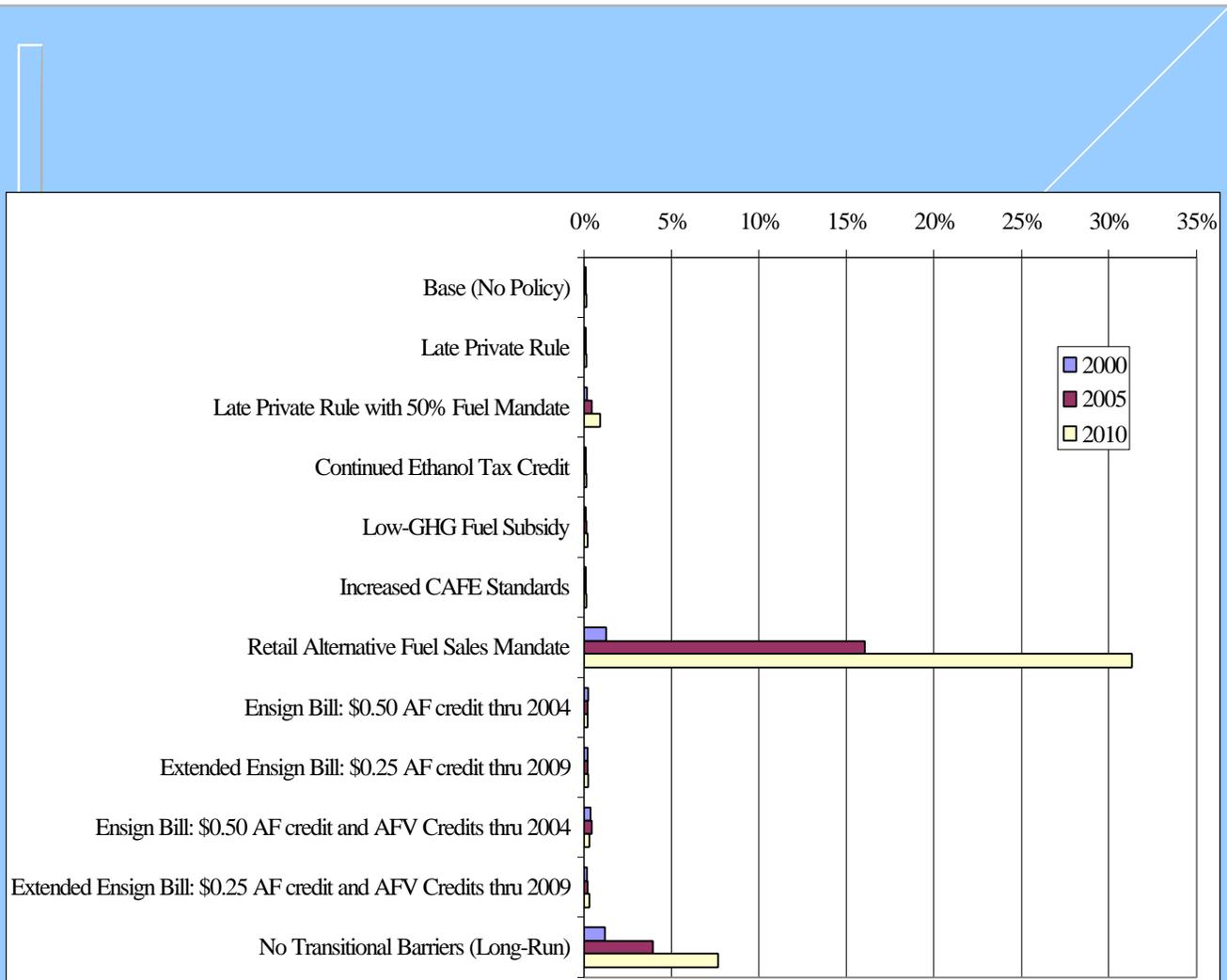
New AFV Demand Share: AEO HWOP, Higher LPG Cost



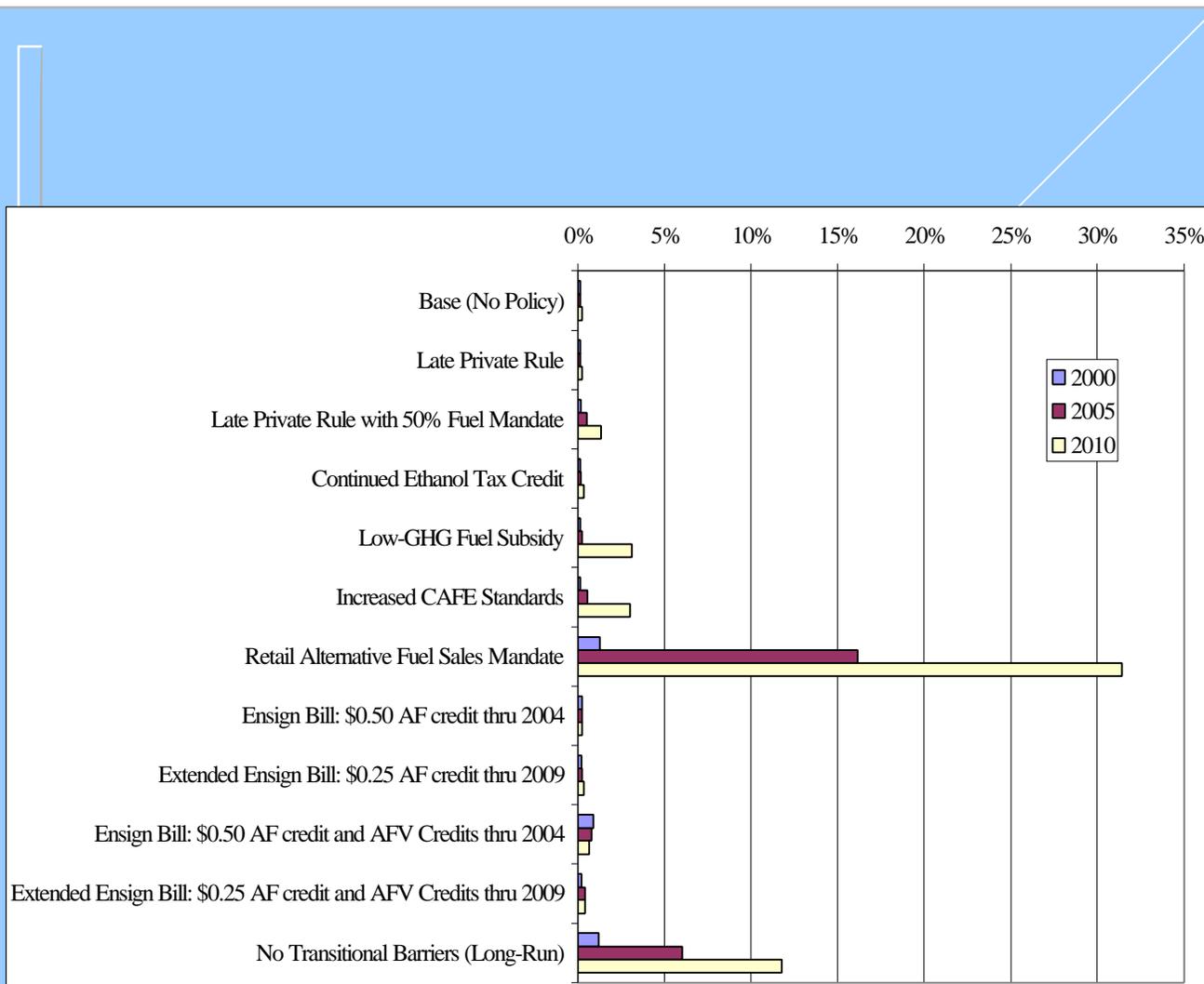
New AFV Demand Share: AEO HWOP, Higher LPG Cost, Tax Credits Inflation Adjusted



