March 25, 2008

Ms. Mary Nichols and Board Members
Mr. James Goldstene, Executive Officer
California Air Resources Board
1001 I Street
Sacramento, CA 95814

Re: A New Vision for California's Zero Emission Vehicles Program: An analysis of the impact of the ZEV program on California's long term global warming pollution goals

Dear Ms. Nichols, Mr. Goldstene and Board Members:

Union of Concerned Scientists (UCS), Natural Resources Defense Council, Friends of the Earth, Center for Energy Efficiency and Renewable Technologies, American Lung Association of California, Coalition for Clean Air, and Energy Independence Now are pleased to submit the following report which shows that the state of California must have 379,000 fuel cell or battery electric vehicles on the road in twelve years to reach the numbers of pure-zero emission vehicles necessary to achieve the state's global warming goals in 2050. To realize the state's goals, we recommend that the ARB Staff create a New Vision for the ZEV Program which places the program on the road to a major role in meeting California's long term global warming, air quality, and petroleum reduction goals.

Sincerely,

Spencer Quong
Union of Concerned Scientists

Bonnie Holms-Gen
American Lung Association

Luke Tonachel
Natural Resources Defense Council

Danielle Fugere
Friends of the Earth

Tim Carmichael
Coalition for Clean Air

Daniel Emmett
Energy Independence Now

John Shears
Center for Energy Efficiency and Renewable Technologies

A New Vision for California's Zero Emission Vehicles Program:

An analysis of the impact of the Zero Emission Vehicle Program on California's long term global warming pollution goals

Union of Concerned Scientists
March 2008

Executive Summary

From reduced Sierra snowpack to increased risk of wildfires, there is overwhelming evidence that global warming emissions will impact all of California. To meet this threat, California has set a long term goal of reducing global warming emissions to 80% below 1990 levels by 2050. This study examines the growth of battery electric (BEV) and fuel cell vehicles (FCV), in the near and long term, necessary to meet these global warming pollution targets.

To achieve California's 2050 global warming emission goals, a study by the California Energy Commission (CEC) and the Air Resources Board (ARB) found that 2.5 billion gallons of gasoline must be displaced by zero tailpipe emission fuels, such as hydrogen or electricity. Using this fuel displacement target, the Union of Concerned Scientists (UCS) estimated that hundreds of thousands of pure-ZEV must be on the road by 2020.

Specifically, under a middle scenario, California must have 379,000 pure-ZEVs on the road in twelve years to achieve its 2050 global warming objectives.

Unfortunately, the ARB staff proposal to dramatically reduce the number of pure-ZEVs required between 2012-2014, from 25,000 to just 2,500 vehicles, does not put the state on a path to meet its long term global warming goals.

Furthermore, the large reduction in pure-ZEVs sends strong signals to battery and fuel cell suppliers, along with infrastructure providers, not to invest in ZEV technologies. We show that, by decreasing the number of pure-ZEV vehicles in Phase III (2012-2014) by 90%,

the ARB Staff proposal reduces fuel cell and battery component supplier revenue by 68-135 million dollars, and hydrogen fueling and charging infrastructure by up to 163 million dollars. This reduces resources toward getting pure-ZEVs on the road by a factor of 10.

This drastic reduction in supplier and infrastructure investment will affect business decisions in the private sector and delay the investment necessary to move pure-ZEVs to the commercial level.

We recommend that the ARB begin a bold *New Vision* for the ZEV program that puts the state on the road to meet the target of at least 379,000 pure ZEV vehicles in 2020 and, eventually, to achieve California's long term global warming pollution and air quality goals.

The New Vision should increase investment in pure ZEV technology and equipment, simplify and streamline the requirements, and narrow the focus of the program. The new program should not only increase the number of pure-ZEVs on the road, but also restructure the program to determine how the ZEV program can work with other state programs, such as the Low Emission Vehicle and Greenhouse Gas Vehicle regulations to meet California's long term environmental goals.

Introduction

Scientists overwhelmingly agree that in order to prevent the most devastating consequences of global warming, such as a 90% loss of California's Sierra snowpack, global warming emissions worldwide must be significantly reduced. Many scientists agree that reductions for industrialized nations must be on the order of 80% by mid-century. In response to this warning from the scientific community, the state of California has shown national and international leadership in committing to reduce its global warming emissions to 2000 levels by 2010 (11% below business as usual), to 1990 levels by 2020 (25% below business as usual), and 80% below 1990 levels by 2050.

