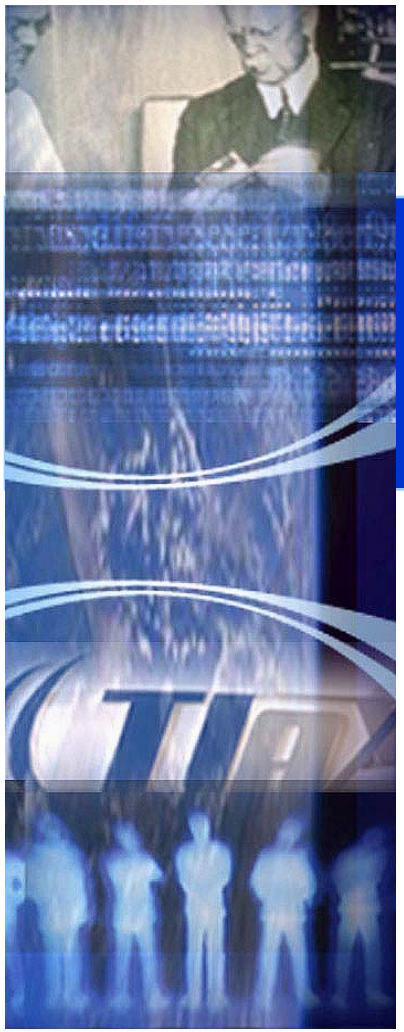

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Allocating AB118 Funds to Meet California's 2050 Climate Change Goals

Review of TIAX White Paper for SCE

July 2008

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Summary

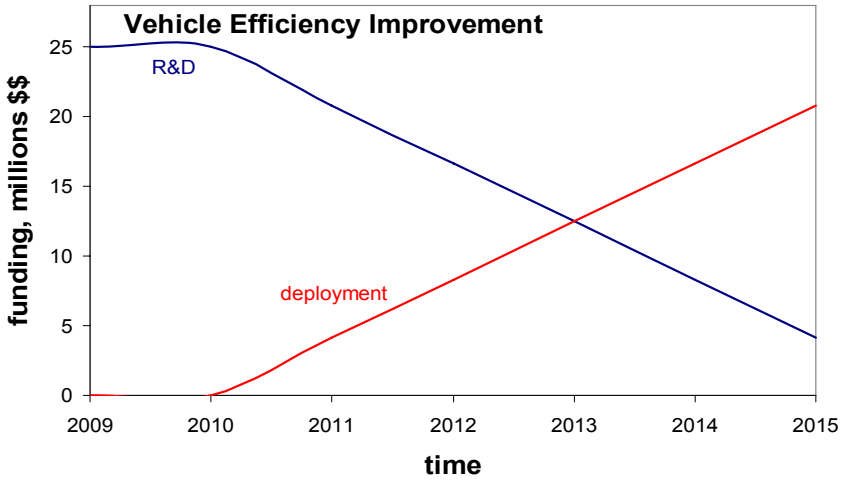
- Identified and explored qualitative approaches to distribute AB118 funding, and recommend that projects be separated and evaluated by **technology buckets**:
  1-vehicle efficiency improvements 2-blended biofuels
  3-nonrenewable alternative fuels 4-advanced vehicle technologies
- Determined **GHG reduction potential** of various fuel/engine combinations in both the light-duty and heavy-duty sector compared to a baseline technology.
- Two scenarios: **Unconstrained and Constrained**.
  The Constrained Scenario accounts for compliance with other State policies, rules, and regulations, and introduces plausible market constraints
- Considered **needs of each technology bucket**, broken down by:
  R&D, demonstration, vehicle deployment, and infrastructure
- Recommendations for **scoring projects** using the Evaluation Criteria (listed in AB118 legislation)

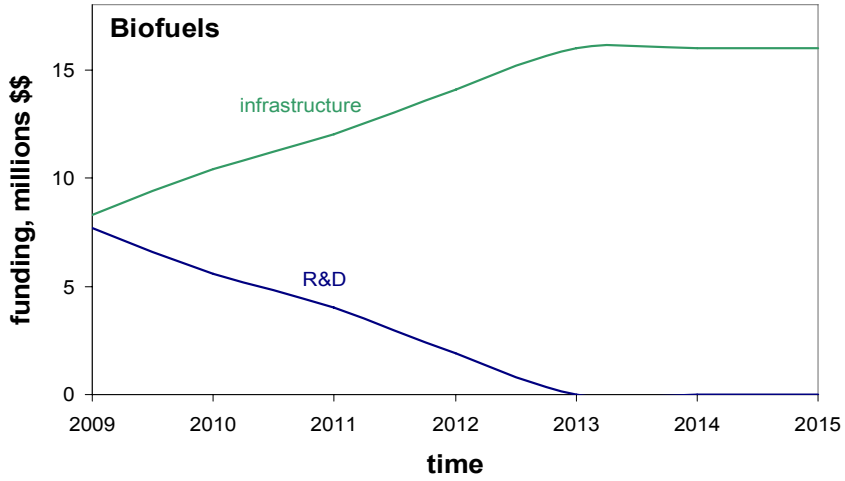
Recommended Allocation based on GHG Reduction Potential

