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Ethanol Biofuels Implementation Plan

Presented at

CEC-ARB Workshop on Developing a State Plan to Increase the Use of Alternative Transportation Fuels

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1. Methodology
2. Overall Impact
3. Low Level Blends
4. E85
5. Mid-Level Blend
6. Ethanol Diesel Blends

Strategies evaluated are primary apply to light duty vehicle fleet both legacy fleet and new vehicles

- Goal: estimate possible ethanol and biofuels scenarios and compare effectiveness of strategies
  - Low level blends, FFV E85, FFV Mid Level Blend, E-diesel
  - Estimated GHG and gasoline or diesel displacement

- Vehicle and infrastructure costs “ball parked”
- GHG emissions use Well to Wheels estimates from Full Fuel Cycle Analysis completed for AB1007

- Projected estimated for:
  - Several scenarios depending on ethanol strategy
  - Three or Four years: 2012, 2017, 2022 and out to 2050
  - Fuel use estimated based on new car roll in and retirement and estimate of percent fueling
  - Use 8% discount factor for station/terminal investments
  - Flexible fuel vehicles key to E85 and Mid Level strategies

1. Methodology
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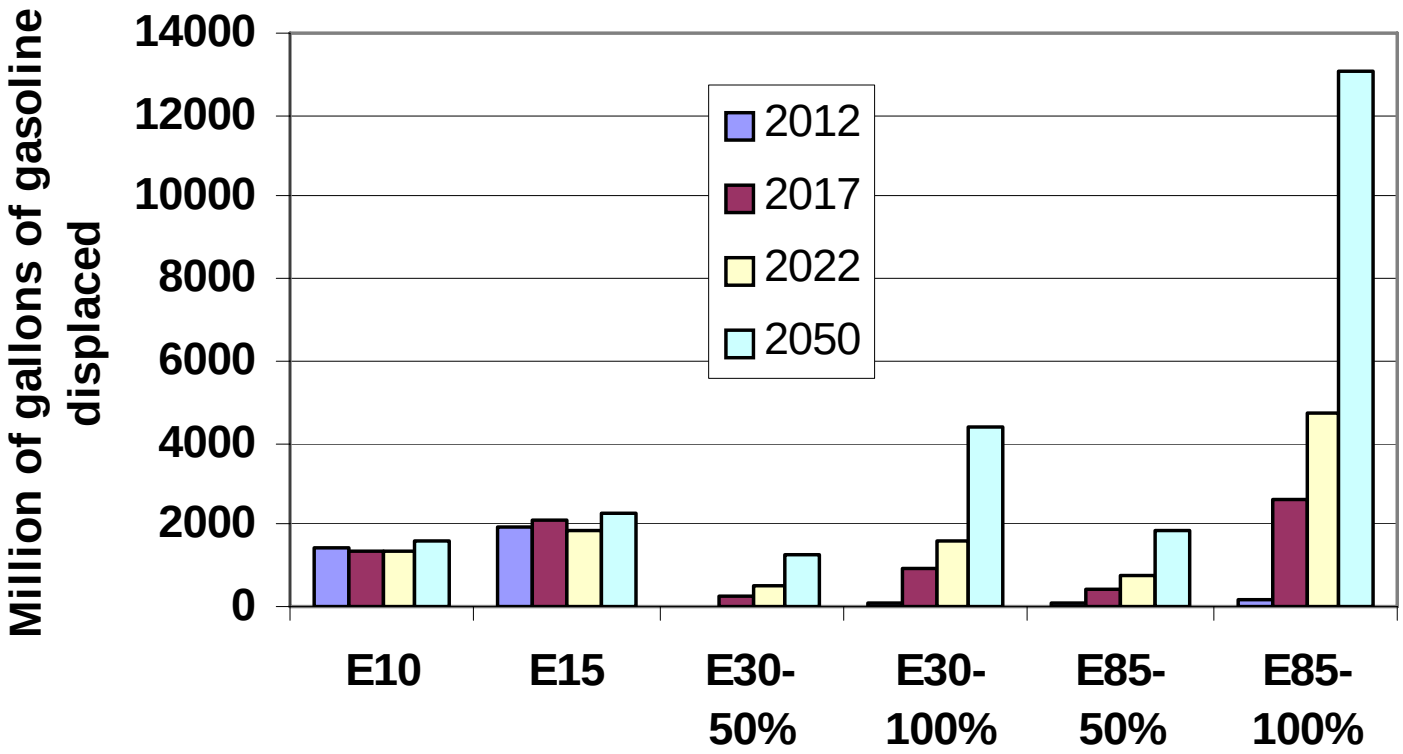
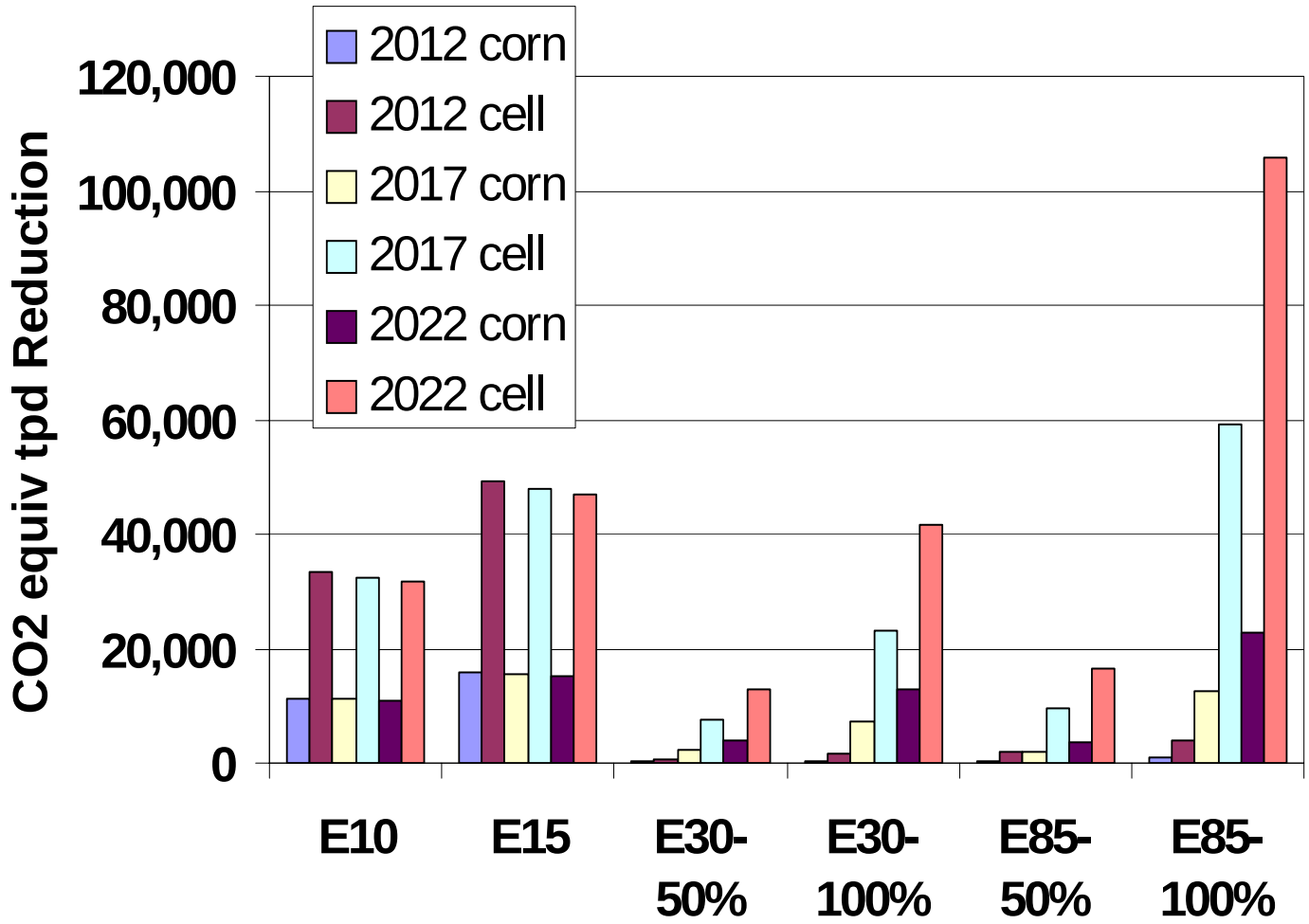
Low level blends provide maximum near term displacement; other strategies require roll in of stations and vehicles—but have higher long term displacement



