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Ref: CEC Contract 600-04-025 Work Authorization #7

Memorandum

Date: September 9, 2008
To: Gerry Bemis, CEC

From: Michael D. Jackson, Matt Kromer, and Stephen Lasher
Phone: 408 517-1560

Subject: Gap Analysis for AB 118
Re: CEC Contract #600-04-025 (TIAX), WORK AUTHORIZATION NUMBER: 7

In 2007, the California Legislature passed and Governor Schwarzenegger signed AB118 which established the "Alternative and Renewable Fuel and Vehicle Technology Program". This program is administered by the California Energy Commission. The program will provide up to $120 million annually for 7.5 years to accelerate advanced vehicle technologies into the market place. These advance technologies will reduce greenhouse gas (GHG) emissions and displace petroleum use. These technologies also have the potential to substantially reduce criteria pollutants throughout the full fuel cycle. The purpose of this assignment was to estimate investment committed to developing advanced vehicle technologies and to identify funding gaps in the investment landscape.

Current annual investments in advanced vehicle technologies are shown in Figure 1. Investments include U.S. federal and state government funding as well as private investments (venture capital, equity, asset financing, and corporate research and development)[1]. We estimate that over $35 billion is spent annually on electric drive, hydrogen fuel cells, improved vehicle efficiency, biofuels, and natural gas and propane technologies. The majority of the investment is focused on biofuels, which is primarily driven by the Renewable Fuels Standard (RFS) [EISA 2007]. The RFS requires up to 15 billion gallons of corn derived ethanol and 21 billion gallons of cellulosic ethanol by 2022. The RFS, along with high prices for petroleum derived fuels (e.g., gasoline, diesel), has driven considerable investment in the production of ethanol from corn and in research and development (R&D) and demonstration of ethanol and other biofuels from cellulosic feedstocks.

Natural gas and propane receive the lowest investments. This is a result of very limited end-use product being offered to the market place. There is only one automaker

[1] Private sector investment data represent global estimates, while public sector data are constrained to the U.S. Also note that federal funding data includes incentives. Incentives, which include tax credits, are somewhat different from direct funding as they are forgone revenues instead of actual spending.

producing a CNG light duty vehicle (Honda) and only one heavy duty engine manufacture providing natural gas or propane engines (Cummins Westport). No automakers are providing propane or LPG for the light duty sector—these vehicles are current upfitted from gasoline vehicles. Both fuels have incentives for vehicle purchases and a $0.50 per gasoline gallon equivalent fuel credit. These incentives encourage the use of these fuels but are not utilized at the same level as biofuels.