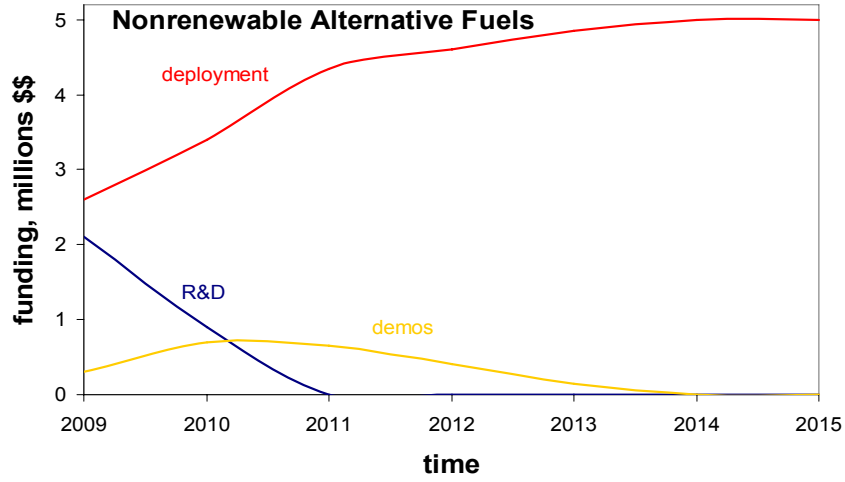
Light Duty + Heavy Duty Buckets	Percent Allocation of AB 118 Funds Constrained
Improved vehicle efficiency	25%
Blended biofuels	16%
Nonrenewable alternative fuels	5%
Advanced vehicle technologies	54%
Total	**100%**

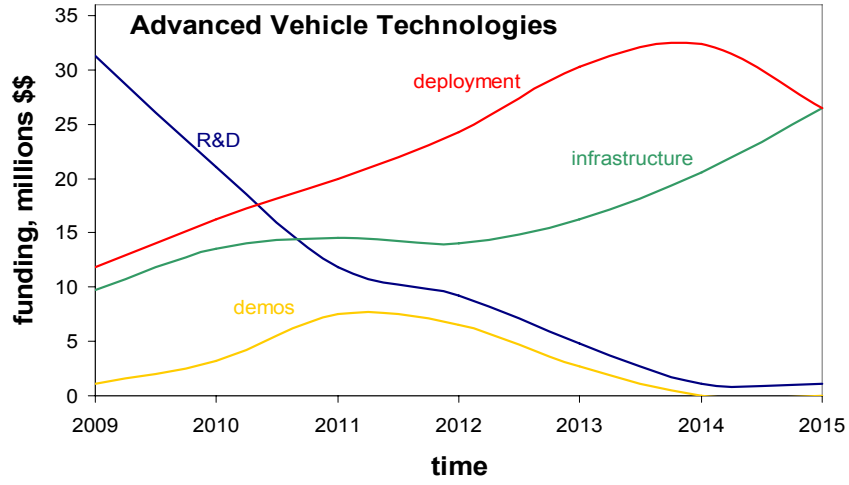
Advanced technologies include on and off road, electric drive applications and include vehicle technologies such as battery electric, plug-in hybrids, and hydrogen fuel cells

Distribution of Funds by Areas of Need for Each Technology









Gap Analysis: The Energy Commission will need to review existing publicly or privately funded programs to avoid doubling current efforts

Evaluation Process: Developing a Portfolio Approach

Evaluation Criteria
GHG Emissions
Petroleum Use
Criteria Pollutants
Water/Toxic Pollutants
Economic Benefits
Sustainability
Infrastructure
Tech Advancement
20% Alt Fuel Blend

Costs
Today v Tomorrow
S-curves
Matching Funds

Cost-Benefit Analysis Methodology

Baseline + Assumptions

1 Business Case (100 pts)
Identify competition
Dependent on other technology?
Cost relative to:
- competition
- price of oil (baseline)

Probability of Commercialization

2 Benefits (100 pts)
GHG Reductions
Petroleum Displacement
Criteria Pollutant Reductions
Water/Toxic Pollutant Reductions
Economic Benefits to CA
Sustainability

Inputs → **Evaluation Process** → **Scored Output**

1. Introduction to AB118
2. Overview of Competitive & Eligible Technologies
3. Qualitative Approach to Distribute Funds
4. Allocating Funds by GHG Reduction Potential
5. Evaluation Process

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Introduction to AB 118 Legislation

- Funding mechanism for AB 1007 – State Alternative Fuels Plan
- Established two programs, with separate funds:
  - **Alternative and Renewable Fuel & Vehicle Technology Program (CEC)**
  - Air Quality Improvement Program (ARB)

- Alternative and Renewable Fuel & Vehicle Technology Fund
  - About $120M available annually, Jul 2008 – Jan 2016
  - "grants, loans, loan guarantees, revolving loans, or other appropriate measures" to "public agencies, businesses and projects, public-private partnerships, vehicle and technology consortia, workforce training partnerships and collaboratives, fleet owners, consumers, recreational boaters, and academic institutions"

Objective of Work

The State has many policies and goals in play with regard to AB118:

- Air Quality Improvement (i.e., Criteria Pollutant Reduction)
- Alternative Fuel Use
- GHG Reductions
- Petroleum Reduction
- Sustainability

How should the money be distributed to ensure that the State reaches its goals in each of these areas?