California's ZEV program has to balance the needs of California's environment with the availability of technology. In the recent Initial Statement of Reasons (ISOR), ARB Staff argues that lowering the number of pure-ZEVs is justified because of the state of fuel cell (FCV) and battery electric vehicle (BEV) technologies.[1] Good policy recognizes the shifting technological landscape, but the recent ISOR puts the brakes on ZEV development just when the state should be committing to a path that will achieve California's long term climate goals. ARB's proposal will not put California on a trajectory towards achieving the state's long-term goal of reducing greenhouse gas (GHG) emissions to 80% below 1990 levels by 2050. This analysis calculates the number of pure ZEVs necessary in the future to meet California's global warming goals. It also highlights the effect of the changes proposed by ARB Staff on ZEV supplier and infrastructure investment.

Approach

The California Energy Commission (CEC) and Air Resources Board (ARB) created the State Alternative Fuels Plan which "assessed various alternative fuels and developed fuel portfolios to meet California's goals to reduce petroleum consumption, increase alternative fuels use, reduce greenhouse gas emissions…"[2]

To meet these long term goals the State Alternative Fuels plan created a 2050 Vision that showed that California's entire transportation system must undergo a transformation. This included replacing gasoline with cleaner fuels; increasing vehicle efficiency; reducing demand; and the increasing use of zero emission technologies. We use the 2050 Vision to show how the development of pure-ZEV technologies must begin today to meet California's GHG goals. Our study does not distinguish between the two main pure-ZEV technologies fuel cell and full battery electric vehicles.

Analysis

The 2050 Vision in the State Alternative Fuels Plan is clear that electricity and hydrogen must play a role in the future of clean transportation. Among the many recommendations to achieve

[1] California Air Resources Board. 2008. *Staff Report: Initial Statement of Reasons 2008 Proposed Amendments to the California Zero Emission Vehicle Program Regulations.* Sacramento, CA. February.

[2] California Energy Commission and California Air Resources Board. 2007. *State Alternative Fuels Plan CEC-600-2007-011-CMF*. Sacramento, CA. December.

California's global warming goals, the 2050 Vision proposes having 28 million plug-in hybrid (PHEV), electric, and fuel cell vehicles that displace 2.5 billion gasoline gallons equivalent (GGE) with hydrogen (H2) and electricity. Some of the other estimates included in the 2050 Vision are shown in Table 1.

	State Alternative Fuels Plan 2050 Vision
Fuel Cell and Plug-in Hybrid Electric Vehicles	28 million
Total Number of Vehicles	39 million
Electricity and Hydrogen Consumed (GGE)	~2.5 billion
Annual Vehicle Miles Traveled	450 billion
Real World Average Miles per Gallon (MPG)	70

Table 1: State Alternative Fuel Plan 2050 Vision

The 2050 Vision does not discriminate between the pure-ZEV technologies and others, such as PHEV and off-road electric vehicles. Therefore, we examined three possible scenarios where 25, 50, and 75 percent of the electricity and hydrogen is consumed by pure-ZEVs (FCV and BEV). We assume that the remaining electricity and hydrogen is consumed by PHEVs and in other parts of the transportation sector.

By starting with the 2.5 billion GGE displaced by hydrogen and electricity in 2050, we were able to calculate the number of pure-ZEVs which needed to be on the road in 2020. The compound annual growth rate from 2020 to 2050 is set at 10.5%, based on two hydrogen-based examples evaluated as part of the State Alternative Fuels Plan.

	Middle	**Aggressive**	**Mild**
% Electricity/H2 consumed by pure-ZEV	**50%**	**75%**	**25%**
Electricity and Hydrogen Consumed (GGE)	1.25 billion	1.88 billion	0.63 billion
2050 Pure-ZEV Vehicles on the road	7.6 million	11.4 million	3.8 million
2020 Pure-ZEV Vehicles on the road	**379,000**	**569,000**	**190,000**

Table 2: UCS Estimated Number of Pure-ZEV required in 2050 and 2020 under three different scenarios.