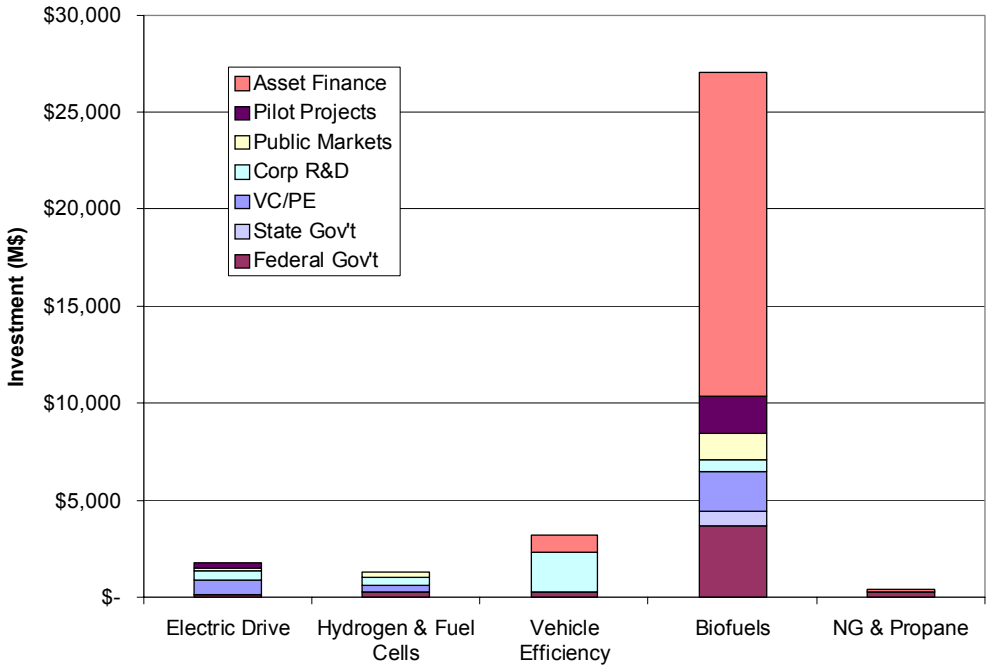


Figure 1. Total Estimated Annual Investment in Advanced Vehicle Technologies

Improving vehicle efficiency is mostly funded by the automakers and engine manufacturers as part of their normal product improvement, although both receive public funding as well. Proposed CAFE standards will require the automakers to invest heavily in advanced conventional technologies to improve fuel economy. These investments will also help to reduce the GHG and criteria pollutant emissions, but further reductions will be necessary beyond what is possible through improvements in conventional technologies alone.

Electric drive technologies, which include battery electric vehicles and plug-in hybrid vehicles (PHEVs), and hydrogen fuel cell vehicles offer considerable reductions in GHG and criteria pollution emissions and substantial displacement of petroleum. Some combination of these technologies will be required in the future to meet the aggressive reduction goals for GHG emissions. Current public and private investments are focusing on R&D and early stage investments (i.e., venture capital [VC], private equity [PE] and

pilot projects) as shown on Figures 1 and 3. The estimated investment in electric drive technologies is $2 billion per year, and that for hydrogen and fuel cells is about $1.2 billion per year. Currently, federal funding is higher for hydrogen and fuel cells than electric drive technologies. Hydrogen fuel cell vehicles are being demonstrated in small numbers with automakers ready to increase the number of vehicles, but this will require additional investment in limited/targeted hydrogen fueling infrastructure to support these limited production vehicles.

PHEVs or range extended electric vehicles are just being developed by the major automakers[2]. No large-scale, coordinated demonstration of these technologies has yet occurred. Current investments are focused on the batteries for these vehicles as well as for "pure" battery electric vehicles. Several automakers are currently developing PHEVs and are committed to demonstrating and ultimately selling these vehicles in the near future. Automakers are developing different vehicle architectures and it is yet to be determined how these differing designs will be accepted in the market place.

Based on our analysis of the current funding landscape and our understanding of the status of the advanced vehicle technologies, we offer the following observations:

Biofuels Considerable money is already being invested and it is not clear that additional funding will accelerate commercialization, especially Generation I biofuels (e.g., starch based ethanol). Nevertheless, a key California objective is to produce biofuels in-state. So, it is recommended that some portion of the AB118 funding be invested in California-based biofuels production. Funding could also be used to support high-blend (e.g., E30+, B20+) biofuel infrastructure and end-use.

Natural Gas and Propane A major funding issue facing these technologies is product development for the light duty and heavy duty vehicle markets. AB118 funding could be used to help bring more products to the market place, including continued incentives for deployment of infrastructure and fleet vehicles. Funds could also be used to develop and demonstrate advanced Gas-to-Liquids technologies if GHG emissions are low enough.

Improved Vehicle Efficiency Most of the investments in theses technologies are being made by the auto industries. Public funding is also helping the industries, but more work could be performed on concepts to reduce vehicle weight, improve aerodynamics, and other approaches to improve vehicle fuel economy, especially for heavy duty vehicles (e.g., bottoming cycles, auxiliary power units).

[2] However, a number of PHEV retrofits, including bolt-on modifications to the Toyota Prius, have been conducted by individual vehicle owners and some state/local funding agencies.

Hydrogen and Fuel Cells U.S. federal and state governments have made substantial investments in this technology with the hope that the vehicles will be accepted in the market place. These zero tailpipe emissions vehicles will provide significant GHG and petroleum reductions. Automakers are at the verge of introducing limit vehicles but fuel infrastructure will be needed to support these vehicles. At these limited vehicle volumes the infrastructure investments will not be economical and therefore public funding is necessary. AB118 funding could be used to provide this infrastructure in limited areas where vehicles are likely to be demonstrated and sold.