Scope of Work

- Understand **eligible** and **competitive** projects
- Explore approaches **to categorize/sort** projects
- Develop an **allocation strategy** based on **GHG reduction potential**
- Consider **evaluation criteria** and **project selection**

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Eligible and Competitive Projects

- 11 paragraphs of eligibility in the legislation; ranges from low-carbon fuels to efficiency improvements and fueling infrastructure to fuel production
- Consider projects by:
  - **Fuel type:** electricity, hydrogen (H2), biofuels, natural gas (NG), liquefied petroleum gas (LPG)
  - **Stage of Commercialization:** R&D, demonstration, infrastructure, and vehicle deployment
- Note on **infrastructure**: broadly defined to include fuel production, fuel distribution, fueling stations, metering, facility infrastructure (for electric truck refrigeration units (eTRUs) or truck stop electrification (TSE), for instance)
- Use AB 1007 and Storylines to identify likely projects and needs:

● - highest priority ⭘ - medium priority ○ - lower priority

Fuel	Project	R&D	Demos	Infrastructure		Vehicle Deployment	
				Grants	Loans	Grants	Loans
Electricity	electric vehicles						
	LD PHEVs	●	◎	◎	○	●	○
	HD PHEVs	●	◎	○	○	●	○
	LD BEVs	●	◎	◎	○	●	○
	HD BEVs	●	◎	○	○	●	○
	NEVs					●	○
	truck stop electrification (TSE)						
	on-board HVAC systems			○	●	●	○
	off-board HVAC systems			○	●		
	battery APU			○	●		
	cold-ironing			●	○	●	○
	electric truck refrigeration units (e-TRUs)						
	electric standby TRUs					●	○
	diesel-electric hybrid TRUs	○	○	◎	●	○	●
	electric forklifts (e-forklifts) and other industrial equipment[a]	○	○		○		●
	lawn and garden	○	○	○	○	●	○
	rail, boats, personal transportation						
	trolley buses	○		◎	○	●	○
	light rail and commuter rail			◎	○	●	○
	maglev rail	●	◎	○	○	○	○
	electric boats	○	○			●	○
	bikes and scooters					●	○
H2	H_2 fueling stations	◎	●	●	○		
	H_2 home-fueling stations	●	◎	○	○		
	biomass-to-H_2 technologies	●	◎	○	○		
	hydrogen plants	●	◎	○	○		
	FCV technologies					●	○
	FCV production plants in CA	○				●	○
	H_2 on-board storage technology	◎	●			○	○
	H_2 fuel-cell hybrid technologies	◎	●			○	○

Fuel	Project	R&D	Demos	Infrastructure		Vehicle Deployment	
				Grants	Loans	Grants	Loans
Biofuels	ethanol production plant						
	out-of-state feedstock	○		○	●		
	in-state feedstock			●	○		
	proof-of-concept cellulosic ethanol plant	◎	●	○	○		
	ethanol fueling stations			○	●		
	biodiesel production technologies	○	●	◎	○		
	biodiesel optimization technologies	●	◎	○	○		
	biodiesel production plant	○	◎	●	○		
	biofuel production technologies	●	◎				
	terminal storage of biofuels	●	○	○	○		
Natural Gas	LNG stations		○	●	○		
	LNG cryogenic processing/production in CA			●	○		
	CNG stations		○	●	○		
	low-pressure tank designs for fueling stations	●	◎	◎	○		
	biogas as feedstock for H_2	●	◎				
	biogas production technologies	◎	●	○	○		
	NG/LG vehicle purchase incentives					●	○
	NG low-pressure on-board storage technology	●	◎	○	○		
	NG hybrid electric vehicles	○	●			●	○
	NG engines/fuel system technologies MD/HD	●	●			●	○
LPG	LPG fueling stations			●	○		
	LPG vehicle technologies	●	◎			○	○
	HD LPG technologies	◎	●			○	○
	off-road LPG technologies		○			○	●

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Qualitative Approaches to Distributing AB 118 Funds

Think of the distribution of funds as a filter used before the evaluation of projects

Many possible approaches:

- Stage of impact: near, mid-, and long-term
- Fuel type
- Technology buckets: vehicle efficiency improvements, blended biofuels, and advanced vehicle technologies
- Area of need: R&D, demonstration, deployment, or infrastructure
- Hybrid of approaches listed above

The best approach should:

- Help the State reach its climate, petroleum reduction, and air quality goals
- Simplify the evaluation process
- Ensure a fair evaluation process
- Maintain technological neutrality (i.e., don't pick winners)