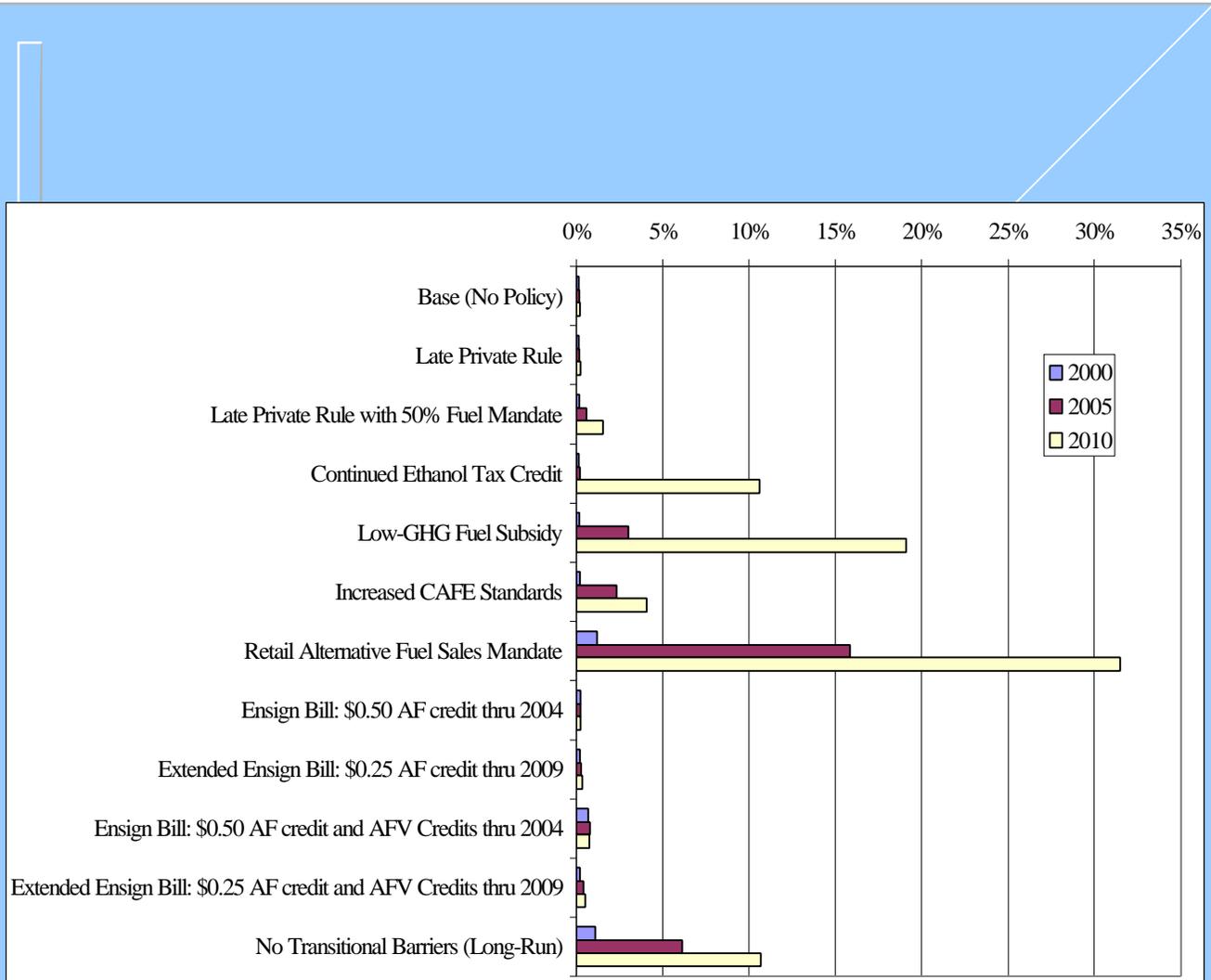
Alt Fuel Demand Share: AEO Base, Higher LPG Cost



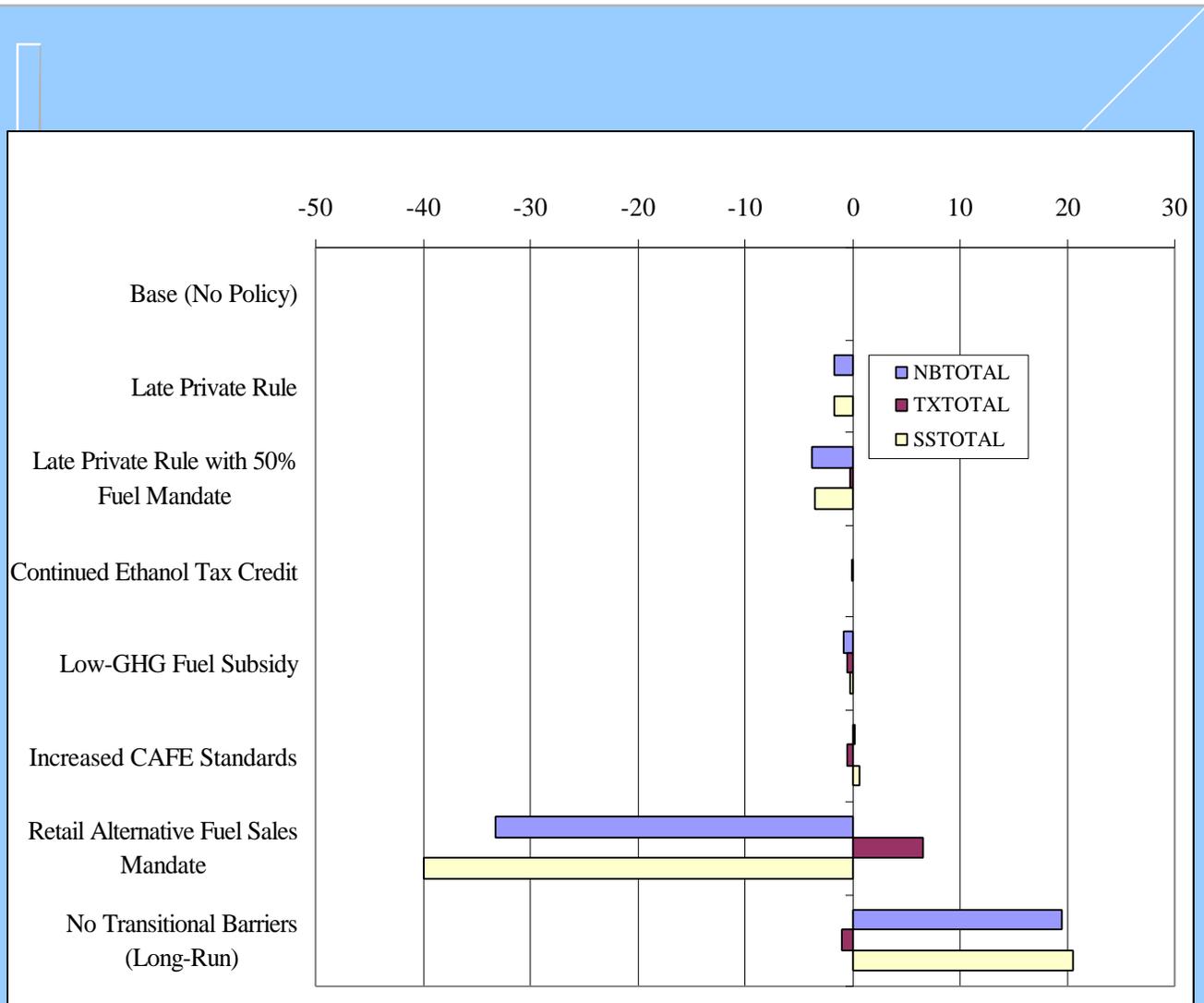
Alt Fuel Demand Share: AEO HWOP, Higher LPG Cost