Plug-in Hybrids and Battery Electric Vehicles Considerable investments are being made in battery technologies for these vehicles, but substantial work is necessary to "prove" these vehicles in the market place. Will smart meters be necessary to encourage night charging? What is the impact on the electric grid? Will the vehicle architectures incorporate large enough batteries to gain the GHG benefits of California's clean grid? Large scale demonstrations of varying vehicle types and architectures will be need to better understand their impacts and value proposition in a carbon constrained world.

Introduction

The objective of this work assignment was to identify funding that is committed or is already being spent on the development and commercialization of cleaner, more efficient technologies for the transportation sector. As used here the transportation sector includes on and off road applications, except for aircraft.

During the process of developing California's Alternative Fuels Plan [CEC 2007], industry working group meetings were held with representatives from the fuel and vehicle industries. The purpose of these meetings was to determine the barriers to commercialization of alternative fuels and advanced vehicle technologies and what is needed to overcome these barriers. Stakeholders were also asked what funding would be needed to bring these technologies to the market place. Much of this work was summarized for each affected industry in the draft storylines [Jackson 2007]. Also, some work was completed to account for other government funding available for developing these advanced transportation systems. For example, TIAX estimated the amount of funding the federal government was providing to the hydrogen and fuel cell program.

The outcome of the analysis performed as part of the Alternative Fuel Plan was a first look at the investments made in research and development (R&D), demonstrations, fuel production, infrastructure, and incentives. The implementation of AB118 requires an update and extension of the previous analysis. This information will help the Energy Commission continue to develop an investment plan for the Alternative and Renewable

Fuel and Vehicle Technology Program (AB118). This plan needs to consider on-going investment in fuels and vehicle technologies so that the plan does not duplicate existing efforts. Just as important, however, the plan needs to build upon and leverage existing investments to maximize market commercialization and environmental benefits.

Methodology

TIAX reviewed the AB1007 storylines and developed spreadsheets/matrices that summarize the prior findings related to the types of funding and funding sources for each alternative fuel or advanced vehicle technology. A quick literature review was performed to supplement and update the previous information and data. We focused on funding and investments made by the federal government, individual states, and private industry into developing the following vehicle technologies: electric drive (including battery electric vehicles, plug in hybrid vehicles, and enabling technologies such as batteries and motors), hydrogen and fuel cells, improved vehicle efficiency (conventional hybrids, diesel, weight reduction, and aerodynamics), biofuels, and natural gas and propane. We broke down the funding and investments into the following categories: R&D, Demonstration, Infrastructure (fuel production, storage, distribution, and dispensing), and Incentives or Commercialization (Deployment). The results of this effort were summarized in tables and figures.

We also contacted key government and industry stakeholders to confirm our estimates of funding/investments. As part of this effort we also asked the stakeholders to provide their perspective on the barriers and needs to overcome these barriers. Each stakeholder was also asked to identify—from their perspective—the best use of the AB118 funding to accelerate the introduction of advanced transportation technologies into the market place.