GHG reductions depend on ethanol production pathway and on implementation strategy—overall tpd reductions comparable to ARB's GHG LDV emission standards



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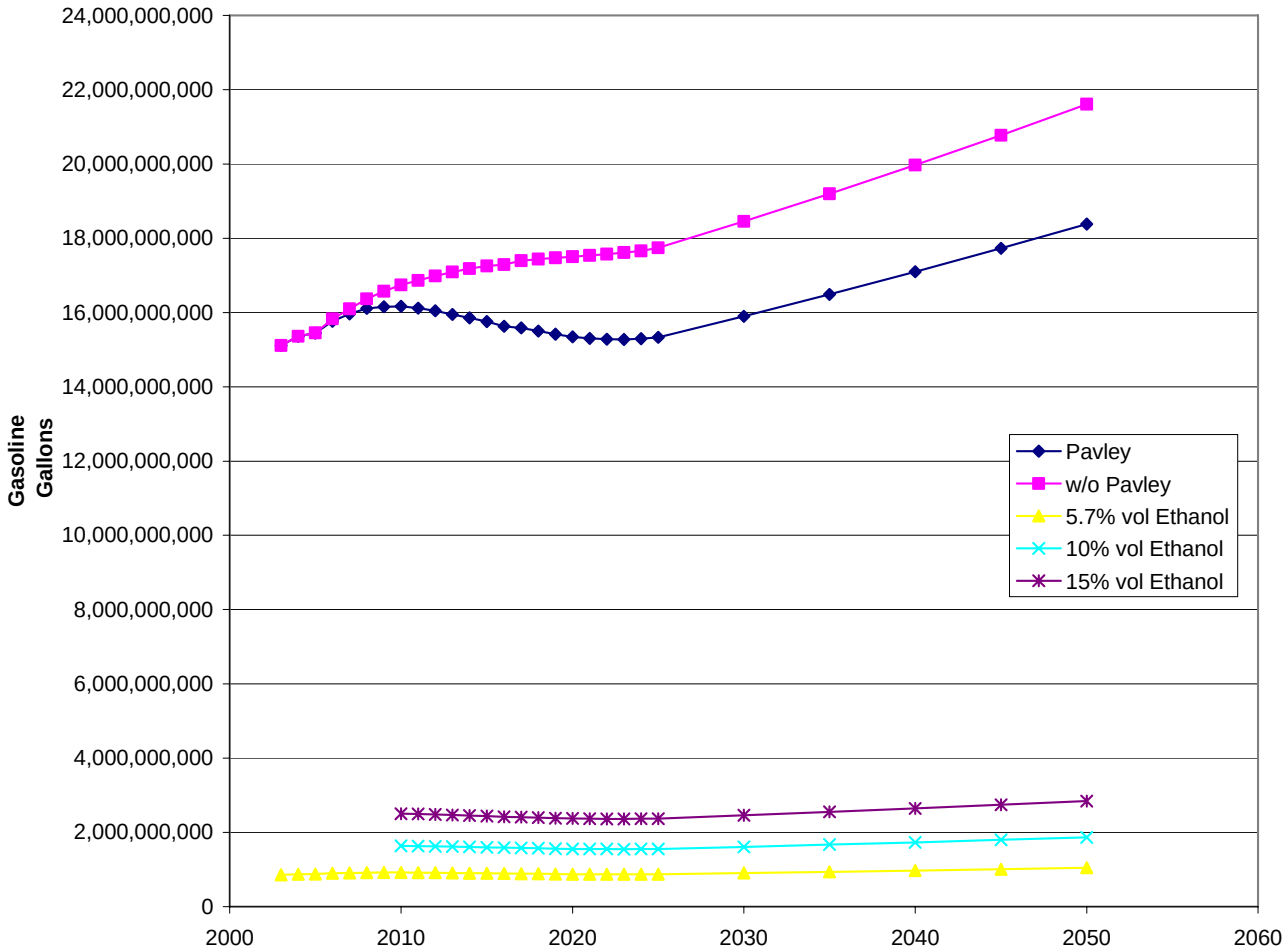
Blending ethanol into gasoline and using in existing vehicles very effective strategy to displace gasoline

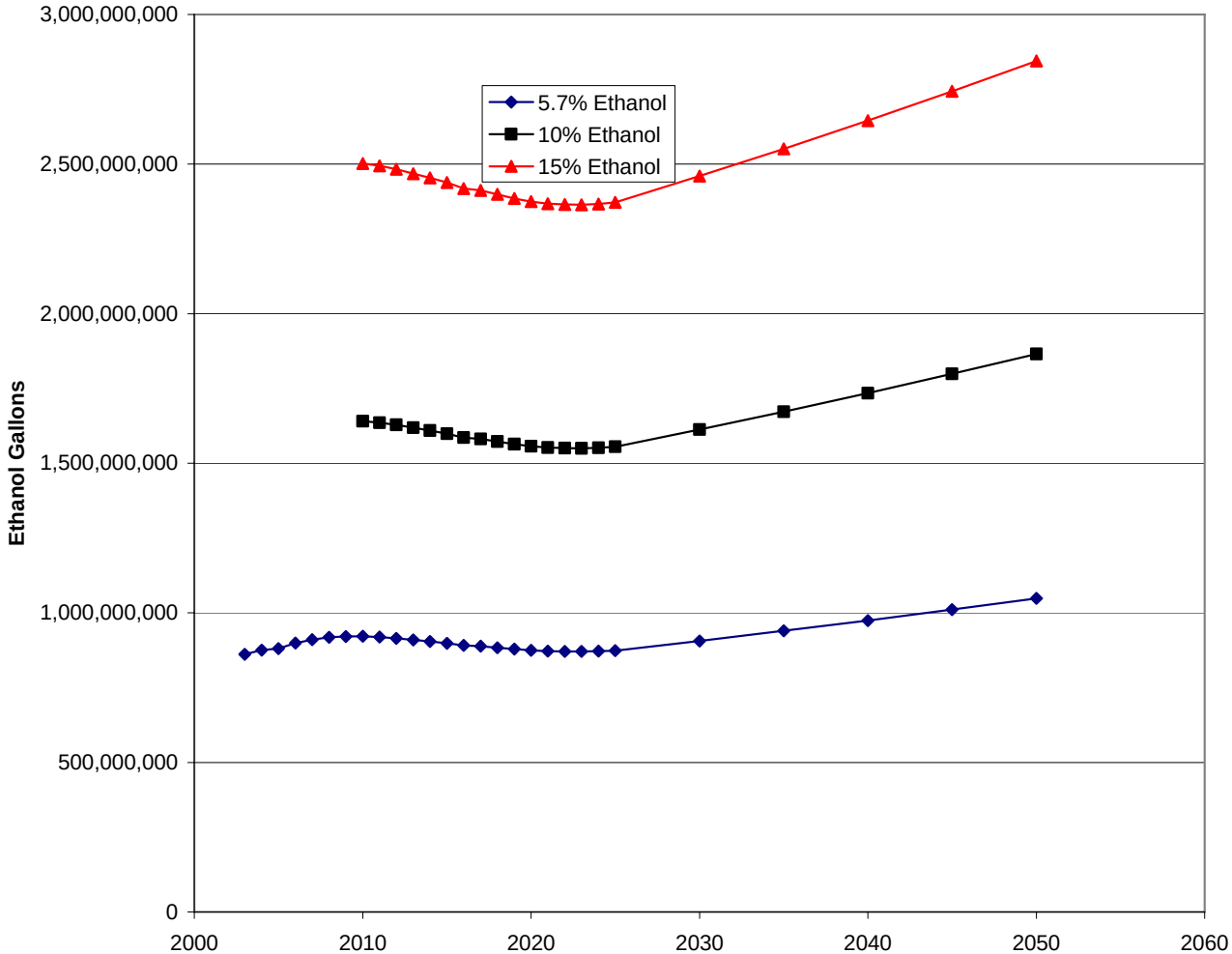
- Immediate displacement (no waiting for vehicles or stations to roll in)
- Have to design/tailor gasoline blend stock for percentage of ethanol
  - Increased RVP
  - Increased permeation emissions
- Does not require vehicle modifications up to 10%
  - Higher blends would need testing
- Infrastructure modifications
  - Dispensing equipment good to 15% (UL)
  - Underground Storage Tanks (UST) good to 10%, higher?