Alt Fuel Demand Share: AEO HWOP, Higher LPG Cost, Tax Credits Inflation Adjusted



Net Benefits of Policies (Base Scenario, NPV, \$Bill)



Results and Insights 1: Re: AF Transitional Barriers

- Market barriers to significant AF and AFV use are substantial
 - Limited retail fuel availability
 - Vehicle production scale economies
- Absent new policy initiatives and or a significant change in world oil prices, EPACT 2000 and 2010 goals will not be achieved.
- 2010 Fuel displacement ~ 9% by 2010
- With no transitional barriers fuel displacement 15% - 25% depending on oil price assumptions

Results and Insights 2: Re: AF Transitional Barriers

- Non-fleet AFV purchases respond to fleet policies
 - Late rule making induces additional 3% vehicle purchases (over a base of 1.2%)
- Late rule making not effective in inducing AF use
- Fleet policies mandating 50% fuel use not very effective given new lower world oil prices contained in AEO98

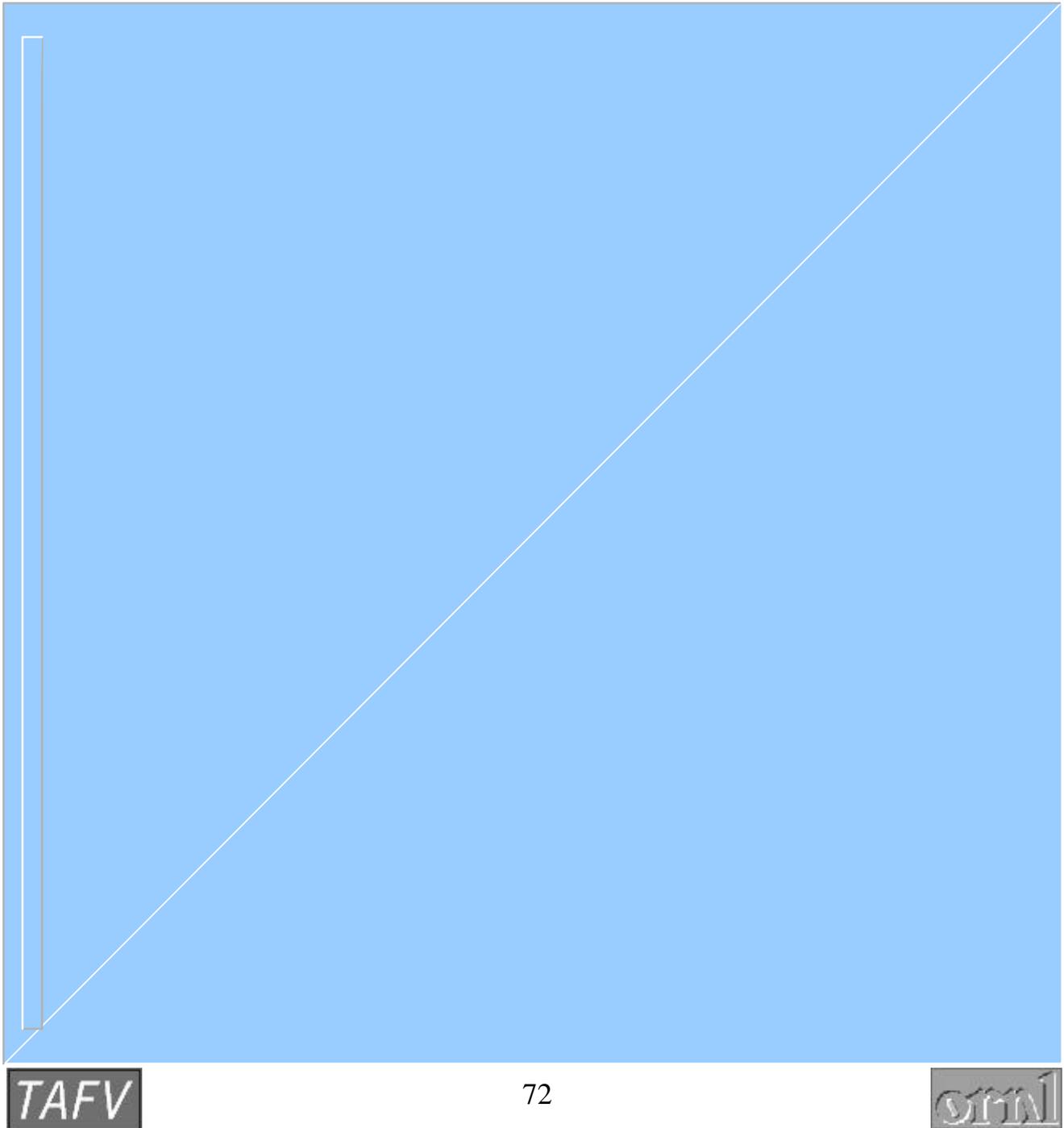
Results and Insights 3: Regarding Ethanol

- **Ethanol makes much smaller contribution than previously, due to:**
 - Higher revised ethanol production costs
 - Lower AEO98 gasoline price projections
 - Assume ethanol credit declines with inflation
- **Even in No Transition Barriers case, ethanol not used**
- **Year 2010 Net ethanol demand could be 3% to 11% IF:**
 - Ethanol credit continued and Inflation-adjusted and/or High World Oil Prices
 - Low-GHG credit with Inflation adjustment and/or High World Oil Prices