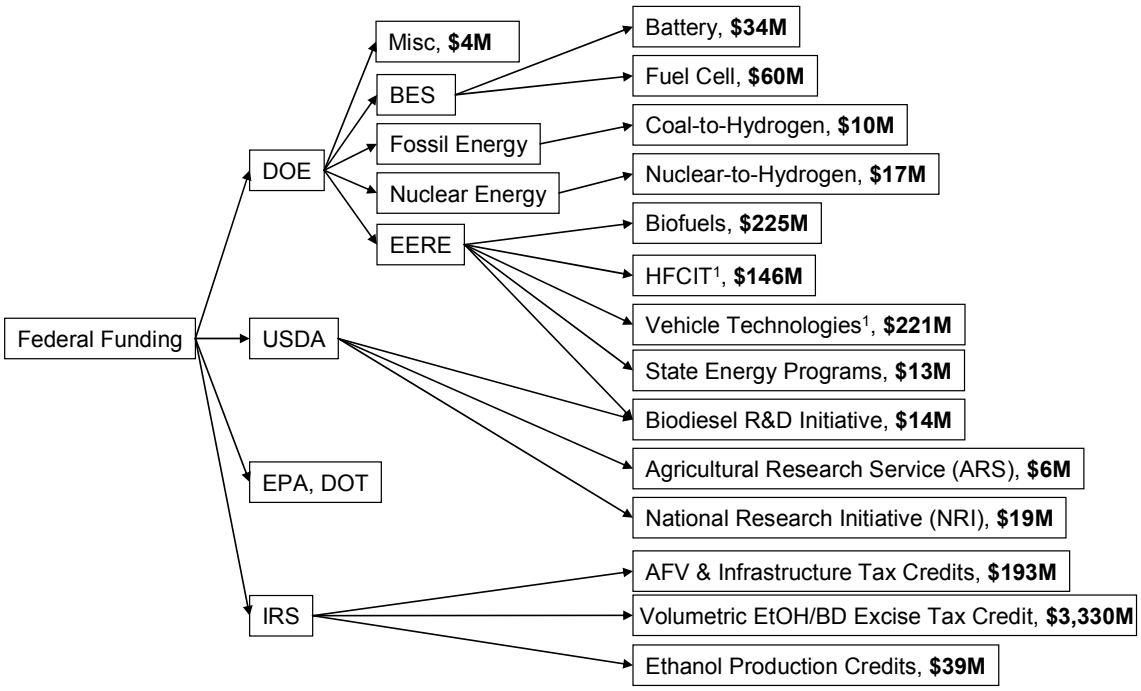
The data collection efforts where summarized in a PowerPoint presentation report and high-level conclusions were presented at the AB 118 Investment Plan Workshop held on September 2, 2008. See attached presentation/reports.

Results

Federal investment was determined for fiscal year 2009 from requested agency funding documents[3] as well as credits that we project will be given by the IRS based on the current tax code[4]. The FY2009 budgets have not been appropriated yet by Congress and probably will not be appropriated until after the presidential election. However, the 2009

[3] DOE-EERE 2008, DOE-BES 2008, USDA 2008, CBO 2008, Holtz-Eakin 2005, Yacobucci 2008
[4] Incentives, which include tax credits, are somewhat different from direct funding as they are forgone revenues instead of actual spending.

requested funding is reasonably consistent with prior funding levels authorized by Congress. Figure 2 shows the agencies and their projected funding and credits for FY 2009.



[1] A portion of the DOE hydrogen budget is included in the Vehicle Technologies budget.

Figure 2. Federal Agencies Projected FY2009 Funding and Credits

Allocating these budgets to the various vehicle technologies and the various funding activities, gives the results shown in Figure 3. As illustrated, current federal investment for biofuels far exceeds the other categories with an estimated $3.7 billion to be spent in FY2009. Most of this is due the $0.51/gallon ethanol production credit. Incentives are also in place to accelerate commercialization of improved vehicle efficiency technologies (e.g., hybrids and diesels) and natural gas and propane. Although incentives are authorized should vehicles come to market, it is anticipated that incentive payouts for electric drive or hydrogen and fuel cell technologies will be minimal due to lack of commercial product offerings. Similar levels of R&D and demonstration ("demo") funding is planned for electric drive, hydrogen and fuel cells, vehicle efficiency, and biofuels – ranging from $90M (vehicle efficiency) to $340M (biofuels). Little or no R&D, demo, or infrastructure funding is planned for natural gas or propane technologies.