Evaluating the Merits of Each Approach

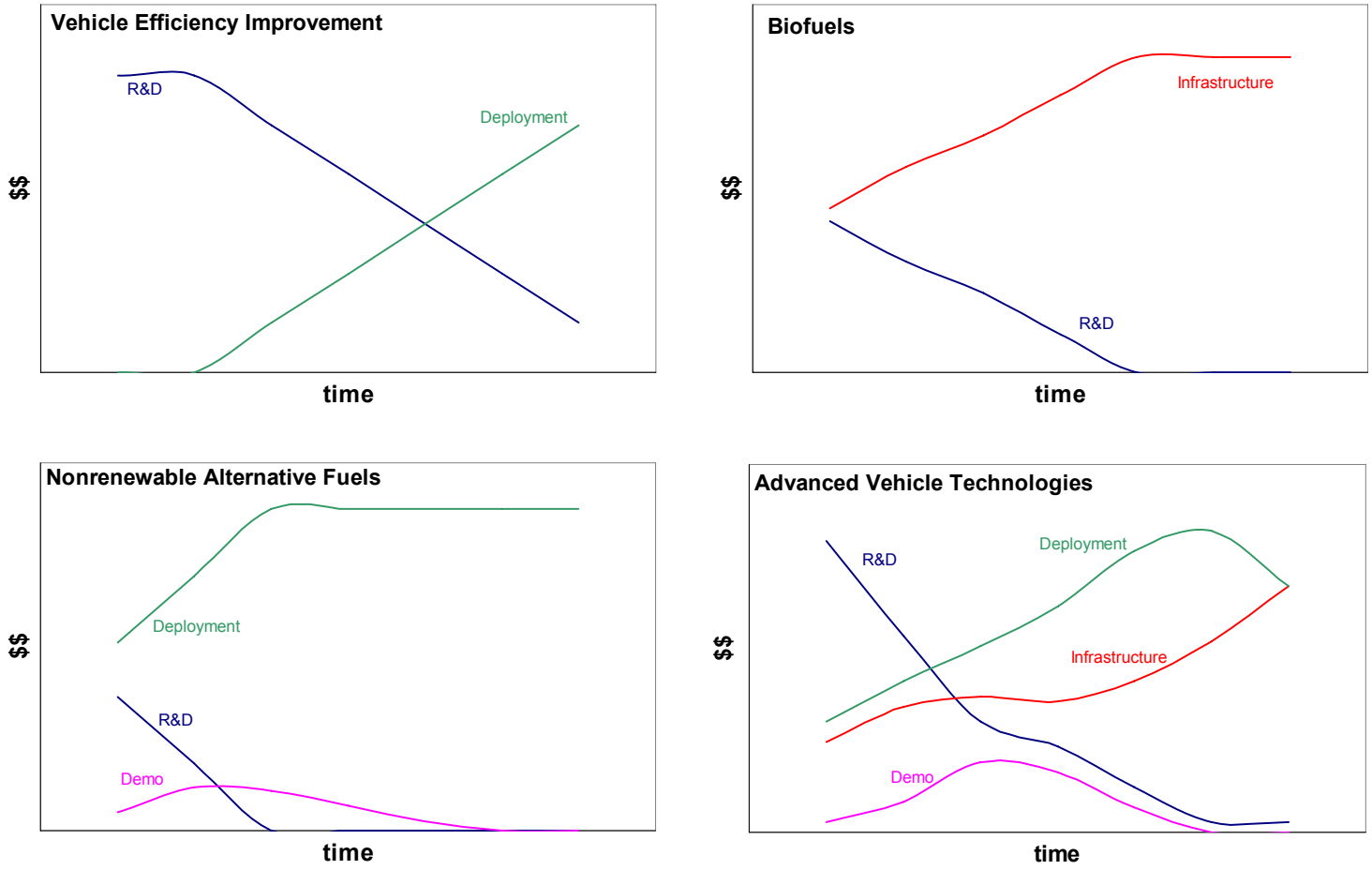
Darker shade = Better Fit for Criteria

	2050 Climate Goals	Simplified Evaluation	Fair Evaluation	Technological Neutrality
Stage of impact				
Fuel type				
Technology buckets				
Area of need				

Technology buckets

- **Vehicle Efficiency Improvements**
  - Advances in engine technologies, hybridized engines, improved transmissions, reductions in weight, and aerodynamic improvements
- **Blended Biofuels**
  - Ethanol (corn, sugar, or cellulosic), advanced bio-hydrocarbons, bio-diesel, renewable diesel
- **Nonrenewable Alternative Fuels**
  - Natural Gas (CNG and LNG) and Liquefied Petroleum Gas (LPG)
  - Focused on heavy-duty sector
- **Advanced Vehicle Technologies**
  - Electric vehicles (PHEVs and BEVs) and hydrogen fuel cell vehicles (FCVs)
  - Light- and Heavy-duty
  - On- and Off-road technologies

Technology Buckets: Funding by Areas of Need



No gap analysis: we have **not** considered existing initiatives; the State will need to ensure that AB118 funds are not duplicating existing efforts

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Unconstrained Scenario: General Approach