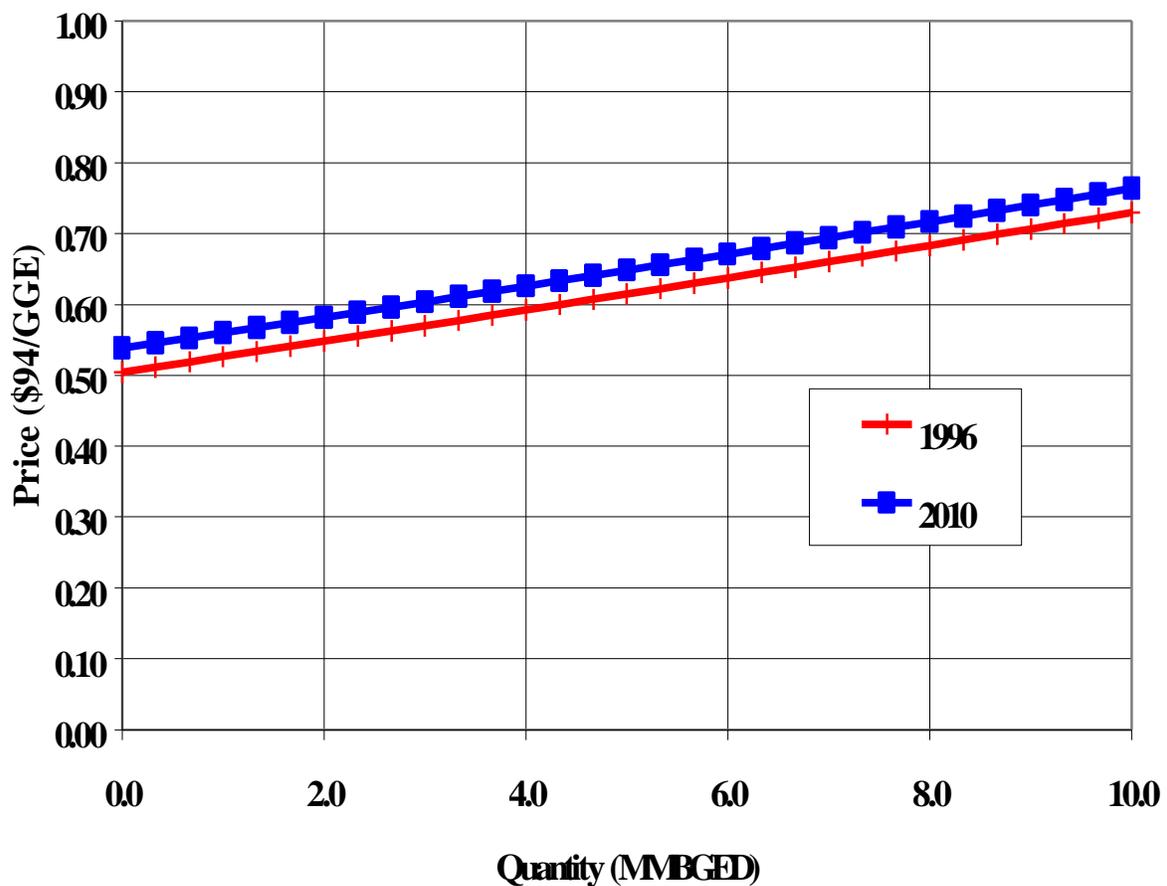
Results and Insights 4: Other Policies

- Retail Sales Mandate Obviously Effect but Very Expensive -
 - \$33 Billion NPV over base
 - 50 Cents per GGE per discounted gallon methanol
- Next most effective: Low-GHG tax credit and Continued Renewable Tax Credit (12% - 22% if HWOP, inflation adjusted credit)
- Ensign Bills Not Effective because not large enough