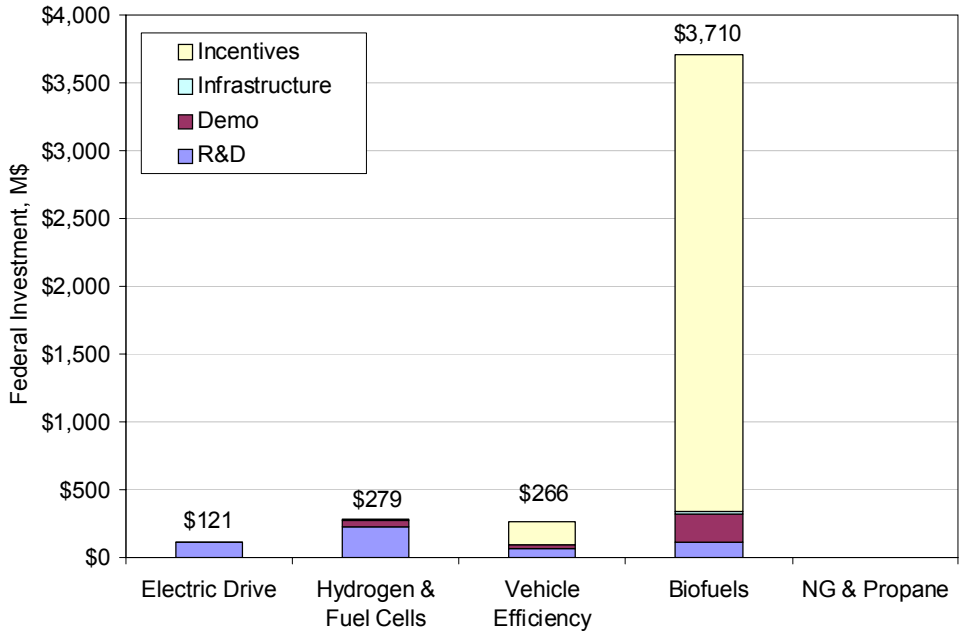


Figure 3. Estimated Annual Federal Investment in Advanced Vehicle Technologies

We reviewed state programs that funded or provided incentives to emerging vehicle technologies. Rather than perform a detailed study of each state's energy programs, we estimated the spending/budgets based on the number of programs that states are undertaking. We found that the state programs tend to focus on biofuel production or infrastructure tax credits, alterative fuel tax credits, and limited R&D. Tax incentives mirror those of the federal government so we scaled these based on the average size of the investment and the number of states with similar programs. We did a fairly detail study of California's transportation energy R&D programs and used this assessment as a proxy for the rest of the country. It was assumed that California's R&D, deployment and infrastructure budgets is 20% of the rest of the states. Figure 4 shows the results of this analysis.

As shown, our estimates of state investments for advanced technologies are very similar in emphasis to the federal government, with most of the investment directed towards incentives for biofuels production. However, the state funding tends to focus on incentives, demonstration, and infrastructure compared to the federal government, which focuses on R&D to a greater extent. Not surprising, the level of funding by the states is about 10 times less than the federal budgets.