- We assume an optimistic 100% market penetration of each vehicle/fuel combination by 2050
- Separate Light- and Heavy-Duty sectors
- Distinguished technologies by fuel type: biofuels, NG, LPG, e-drive, H2
- Used WTW emission factors for GHGs from AB1007 Report (TIAX)
- Calculated a percent improvement over a baseline:
  - Light-duty: ICE using reformulated gasoline (RFG)
  - Heavy-duty: ICE using CA ultra low-sulfur diesel (ULSD)
- Normalized percent improvement for each fuel/engine combination to determine percent allocation:
  - If fuel **A** has a GHG reduction potential of 5 units, and **B** has a potential of 10 units, then B gets twice as much funding:
    A - 1/3 of funding, **B** - 2/3 of funding

Unconstrained, Light-Duty Sector Assumptions

- For **improved vehicle efficiency**, we assumed a 3-fold increase in on-road fuel economy of vehicles by 2050 (e.g., 20 mpg to 60 mpg)
- **Efficiency improvements** via plug-in or battery electric vehicles, fuel cell, and other alternative fuels are excluded entirely; all improvements are reached through hybrid electric drives, advances in engine technologies, improved transmissions, weight reduction, and aerodynamic improvements
- For **blended biofuels**, assumed an **E85** infrastructure and **100% cellulosic ethanol**; no GHG emissions from indirect land-use change
- For **NG**, North American derived natural gas; **LPG** from natural gas well (i.e., not petroleum refining)
- For **electricity**, we used the CA marginal mix for generation assuming 20% renewable generation; on the vehicle side, we assumed a 4:1 ratio of PHEVs to BEVs by 2050
- For **hydrogen** production, we assumed that 20% would come from renewable resources

Unconstrained, Light-Duty Sector Results

Light-Duty Vehicle Technologies	Powertrain	WTW Emissions (g/mi)	% Improvement (over ICE/RFG)	% Allocation
RFG, marginal (baseline)	ICE	431	—	—
Efficiency improvement	ICE	144	67%	22%
E30, cellulosic	FFV	322	—	—
E85, cellulosic	FFV	120	72%	24%
NG, North America	ICE	302	30%	10%
LPG, natural gas	ICE	354	18%	6%
Electricity, natural gas/RPS	PHEV	224	—	—
	BEV	124	—	—
Electricity, 80% PHEV : 20% EV	PHEV/BEV	204	53%	17%
H2, biomass	FCV	40	—	—
H2, NG SR, renewable power	FCV	170	—	—
H2, 20% biomass: 80% NG SR	FCV	144	67%	22%
			Total	**100%**

Source Full Fuel Cycle Assessment: Well-to-Wheels Energy Inputs, Emissions, and Water Impacts (Consultant Report), TIAX LLC, August 2007, CEC-600-2007-004-REV

Unconstrained, Heavy-Duty Sector Assumptions

- For **improved vehicle efficiency**, we assumed that a HEV ICE is the best-case scenario for reducing WTW GHG emissions
- For **bio-diesel**, we assumed a 4:1 ratio of renewable diesel to bio-diesel
- For **electric drive technologies**, we assumed a 9:1 ratio of PHEVs to BEVs; we determined the PHEV miles for a heavy-duty engine by combining the WTW GHG emissions for an EV and an HEV (run on diesel), assuming that the vehicle was in all-electric mode 35% of the time.
- We made no adjustments to the **hydrogen FCVs** in the heavy-duty sector; the WTW emission factor assumes that the hydrogen is generated from steam reforming natural gas

Unconstrained, Heavy-Duty Sector Results

Heavy-Duty Vehicle Technology	Powertrain	WTW Emissions (g/mi)	% Improvement (over ICE/diesel)	% Allocation
Diesel, CA (baseline)	ICE	3255	—	—
Efficiency Improvement	ICE,HEV	2607	20%	15%
Renewable Diesel, FTD 30	ICE	2578	—	
Bio-Diesel, BD 20	ICE	2865	—	
Bio-/Renewable Diesel Mix: 20% Bio, 80% Renewable	ICE	2635	19%	14%
LPG, North America	ICE	2872	12%	9%
NG, North America	ICE	2515	23%	17%
Electricity, NG/RPS	PHEV	2207	—	—
	EV	1463	—	—
Electricity, 90% PHEV : 10% EV	PHEV/EV	2058	34%	26%
H2, on-site NG SR	FCV	2468	24%	18%
			Total	**100%**

Source: Full Fuel Cycle Assessment: Well-to-Wheels Energy Inputs, Emissions, and Water Impacts (Consultant Report), TIAX LLC, August 2007, CEC-600-2007-004-REV

Developing an Allocation Strategy

- Group fuels according the technology buckets discussed previously: 1) vehicle efficiency improvements, 2) blended biofuels, 3)nonrenewable alternative fuels, and 4) advanced vehicle technologies
- Combine light-duty and heavy-duty technologies, weighted by respective GHG contributions (based on gasoline and diesel demand as proxies)