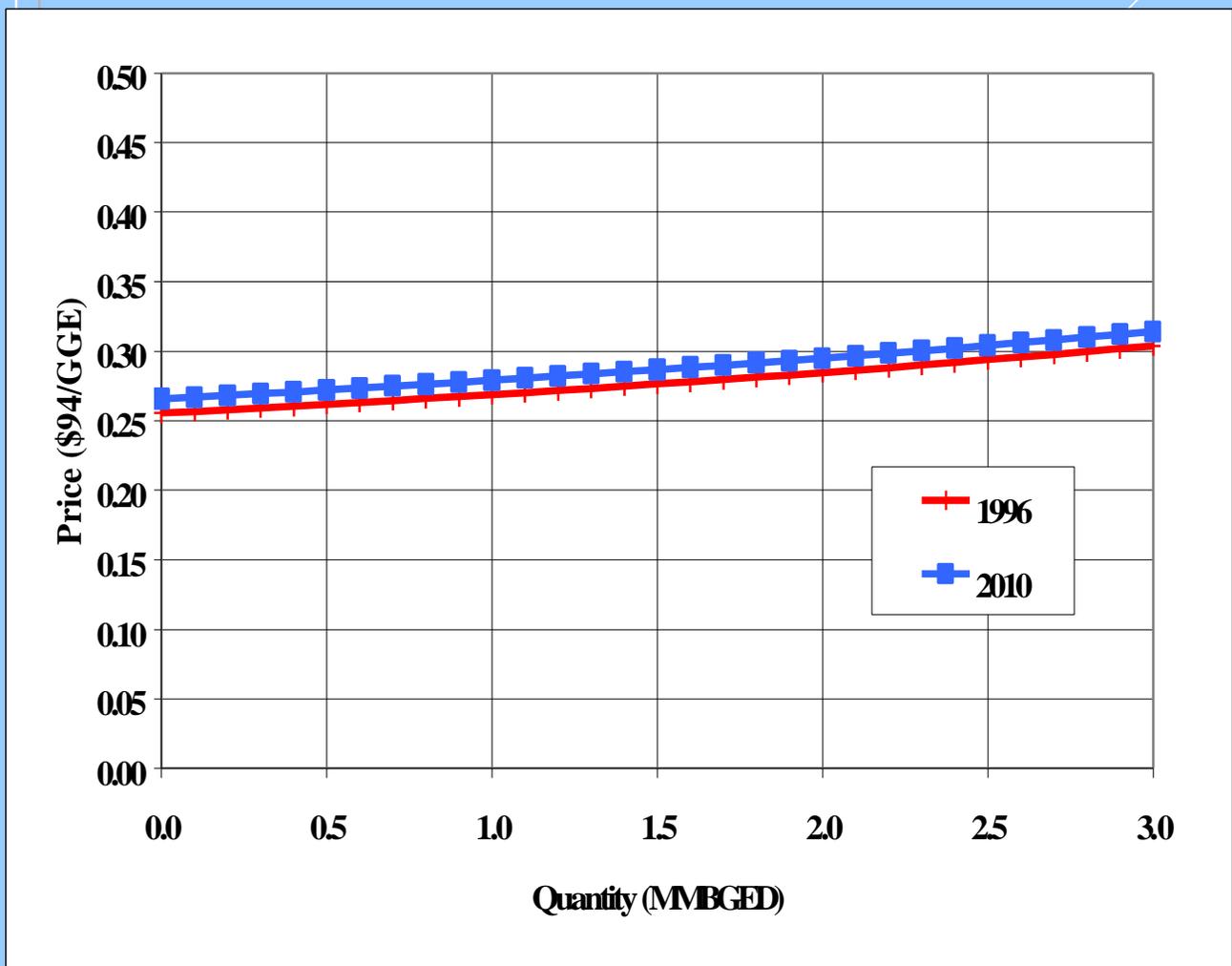
APPENDIX: Backup Information



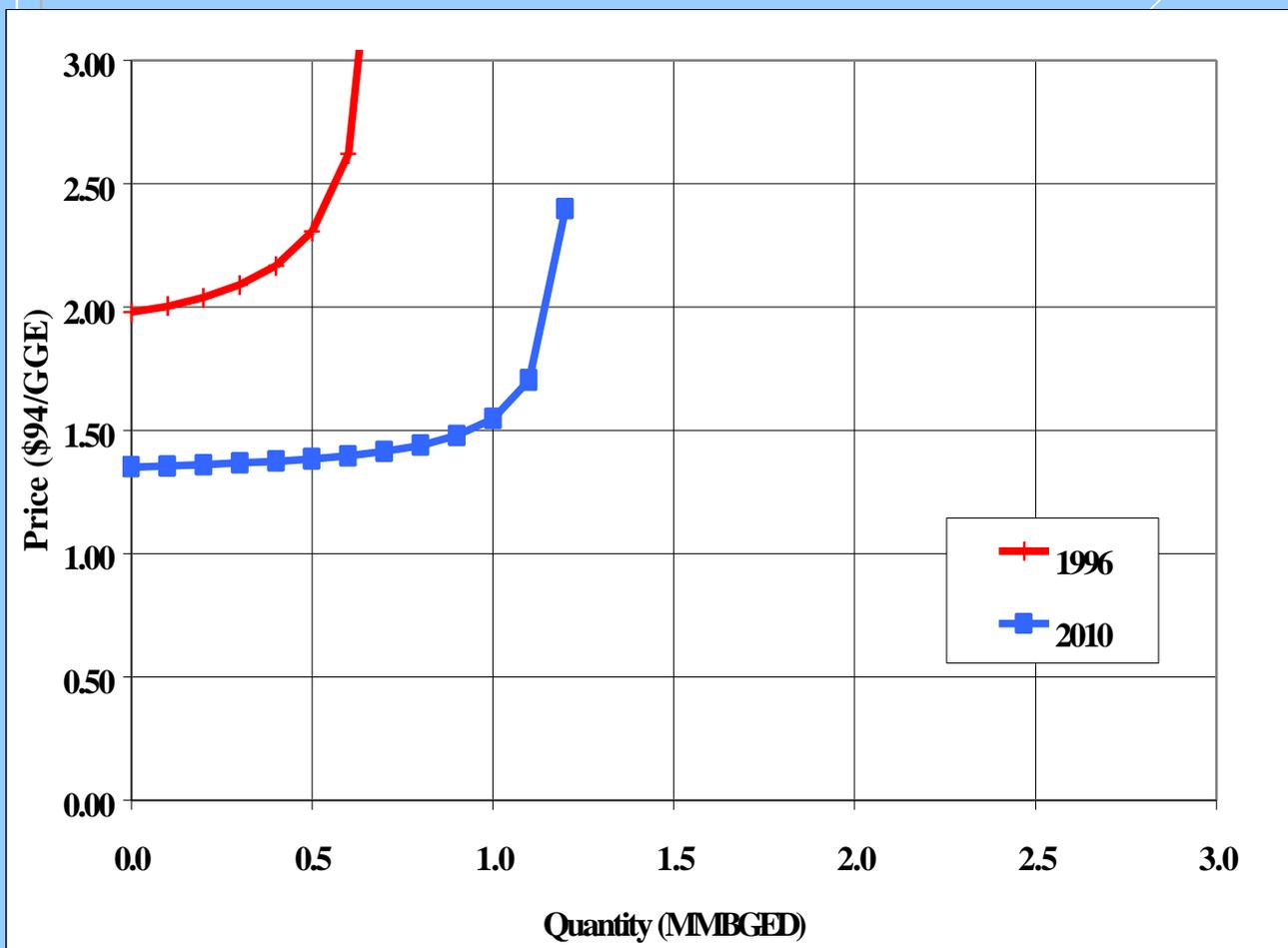
1996 and 2010 Plantgate Gasoline Supply Curves



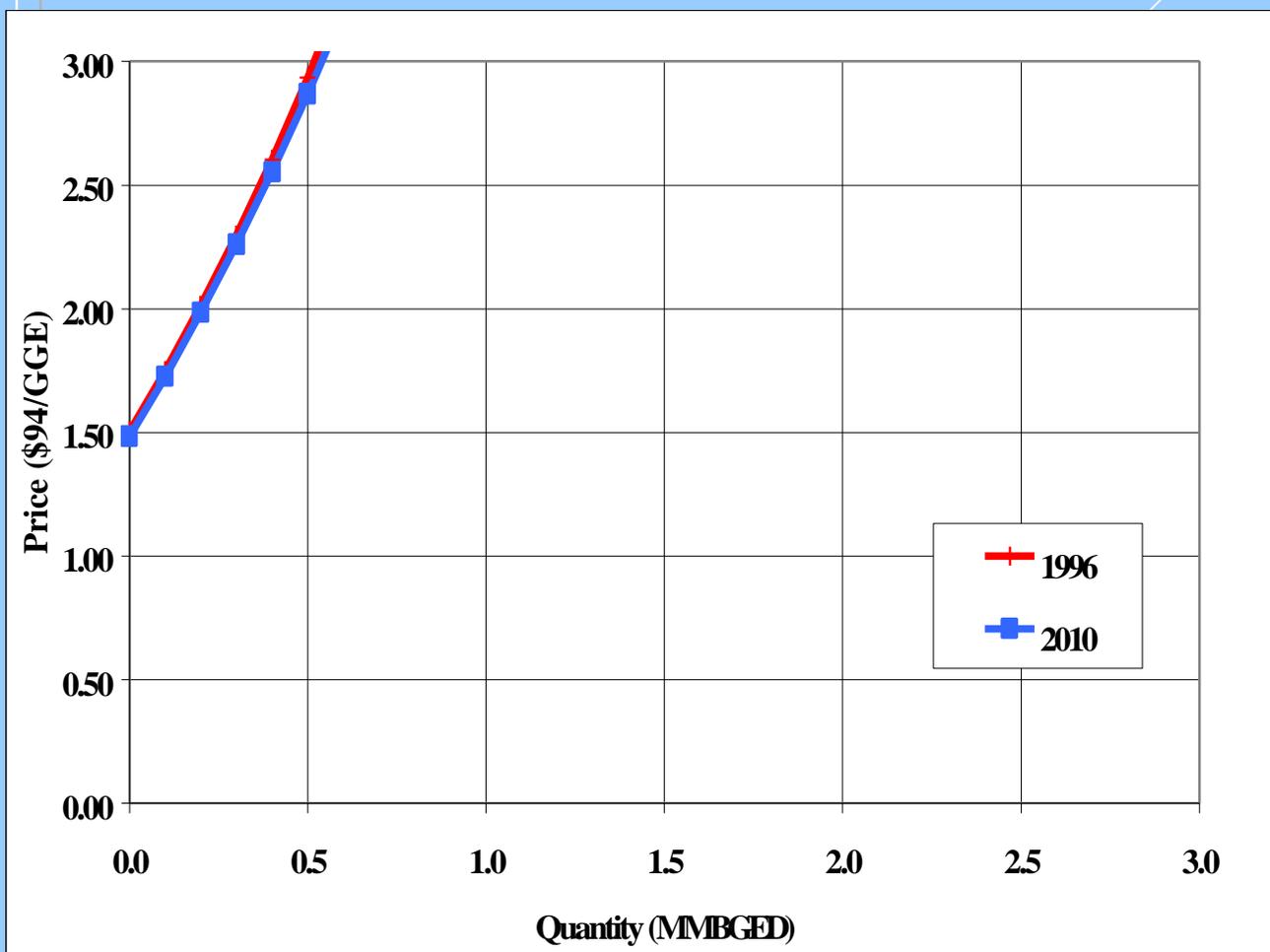
1996 and 2010 Plantgate Natural Gas Supply Curves