Our findings, summarized in Table 2, show that, millions of pure-ZEV vehicles need to be on California's roads in 2050. In the middle scenario, 7.6 million pure-ZEV vehicles which constitute 19% of California's fleet in 2050 will displace 1.25 billion GGE of gasoline. Because the market and infrastructure for these vehicles will not appear over night, we must begin to place a significant number of pure-ZEVs on the road in the near term.

Specifically, under the Middle Scenario the state must place 379,000 fuel cell and battery electric vehicles on the road in twelve years.

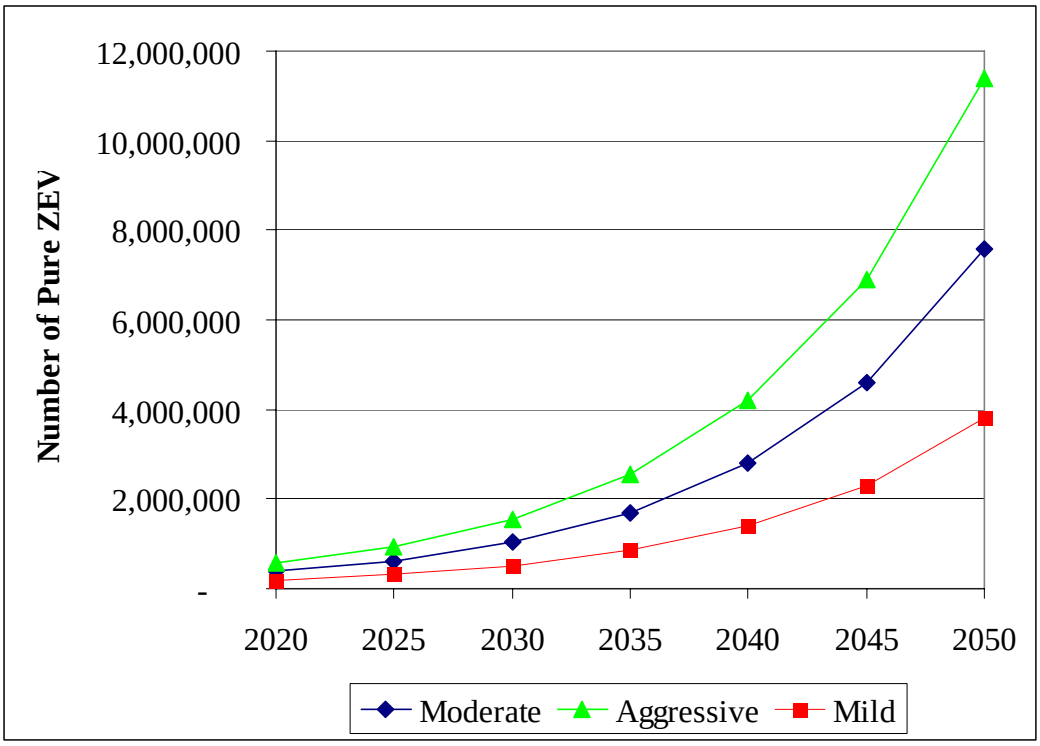

Figure 1: UCS Estimated Growth rate of Pure-ZEV under Three Different Scenarios

Infrastructure and Supplier Base

The car companies have argued that large numbers of pure-ZEVs are not necessary to ensure progress toward commercialization, but they ignore the multiple benefits of increasing the number of these vehicles on the road in the near term. For example, placing larger numbers of pure-ZEVs in the field can be critical to the future commercialization and viability of this technology by helping to adequately prepare consumers, first responders, permit and safety officials, and the general public. Equally important, larger numbers of vehicles will be necessary to support the commercial viability of emerging hydrogen-fueling and battery charging infrastructure and to ensure that there is adequate deployment and use of this infrastructure. Larger vehicle sales are also critical to establishing a supplier base that will allow truly large scale production of pure-ZEVs.

Regardless of technology, both BEV and FCV require significant investment in infrastructure. If the 379,000 pure-ZEV vehicles from the 2020 Middle Scenario above were entirely composed of fuel cell vehicles, it would require an additional 62.5 million gasoline gallon equivalent (GGE) of hydrogen annually or an increase in U.S. hydrogen production by less than 1%.[3] Based upon data from the Hydrogen Highway Blueprint plan, [4] Table 3 shows that reducing the number of Phase III vehicles from 25,000 to 2,500 will decrease the amount of revenue to hydrogen infrastructure suppliers by $163 million.