Light-duty + Heavy-duty **Buckets**	**Percent Allocation Unconstrained Scenario**
Improved vehicle efficiency	21%
Blended biofuels	22%
Nonrenewable alternative fuels	17%
Advanced vehicle technologies	40%
Total	100%

Constrained Scenario: General Approach

Introduce plausible circumstances in the light-duty sector; heavy-duty sector remains unchanged

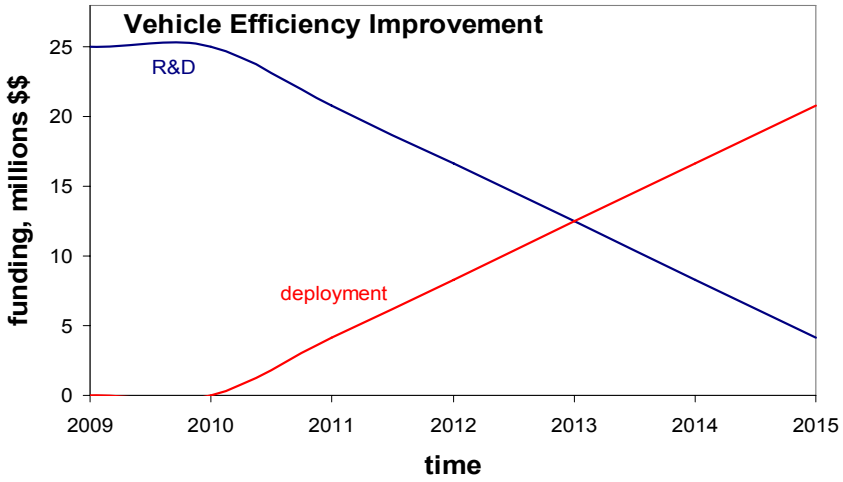
- For vehicle efficiency improvements, only GHG reductions going above and beyond a CAFE standard are credited; whereas, for blended biofuels, only reductions better than LCFS are credited
- Introduce a supply constraint on ethanol based on available biomass; ethanol can only displace about 40% of gasoline fuel supply
- The market penetration for both NG and LPG vehicles is severely limited; effectively no light-duty vehicles
- The market penetration for PHEVs/BEVs and FCVs is constrained; capped based on 2050 Vision from the State Alternative Fuels Plan (AB 1007) – about 70% by 2050

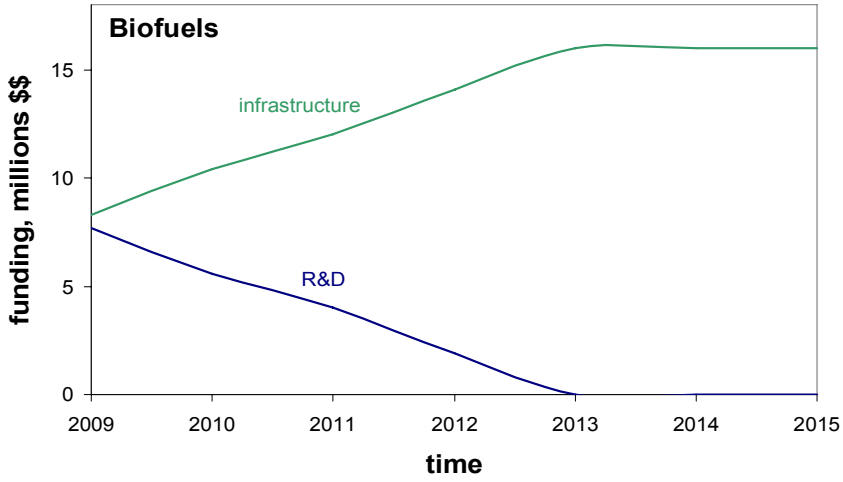
Constrained vs Unconstrained: Results

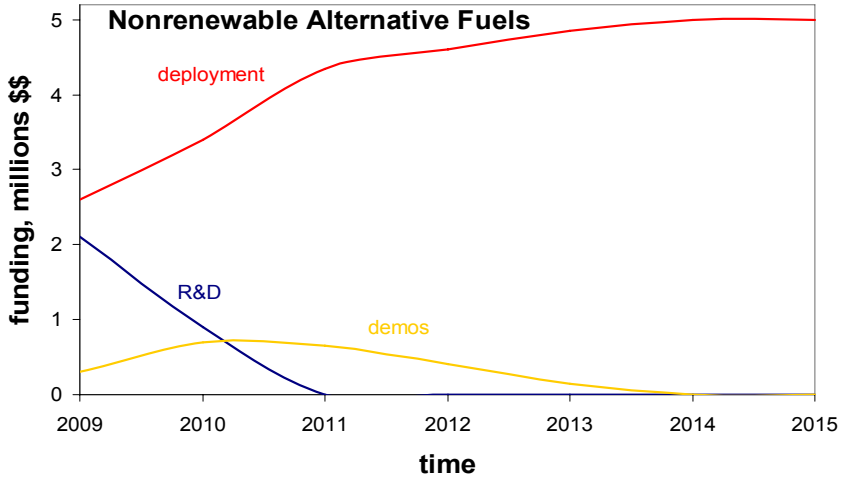
Light-duty + Heavy-duty **Buckets**	**Percent Allocation of AB 118 Funds**	
	Unconstrained	**Constrained**
Improved vehicle efficiency	21%	**25%**
Blended biofuels	22%	**16%**
Nonrenewable alternative fuels	17%	**5%**
Advanced vehicle technologies	40%	**54%**
Total	100%	**100%**