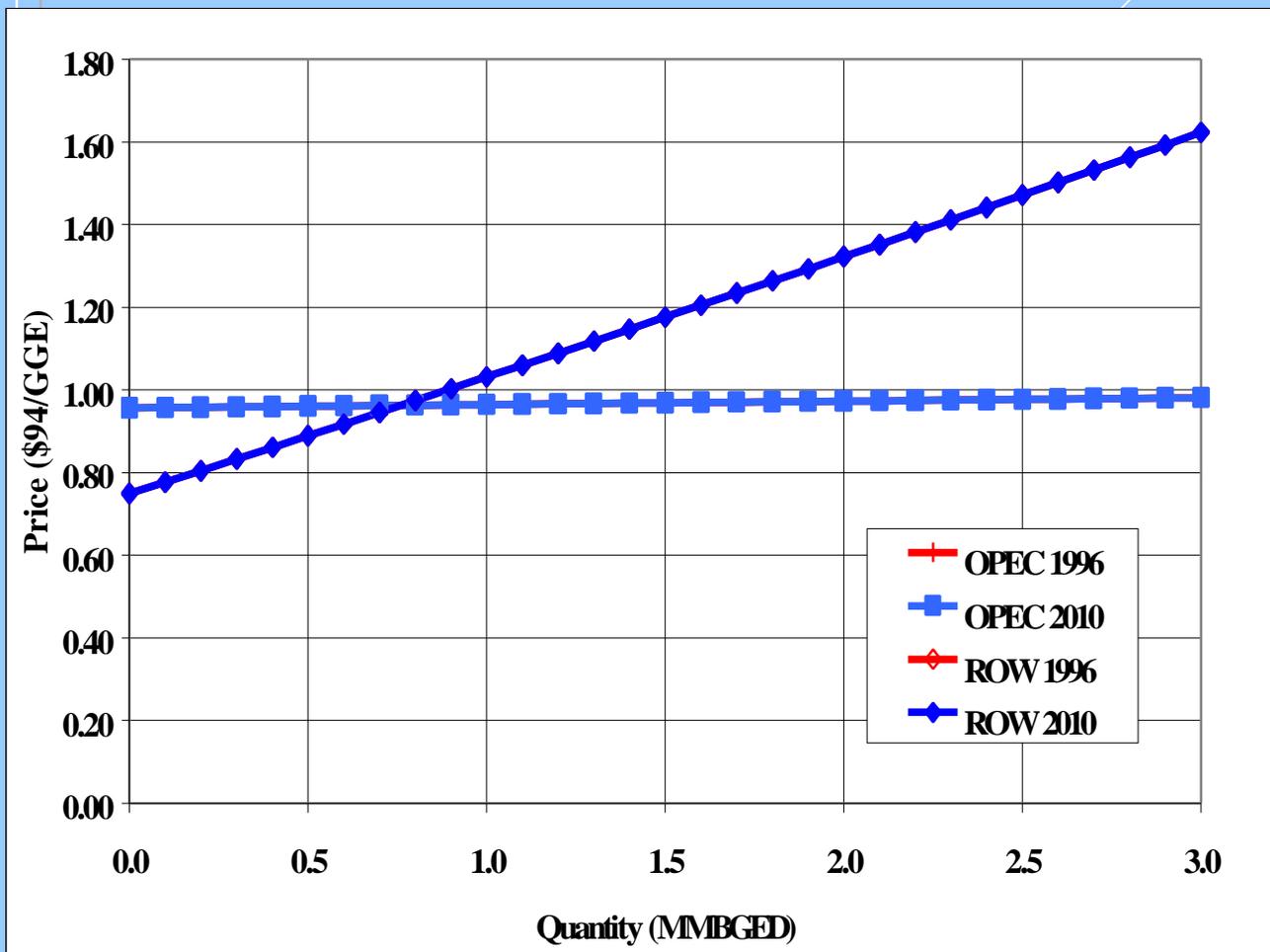
1996 and 2010 Plantgate Cellulosic Biomass to Ethanol Supply Curves