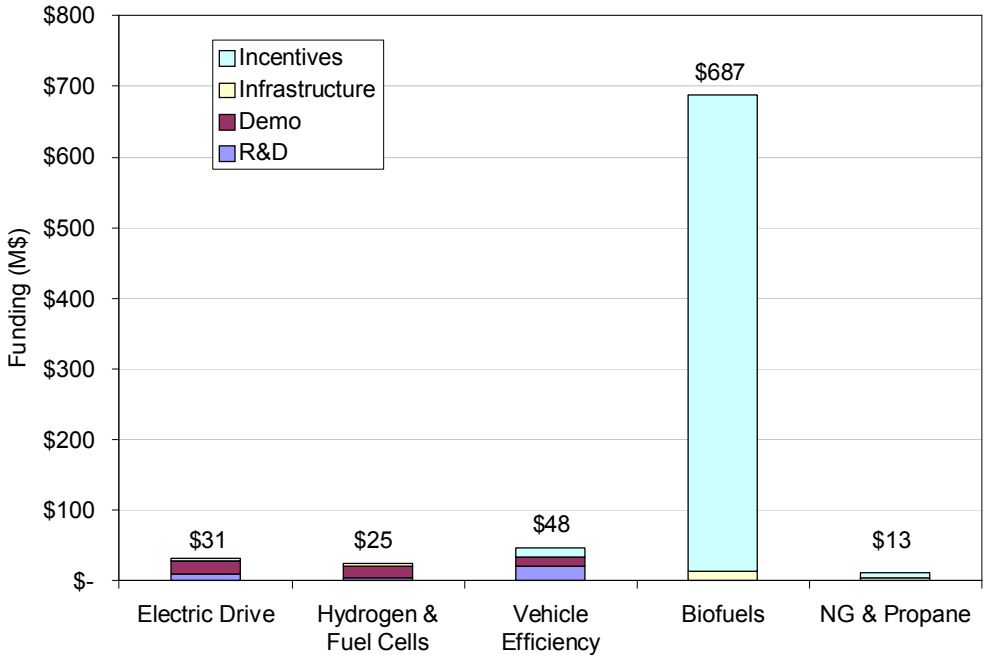


Figure 4. Estimated Annual State Investment in Advanced Vehicle Technologies

The private sector investment was estimated from "Global Trends in Sustainable Energy Investment 2008" [Boyle 2008]. This report was prepared by the Sustainable Energy Finance Initiative (SEFI) and is the result of collaboration between the United Nations Environment Program and New Energy Finance (an energy investment research firm). This report offers detailed estimates of investments at different stages of the commercial pipeline from emerging technologies to those sold into the market place. Several technologies are identified in this report: biofuels, fuel cells, and energy storage. The report also provides detailed estimates of global investment in venture capital (VC) and private equity (PE), public markets, asset finance, and merger and acquisitions. Merger and acquisitions estimates were not used in this study as they do not represent "new" investment in clean energy, but rather transfer of ownership.

The SEFI report provides estimates of global private sector R&D investments in clean energy, but does not segment this estimate into investment by individual technology. Also, on-going R&D—like automakers investment in higher efficiency vehicles—is likely not captured in the report.

To supplement the SEFI data, we used several other reports. Both the National Science Foundation (NSF) [NSF 2008] and the National Institute of Standards and Technology (NIST) [Auerswald 2005] track statistics on R&D. Based on these three reports and

limited research on the size of the fuel cell, battery, and biofuels industries[5] we made estimates of the VC investment.

We made several key assumptions to estimate private investments for each technology category. For corporate R&D, we used the NIST and NSF reports to estimate that about 10% of the total private R&D budget is directed towards improving vehicle efficiency. For emerging technologies, we used the results of the SEFI report for VC funding and compared this to the federal R&D requests. Corporate R&D was estimated based on averaging the contribution of VC investment to total investment and federal investment to total investment. The results are shown in Table 1.

Table 1. Estimated Annual Private R&D Funding for Advanced Vehicle Technologies ($ Millions)

	Estimates from the Literature			Corporate R&D Estimates				
Technology	VC Funding[1]	Federal R&D[2]	Corporate R&D[1]	Using VC sectoral ratio		Using Corp:Fed R&D Ratio		Avg (VC & Fed)
				% of Total	Est.	Ratio	Est.	
Biofuels	$298	$323	?	8.1%	$789	1.38	$446	$618
Fuel Cells	$164	$298	?	4.4%	$434	1.38	$412	$423
Batteries & Motors	$300	$104	?	8.1%	$795	1.38	$143	$469
Total (Global, ALL Clean Energy Sectors)	$3,700	$7,100	$9,800					

Figure 5 shows our estimate of the private sector investment for the various technologies by R&D, demonstration, infrastructure, and commercialization. Again, we see that biofuels dominate the investment landscape by about a factor of 10 or more than any of the other technologies. This is driven mostly by the private investment in Generation I (starch based) biofuel production facilities. R&D and demonstration are focused on Generation II cellulosic biofuels.