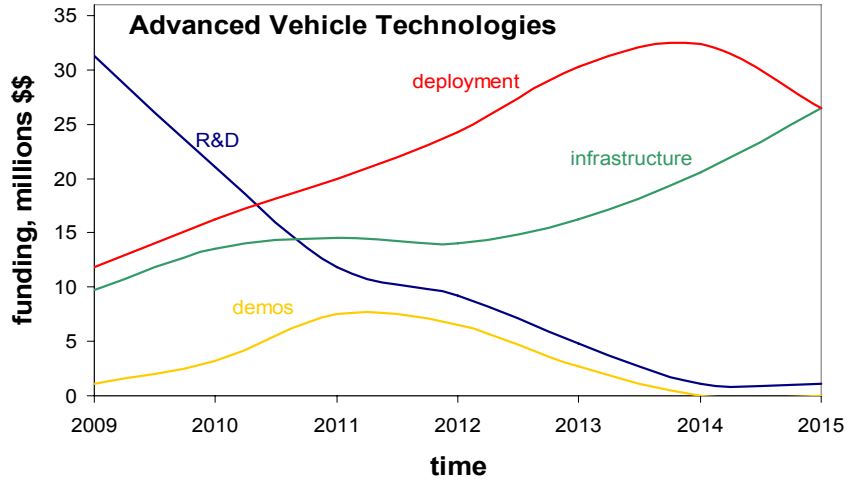
Advanced technologies include on and off road, electric drive applications and include vehicle technologies such as battery electric, plug-in hybrids, and hydrogen fuel cells

Technology Buckets: Assuming $100M invested annually









Gap Analysis: The Energy Commission will need to review existing publicly or privately funded programs to avoid doubling current efforts

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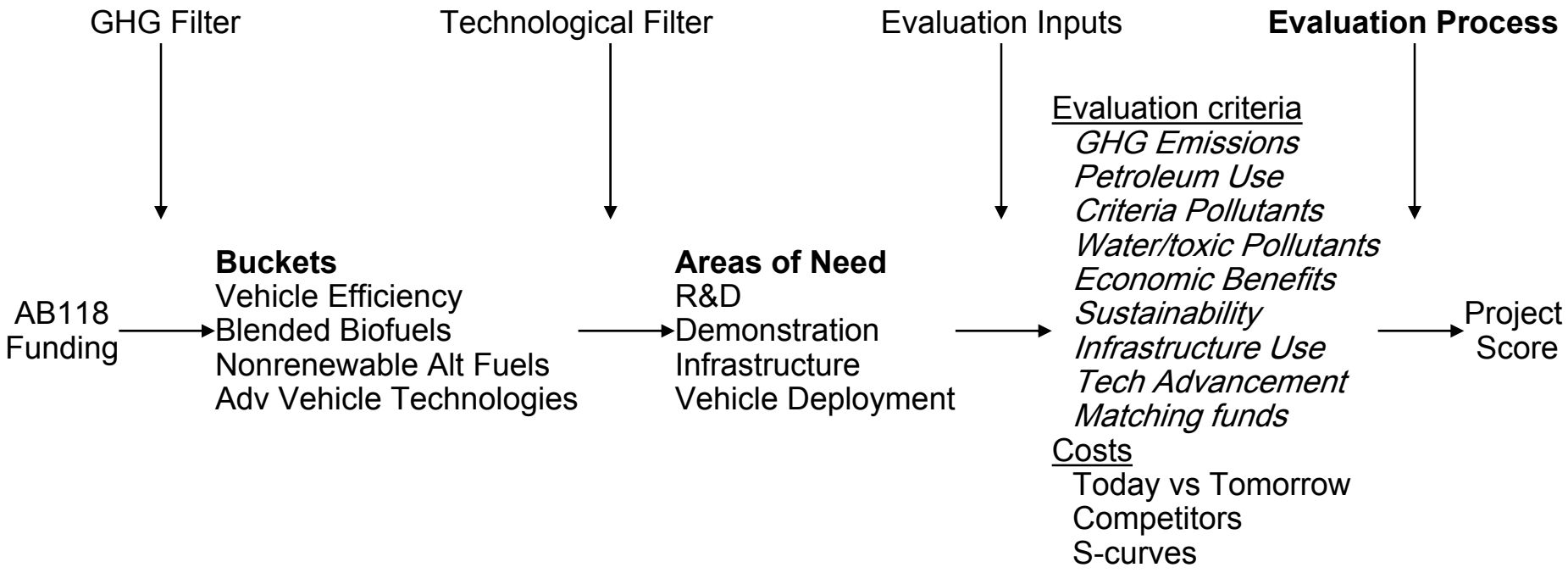
Evaluation Criteria and the Evaluation Process



AB118 legislation lists **evaluation criteria**, but what is the **process**?