Low level blends of 5.7%, 10%, and 15% considered



- Used 2005 CEC IEPR Projections for Gasoline Demand

Ethanol demand varies from 1 to 3 billion gallons per year. Higher blend scenario would require additional infrastructure investment as might 10% blend especially in later years

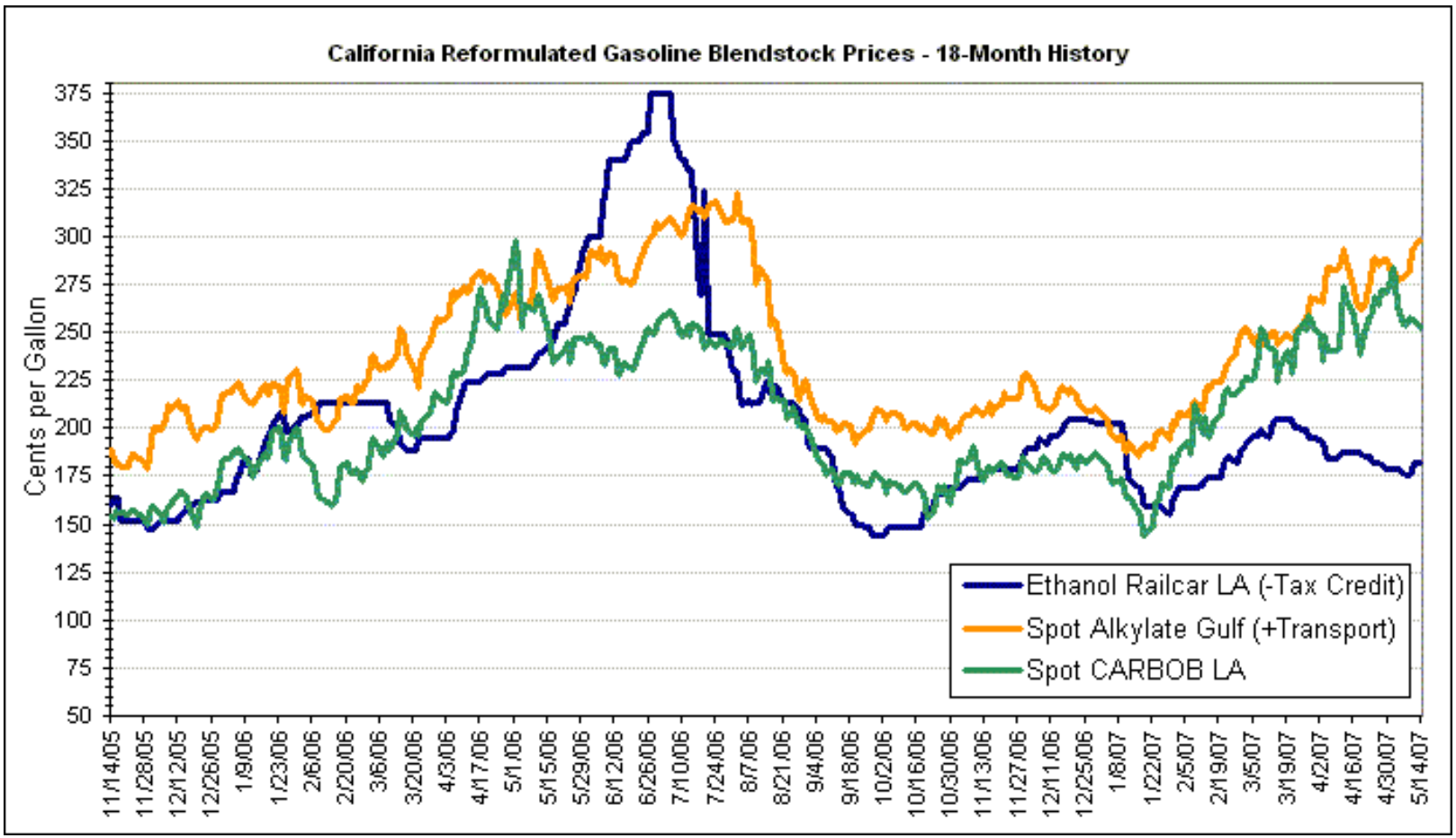


Low level blend displacement and GHG emission reductions

	2012			2017			2022		
Scenario—Blend %	**5.7%**	**10%**	**15%**	**5.7%**	**10%**	**15%**	**5.7%**	**10%**	**15%**
Gasoline Consumption (million gals)	16,046	16,281	16,554	15,589	15,816	16,081	15,285	15,508	15,768
Ethanol (million gals)	915	1,628	2,483	889	1,582	2,412	871	1,551	2,365
Gasoline Displaced (million gal.)	915	1,394	1,976	889	1,354	2,147	871	1,327	1,882
GHG Reduction (tons/day) MW Corn NG		11,434	15,896		11,107	15,442		10,891	15,141
GHG Reduction (tons/day) Cellulosic CA Poplar		33,334	49,296		32,383	47,889		31,751	46,955