[5] PWC 2008, Makower 2008, RFA 2008

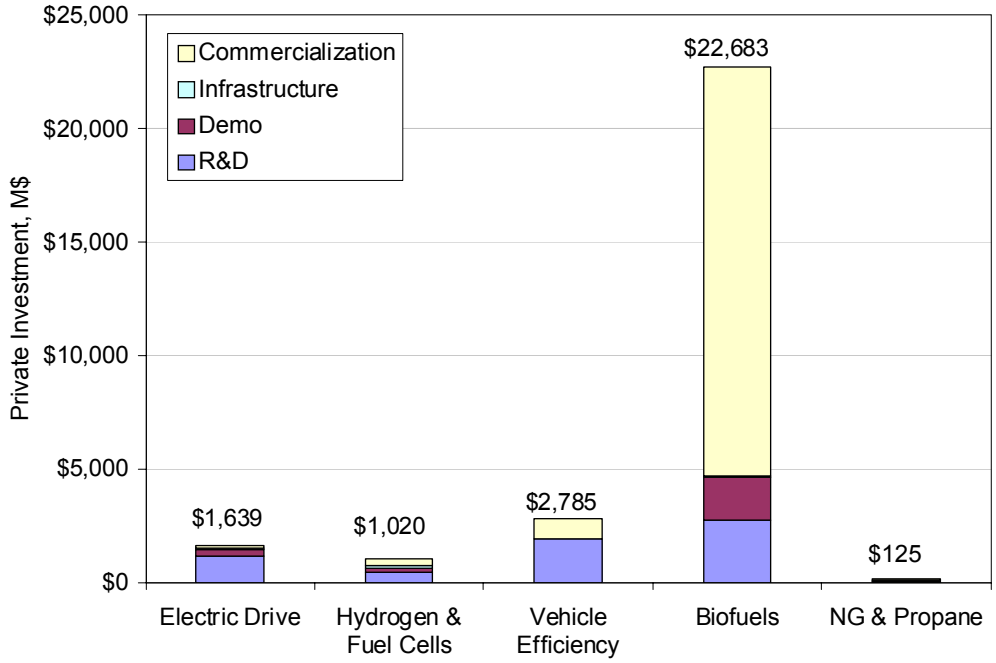


Figure 5. Estimated Annual Private Investment in Advanced Vehicle Technologies

Finally we reviewed the results of our literature review and investment estimates with several stakeholders. Table 2 shows the individuals we spoke to during this review. Generally, the stakeholders agreed that the estimates look reasonable, although they mostly focused on their respective budgets or knowledge of the industry.

We also asked the stakeholders for their perspective on how additional funding provided by AB118 should be invested. Overall the stakeholder emphasized helping the emerging technologies get through the transition period from R&D to a commercial product. Most see this as a major barrier to advanced vehicle commercialization. They support getting vehicle and fuel infrastructure technologies into the market place by providing funding for demonstrations, tax incentives, and streamlining permitting and licensing. This funding could be used to create an "early mover" advantage to manufacturers and suppliers introducing new vehicle and fuel technologies. Other key points emphasized for state funding were:

- Fund multiple technologies to hedge bets and recognize technologies are not mutually exclusive
- Focus funding on deployment rather than basic R&D for most technologies
- Collaborate with national partnerships, OEMs, and the federal government on planning, testing, codes and standards, and vehicle and infrastructure demonstrations

Table 2. List of Stakeholders Contacted

DOE EERE

- Vehicle Technologies Program
  - Patrick Davis; Acting Program Manager
  - Phil Patterson, Chief Analyst
  - Rogelio Sullivan, Hybrids and Materials Team Leader
- Office of Hydrogen, Fuel Cells, and Infrastructure Technologies
  - Sunita Satyapal; Acting Program Manager / Hydrogen Storage Team Lead
  - Fred Joseck; Systems Analysis Team Lead
- Office of the Biomass Program
  - Valri Lightner; Strategic Planning, DFO / Integrated BioRefinery Team Lead
  - Valerie Reed, PhD; Conversion Technologies / Outreach Platforms Team Lead

National Labs

- National Renewable Energy Laboratory
  - Dale Gardner; Renewable Fuels Science and Technology Director
- National Energy Technology Laboratory
  - Geo Richards; Focus Area Leader for Energy System Dynamics

USDA

- Rural Development
  - Mike Kossey; Special Assistant to the Administrator of the USDA's Utilities Program

Other Organizations

- Chevron Technology Ventures LLC
  - Puneet Verma; Biofuels and Hydrogen Program Manager
- Southern California Edison
  - Dean Taylor; Electric Transportation
- Great Plains Institute
  - Rolf Nordstrom; Executive Director
- American Council on Renewable Energy (ACORE)
  - Bill Holmberg; Chairman of the Biomass Coordinating Council
- American Honda Motors
  - Ben Knight, Vice President North America Research & Development

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Attachments

1. Jackson, M, L. Waterland, S. Lasher, B. Wilson, M. Kromer, and W. Bockholt "Status of Gap Analysis for AB 118". TIAX presentation to the CEC Workshop on Developing AB118 Investment Plan. September 2, 2008.
2. Jackson, M, L. Waterland, S. Lasher, B. Wilson, M. Kromer, and W. Bockholt "Gap Analysis for AB 118 – Identification of Funding Gaps to Commercialized Cleaner, More Efficient Transportation Technologies". TIAX PowerPoint Report. August 29, 2008.