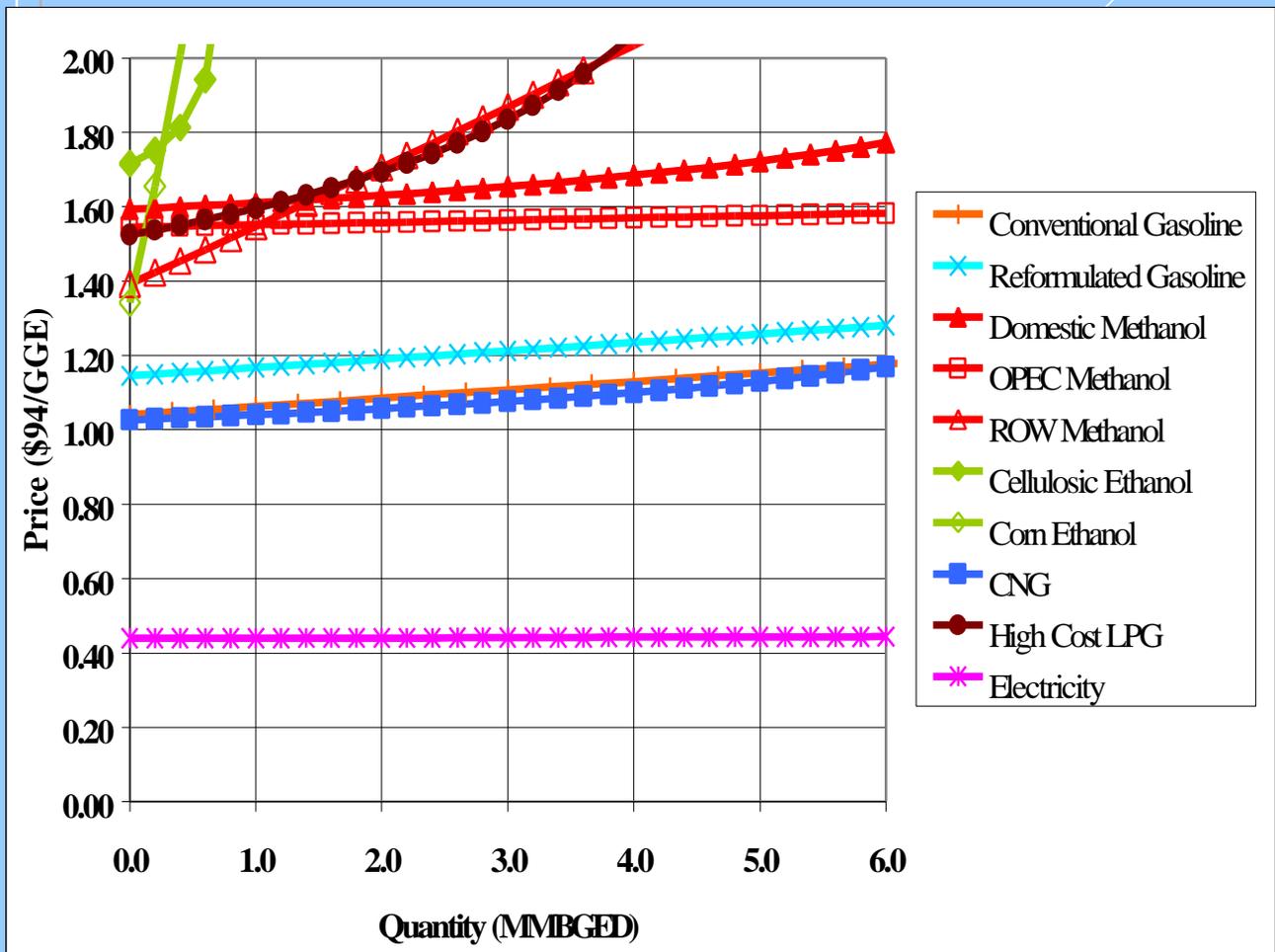
1996 and 2010 Plantgate Corn to Ethanol Supply Curves



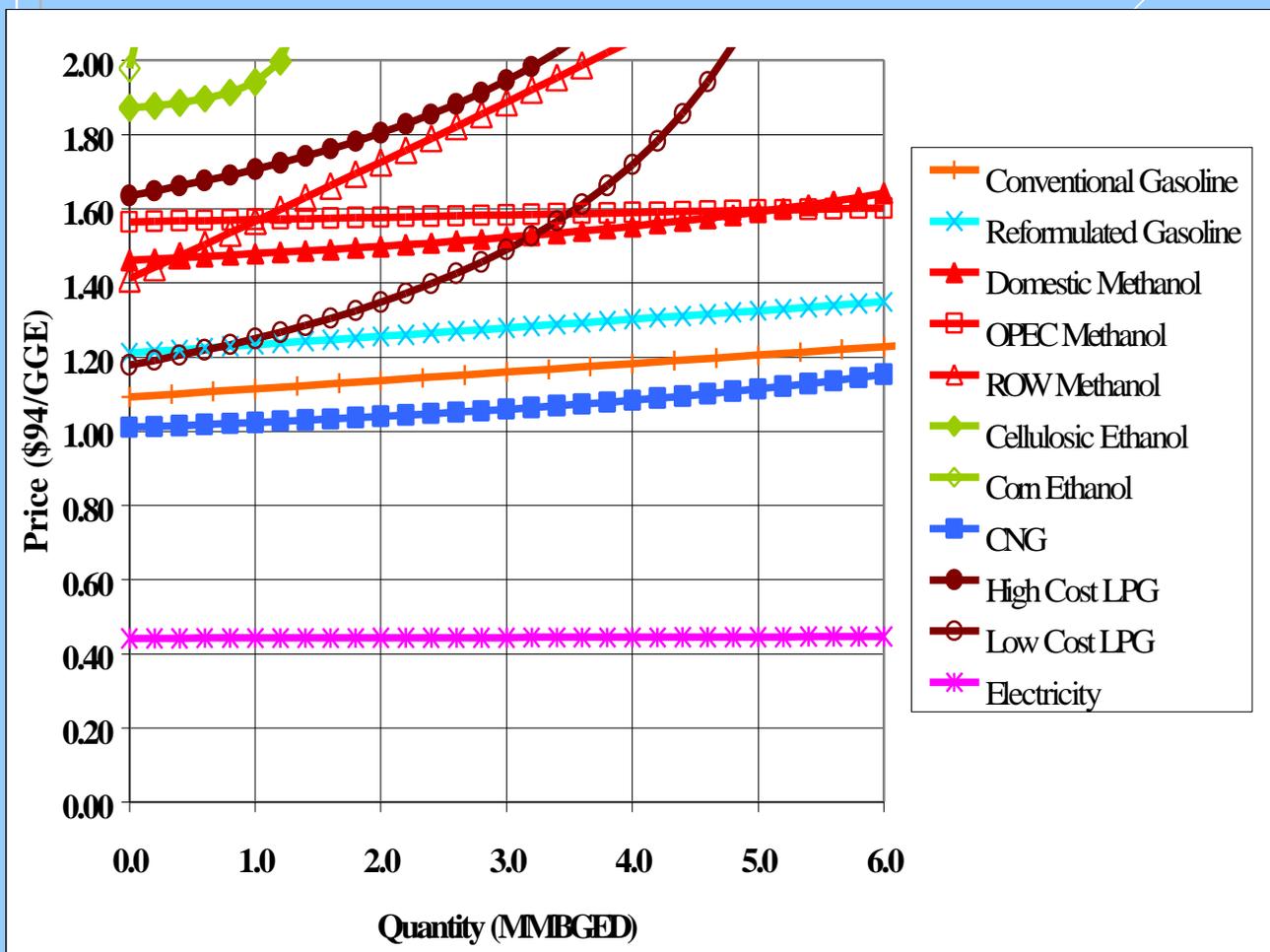
1996 and 2010 Foreign Methanol Supply Curves