- Summary of results
  - Gasoline displaced corrected to energy content compared to 5.7% vol
  - Corn and Cellulosic GHG estimates to provide range
  - Get immediate GHG reductions but upper bound limited unless blend % increased
  - Strategy probably not supply limited even at 15% in 2050 (~3 billion gallons
  - Strategy will require terminal investments and possibility refinery investments to tailor gasoline blend stock
  - Station or vehicle changes probably not needed (>10% ??)

Ethanol priced at blend component levels in this market. Competes on a volume basis



Current and future(?) incentives boost production and economics of blending ethanol in gasoline

- Current incentives
  - 51 cent/gal blenders credit and up to $30,000 tax credit for facilities (30%)
  - Authorized in 2005 EPAct; will require reauthorization
  - 52 cent/gal tariff on imported ethanol
  - Federal Renewable Fuels Standard (RFS)
    - EPA program—7.5 billion gallons by 2012
    - President's goal is 35 billion gallons (not necessarily all ethanol)
- U.S. corn based ethanol production limit about 14 billion gallons; cellulosic developing
- Current U.S. ethanol production about 6 billion gallons per year and will exceed RFS this summer

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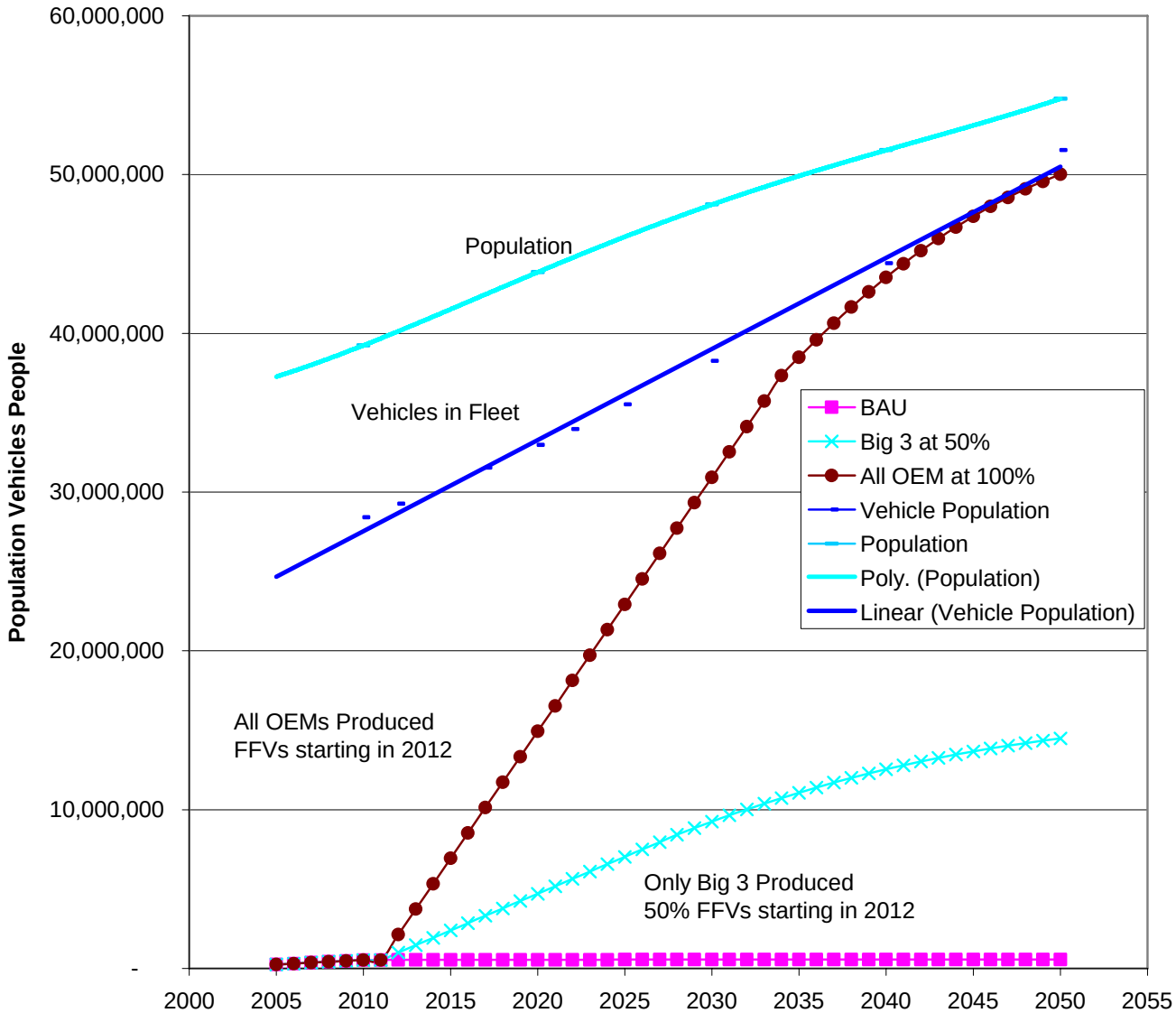
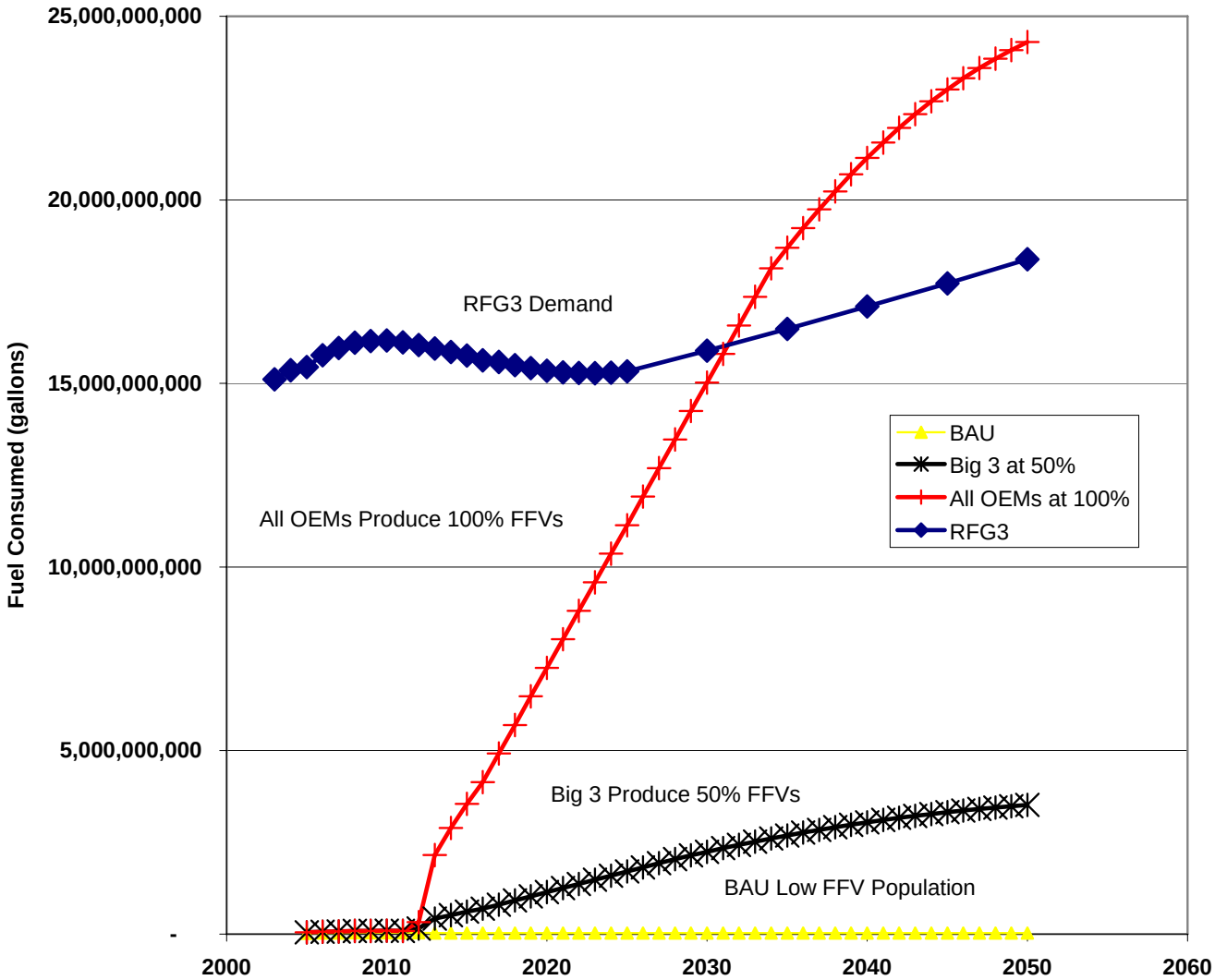
E85 scenario includes OEMs offering FFVs and fuel providers making the necessary station investments to build the E85 fueling infrastructure

- Three bounding scenarios were considered:
  - Business as usual—FFV fleet of 500,000 vehicles in California
  - 50% Big 3—GM, Ford, Chrysler provide FFVs for 50% of new car production in 2012
  - 100% OEM—all vehicles sold in 2012+ are FFVs
- Fuel station assumptions
  - 50% Big 3—FFVs use E85 25% of time to 2011 then 50% in 2012+
    - Station density builds to volumes of FFVs
  - 100% OEM—FFVs use E85 25% of time to 2011 then 100% in 2012+; clearly unrealistic but does provide maximum (results can be scaled)

Vehicle population scenarios match 2005 IEPR future vehicle projections



E85 volume estimates compared to RFG3 projected demand



E85 volumes, gasoline displaced, estimated GHG reductions, and possible vehicle costs