Developing a Portfolio Approach

Evaluation Criteria
GHG Emissions
Petroleum Use
Criteria Pollutants
Water/Toxic Pollutants
Economic Benefits
Sustainability
Infrastructure Use
Tech Advancement
Matching Funds
20% Alt Fuel Blend

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Cost-Benefit Analysis Methodology

Baseline + Assumptions

1 Business Case (100 pts)
Identify competition
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Cost relative to:
- Competitors
- Price of oil

Probability of Commercialization

2 Benefits (100 pts)
GHG Reductions
Petroleum Displacement
Criteria Pollutant Reductions
Water/Toxic Pollutant Reductions
Economic Benefits to CA
Sustainability

Inputs → **Evaluation Process** → **Scored Output**

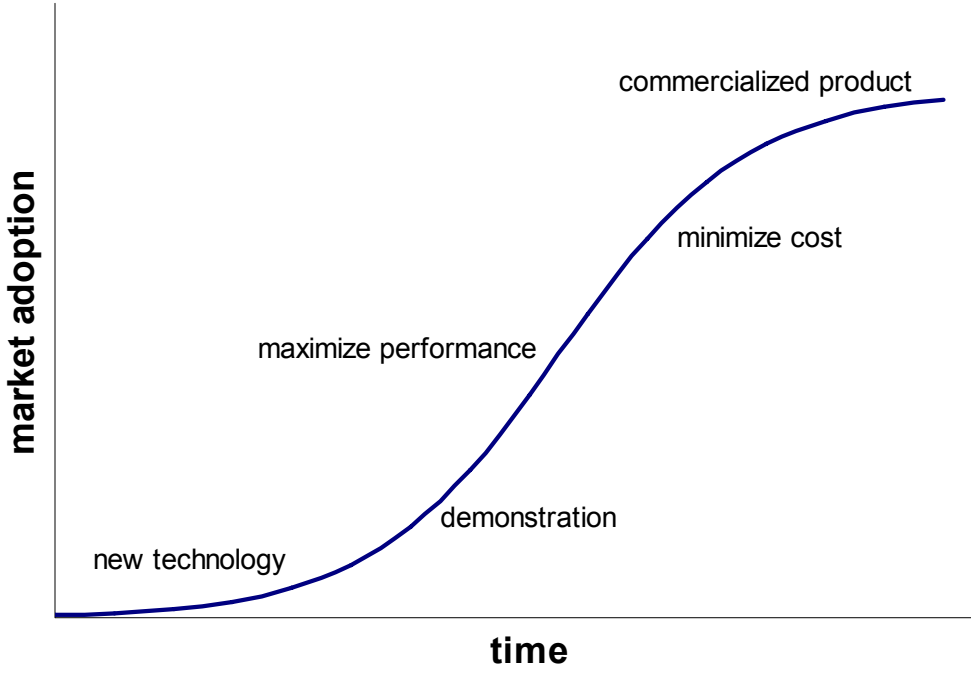
Developing a Portfolio Approach for Evaluation

- Consider the evaluation criteria as **inputs** for the evaluation process
- Consider the assumptions made by applicant regarding an **integrated system**, as opposed to a singular component.
  Example: A battery technology is evaluated based on the attributes of the entire vehicle system and assumptions regarding market penetration
- Consider the cost of the integrated system, not just the component:
  cost today vs commercial cost (tomorrow)
- Perform **gap analysis** to ensure efforts are not being doubled
- Assess the **probability of achieving cost reductions** (today vs tomorrow)
- Assess the **probability of achieving the metrics** determined in the evaluation criteria inputs
- Compare GHG reduction potential of appropriate sectors
  light-duty vs heavy-duty; on-road vs off-road
- Consider **positive and negative attributes** in the application, including, but not limited to: vehicle range, acceleration, storage, etc.
- Compile information to **determine risk of investment** and weight the scoring appropriately

The Business Case (100 points)

The applicant should have a business case that includes:

- Plan to accelerate commercialization
- Financial solubility
- Competitive costing, f(time, volume)
  - Relative to baseline: oil
  - Relative to threats
- Anticipated market penetration
  - f(time, volume, cost)
- Enabling technologies
- The probability of success:
  - Consumer acceptance
  - Cost reductions
  - Environmental performance metrics



Scoring the Benefits: 10 Criteria in Legislation

Evaluation Criteria	Point Allocation
GHG Reductions (WTW)	30
Petroleum Displacement (WTW)	15
Criteria Pollutant Reductions (WTW)	15
Water/Toxic Pollutant Reductions (WTW) Economic Benefits to California Sustainability Matching Funds Existing/Proposed Fueling Infrastructure 20% Alternative Fuel Blend* Technology Advancement	40
Total	100

* We assume the 20% alternative fuel blend criterion is unique to the blended biofuels bucket

- GHG Reductions given highest priority, followed by petroleum displacement and criteria pollutant reductions
- Remaining 40 points should be more-or-less equally divided amongst remaining criteria (5-7 pts)