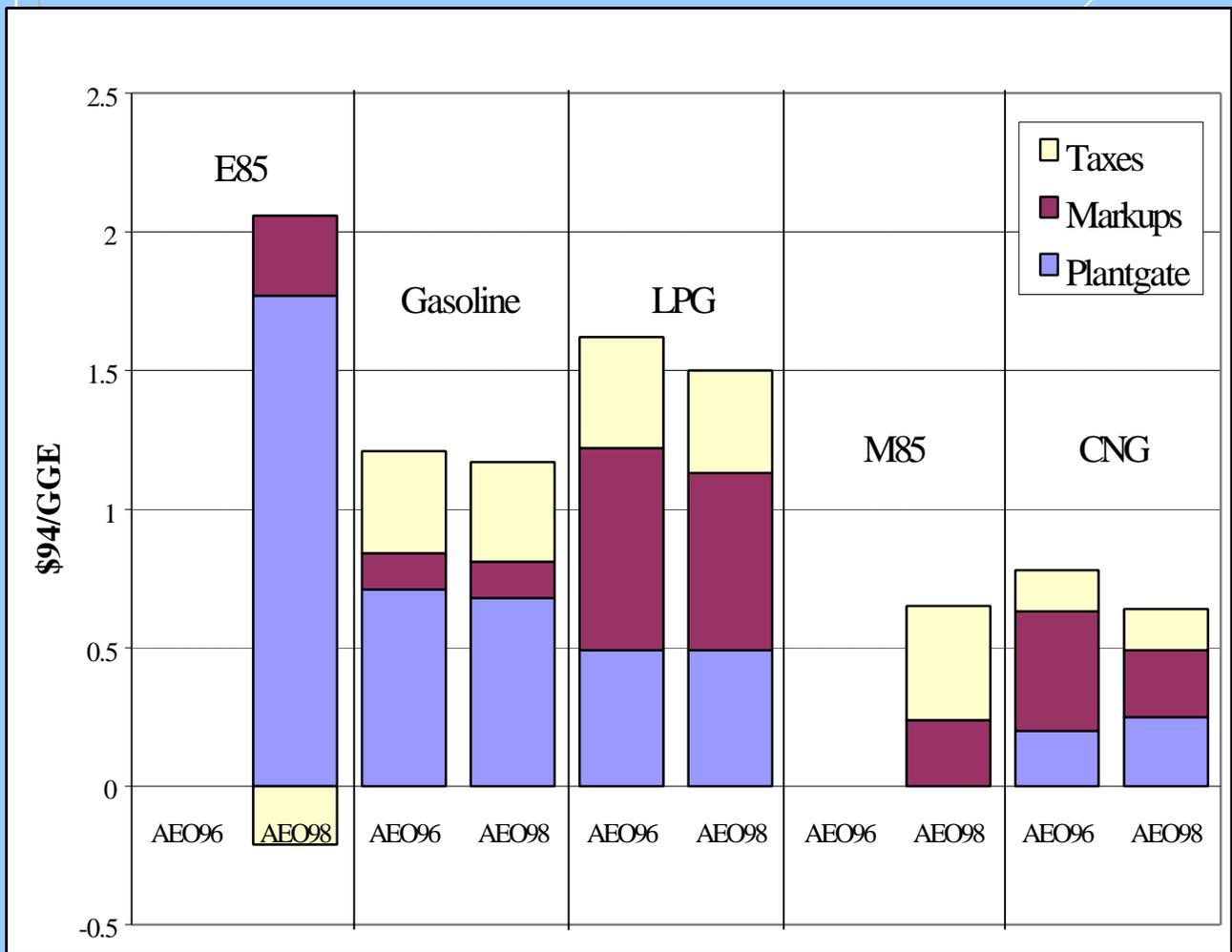
Retail Fuel Supply Curves for 1996



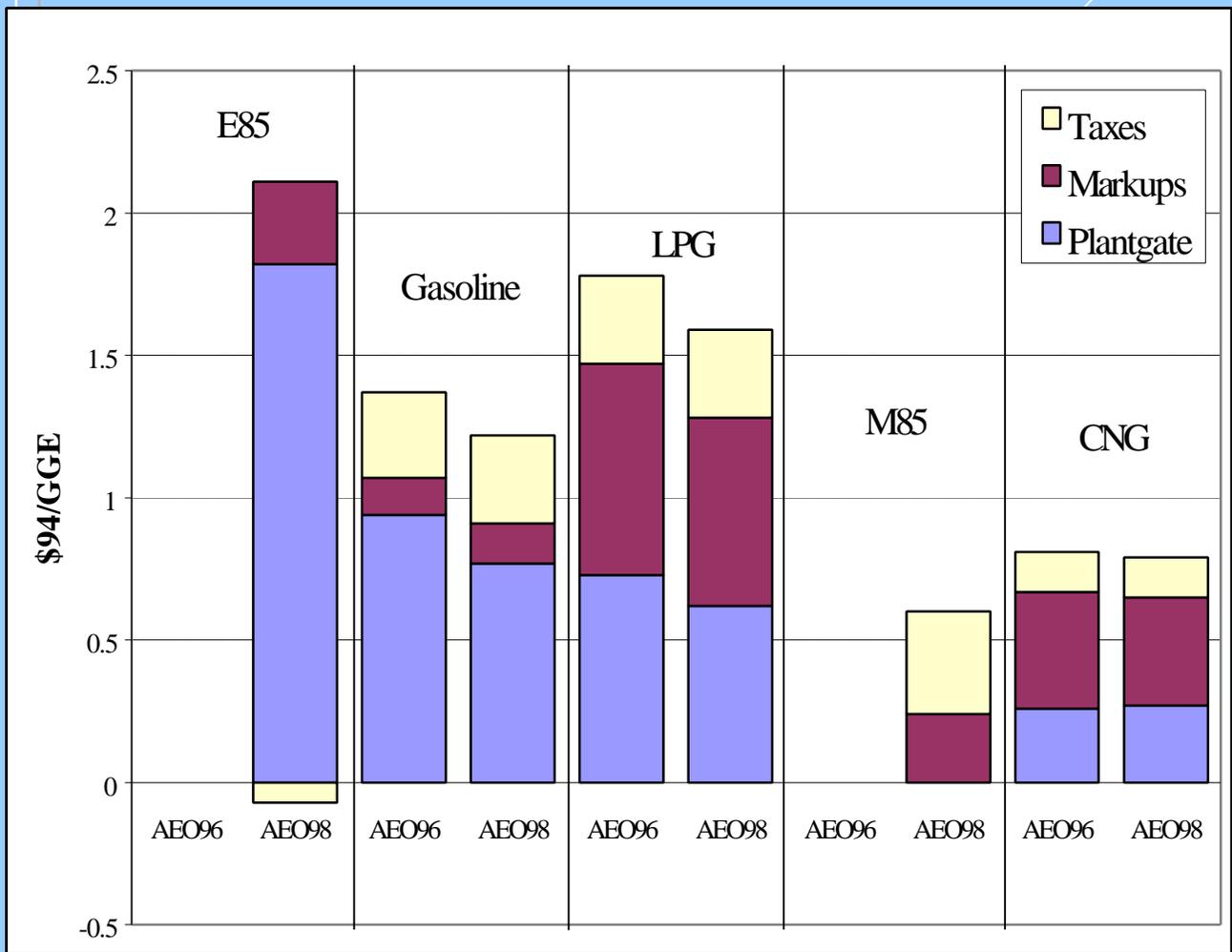
Retail Fuel Supply Curves for 2010



Comparison of AEO96 and AEO98 Fuel Prices: Year 1996



Comparison of AEO96 and AEO98 Fuel Prices: Year 2010



Additional Information

Sources

- See TAFV Website:
<http://pz11.ed.ornl.gov/altfuels.htm>
- “The Alternative Fuel Transition: Draft Final Results from the TAFV Model of Alternative Fuel Use in Light-Duty Vehicles 1996-2010,” February 27, 1998, Paul Leiby and Jonathan Rubin.
- “The Transitional Alternative Fuels and Vehicles Model,” 1997, (*Transportation Research Record* 1587) Paul Leiby and Jonathan Rubin.