	2012				2017				2022			
	RFG3	E85			RFG3	E85			RFG3	E85		
Scenario*	5.70%	BAU	50%	100%	5.70%	BAU	50%	100%	5.70%	BAU	50%	100%
Number Vehicles gasoline/FFVs (million)	29	0.53	1.00	2.13	32	0.54	3.32	10.13	34	0.55	5.64	18.13
Gasoline-Ethanol Consumption (million gals)	16,046	33	153	328	15,589	26	805	4,922	15,285	27	1,369	8,808
Ethanol (million gals)	915	26	122	260	889	21	639	3,903	871	21	1,085	6,985
Gasoline Displaced (million gal.)	915	18	82.61	177	889	14	434	2,652	871	14	738	4,746
GHG Reduction (tons/day) MW Corn NG		129	600	1,285		103	3,153	19,270		104	5,359	34,486
GHG Reduction (tons/day) Cellulosic CA Poplar		480	2,236	4,787		385	11,742	71,768		389	19,960	128,439
Vehicle Costs (Million $/year)		53.4	99.5	213.1		54.3	331.5	1,013.1		54.9	563.5	1,813.1

- Corn and cellulosic/sugar cane production pathways consider to bound possible benefit
- Vehicle costs estimated at $100 per vehicle
- If all 9600 stations in California are E85 capable total investment > $2.4 billion; assumes $200k per station, 8% discount rate

Implementing E85 strategy requires matching not only vehicles to fueling infrastructure but also consumer's willingness to purchase E85 instead of gasoline at each fill

- Probably will not be able to leverage existing infrastructure and stations will go to 3 tank gasoline system (RUL, PUL, and E85)
- Probably need at least 20% station coverage depending on number of FFVs in vehicle fleet. Use to say 10%
- E85 pricing important—consumer decides at each fill
  - Sets up competition between gasoline
  - What are the value propositions for consumers? Cost, performance, other?
- Station equipment
  - Dispensers and stage II vapor recovery

Other considerations with E85 implementation

- FFVs ultimately will need to be designed to meet PZEV standards
  - Challenge meeting tailpipe and evap standards
  - Will require at least material changes
  - Impact on vehicle costs ??
- Same incentives of 51 cent per gallon blenders credit; 30% up to $30,000 station/facility tax credit
- E85 strategy most surely supply limited; will only be able to capture some percentage of the total energy used in light duty vehicle segment
  - What is a realistic upper bound?
- Fuel availability at stations will have to be as convenient and “main stream” as RUL and other grades

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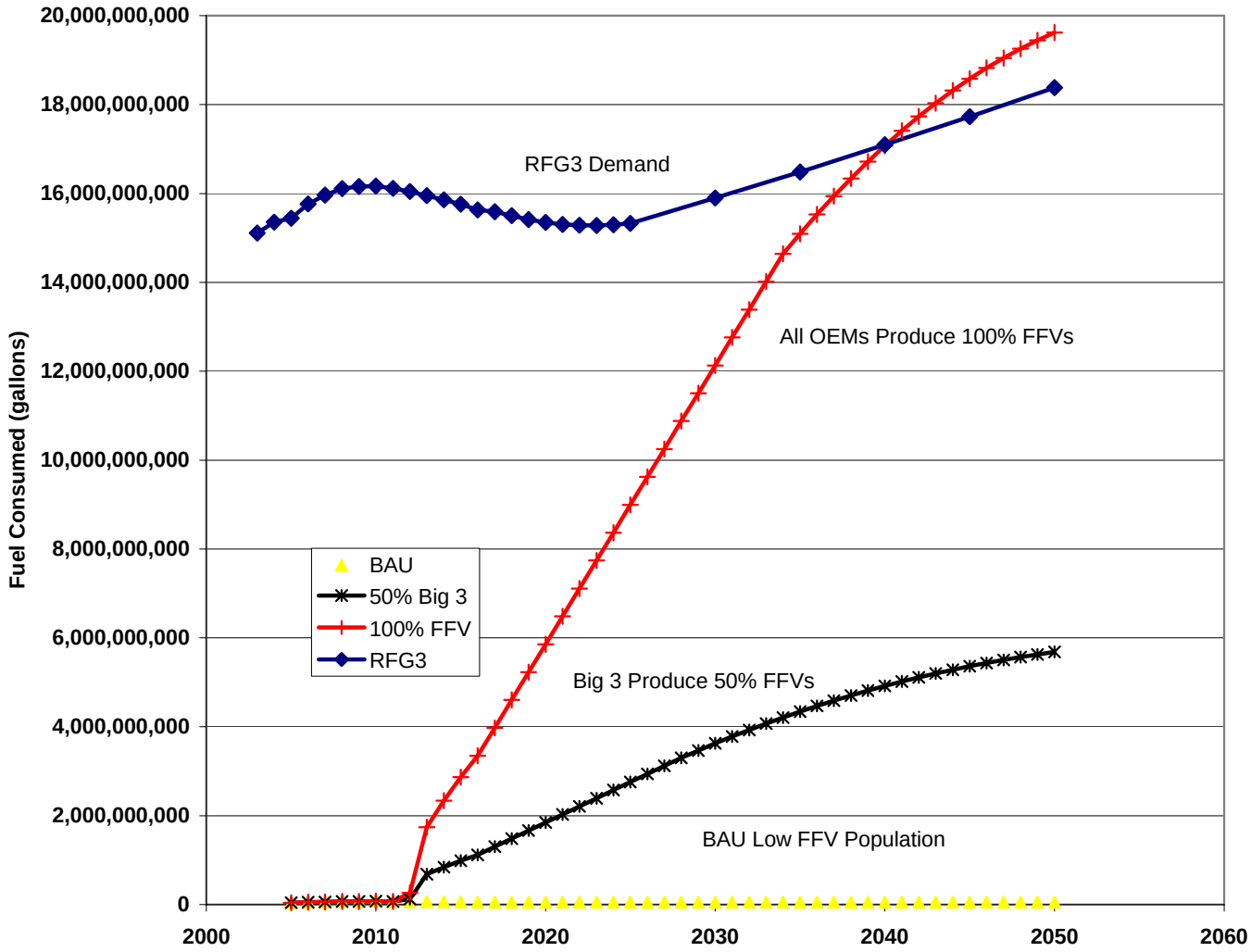
Mid level blend could minimize infrastructure changes and costs

- Instead of introducing E85 which would require 3 tank (3 fuel) system at stations design unleaded and mid level blend to maintain 2 tank/2 fuel system
  - RUL with or without ethanol, perhaps even higher octane rating
  - Mid level blend like E30 with high octane rating
  - Blend to other unleaded grade(s)
- Could possibly leverage existing UST systems at stations. Would need to change out other equipment for E30 blend
  - Should lower station costs
- Introduce and sell E30 to all new vehicles; no consumer choice like E85 case
  - Similar to unleaded transition; E30 cheaper than RUL, no competition between alternative fuel and gasoline
- FFVs would be required but could optimize around E30 blend instead of full spectrum of any mixture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Fuel Consumed (gallons)
2000
2010
2020
2030
2040
2050
2060
RFG3 Demand
All OEMs Produce 100% FFVs
Big 3 Produce 50% FFVs
BAU Low FFV Population
BAU
50% Big 3
100% FFV
RFG3

Estimates of E30 volumes, ethanol gallons, gasoline displaced, GHG reductions and vehicle costs

	2012				2017				2022			
	RFG3	E30			RFG3	E30			RFG3	E30		
Scenario*	5.70%	BAU	50%	100%	5.70%	BAU	50%	100%	5.70%	BAU	50%	100%
Number Vehicles gasoline/FFVs (million)	29	0.53	1.00	2.13	32	0.54	3.32	10.13	34	0.55	5.64	18.13
Gasoline-Ethanol Consumption (million gals)	16,046	66	124	265	15,589	53	1,300	3,974	15,285	54	2,210	7,112
Ethanol (million gals)	915	20	37	80	889	16	390	1,192	871	16	663	2,134
Gasoline Displaced (million gal.)	915	15	28	59	889	12	291	889	871	12	494	1,591
GHG Reduction (tons/day) MW Corn NG		121	226	484		97	2,372	7,250		98	4,032	12,974
GHG Reduction (tons/day) Cellulosic CA Poplar		389	725	1,553		312	7,620	23,286		315	12,952	41,673
Vehicle Costs (Million $/year)		53.4	99.5	213.1		54.3	331.5	1,013.1		54.9	563.5	1,813.1

- FFV implementation scenarios are same as E85 strategy
- Vehicle costs also same ~ $100 per vehicle
- Leveraged station costs about 1/10 of E85 but could be the same depending on material compatibilities (especially USTs)

Possible advantages of mid level blend strategy

- Eliminates competition between gasoline and ethanol
  - Two fuel/two tank system
  - Could move ultimately to one tank system as old cars turn over
  - Potential to design fuel with higher octane
- Potential lower infrastructure costs, but even if same as E85 there is a captive fleet of new vehicles need fuel. Easier to justify station investment
- Blend component does not have to be ethanol
  - Could biofuels derived like biobutanol or other to be define
- Strategy still probably blend component limited
  - for 100% FFV case would require 6 billion gallons per year for E30 blend
- Implementation of blend could be designed to match ethanol or blend component supply—start out at lower blend level and increase as production is increased (assuming no vehicle changes)

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O2 Diesel has ethanol diesel blend fuel in market place today

- O2 Diesel in market place with 7.7% vol blend with proprietary additives in the 0.6 to 1% vol range
- O2 has verification status and gets $0.51 blenders tax credit
- Two scenarios developed aimed at on and off road fleet users only:
  - Moderate growth case assumes market penetration <10% and engine manufactures not show stopper
  - Higher growth case has broader customer and engine manufacturer acceptance building to 25% acceptance in targeted fleets
- Other factors that will affect market penetration
  - EPA Tier II health effects testing funded and outcome positive
  - Engine durability no different than diesel
  - ASTM standard developed
  - Verification retained and ethanol diesel blends continue to show emission benefits

Million of gallons of possible O2 diesel sales into centrally fueled fleets

Fleet Application	2010		2025	
On-Road Centrally Fueled	**Diesel Gal Displaced**	**Ethanol Volume**	**Diesel Gal Displaced**	**Ethanol Volume**
Moderate	1.8	3.0	6.6	11.0
Higher Growth	2.7	4.5	10.2	17.0
Off-Road Centrally Fueled				
Moderate	2.4	4.0	6.6	11.0
Higher Growth	6.0	10.0	21.0	35.0