[3] Current U.S. hydrogen demand is about 9 million tons, or just over 8 billion gallons of gasoline equivalent. U.S. Department of Energy. 2008. *Today's Hydrogen Production Industry.* Available online at http://www.fossil.energy.gov/programs/fuels/hydrogen/currenttechnology.html

[4] California 2010 Hydrogen Highway Network. 2005. *Economy Topic Team Report.* Sacramento, CA. January.

Low Volume Station Construction Cost (40 Vehicles per Station)	$294,000
Mid-Volume Station Construction Cost (80 Vehicles per Station)	$579,600
Decrease in number of hydrogen fueling stations by adopting ISOR Proposal	200
Decrease in revenue for hydrogen infrastructure suppliers by adopting ISOR Proposal[5]	$163 million

Table 3: Decrease in revenue for hydrogen infrastructure suppliers by reduction in pure-ZEV requirement

Also at stake are tens of millions of dollars in lost revenue linked to fuel cell vehicle component suppliers. Using U. S. DOE FreedomCar targets,[6] we estimated that $68 million in revenue is lost by fuel cell stack and hydrogen storage suppliers if the number of fuel cell vehicles is reduced in Phase III from 25,000 to 2,500.

Fuel Cell Stack		**Hydrogen Storage**	
Stack Power per Vehicle	100 kW	Storage per Vehicle	5 kg
DOE 2015 Cost Target	$30/kW	DOE 2015 Cost Target[9]	$6/kg
Stack Cost per Vehicle	$3000	Hydrogen Storage Cost per Vehicle	$2500
Fuel Cell Revenue Lost through ARB Proposal	$67.5 million	Hydrogen Storage Revenue Lost through ARB Proposal	$675,000

Table 4: Revenue lost to fuel vehicle component suppliers based upon DOE Freedom Car targets.

Thus, reducing the Phase III Gold Floor from 25,000 to 2,500 vehicles would eliminate $163 million from potential hydrogen infrastructure suppliers, and $68 million of revenue from potential fuel cell stack and hydrogen storage suppliers.

This loss of income sends a strong signal to the supplier base not to invest in automotive hydrogen technology, putting in jeopardy the practicality of achieving the 379,000 FCVs by 2020. Even if the fuel cell assembly is performed by the automakers, they still must purchase components and materials such as membranes and storage tanks from secondary suppliers.

The potential decrease in pure-ZEVs through the program may already be having an effect on the private sector. In November 2007, Ballard Power Systems sold their automotive fuel cell assets to Ford Motor Company and Daimler AG[7]. Also, in the same month, Hydrogenics Corp., a supplier of hydrogen fueling stations and electrolyzers announced a restructuring which resulted in layoffs[8].

[5] Assumes 313 mid-volume stations replaced by 63 low volume stations
[6] U.S. Department of Energy. 2008. *FreedomCar and Fuel Technical Partnership Technical Goals.* Available online at www1.eere.energy.gov/vehiclesandfuels/about/partnerships/freedomcar/fc_goals.html
[7] Ballard Power Systems. 2007. *Ballard Agrees To Sell Automotive Fuel Cell Assets; Will Concentrate On Commercial Markets.* November 7. Available online at http://www.ballard.com/Investors/News_Releases/
[8] Hydrogenics Corporation. 2007. *Hydrogenics to Streamline Operations and Further Reduce Cost.* November, 21. Available online at http://www.hydrogenics.com/ir_newsdetail.asp?RELEASEID=276571

If only electricity is used to displace gasoline in the Middle Scenario, the battery electric vehicles would consume 2,271 GWh of electricity generation annually, about 1% of California's current total electricity generation or 7% of its renewable portfolio. In the 1990's, approximately 1,000 public charging stations served the needs of 4,000 BEV. Because much of the BEV charging will be done at home or businesses, we assumed that a large expansion of such vehicles would require half the charging stations per vehicle. We then estimated that the state would need to install approximately 47,000 charging stations to support the 379,000 BEV in 2020.

Public Charging Stations per Vehicle	8
Estimated number of charging stations in 2020	47,000

Table 5: Electrical Infrastructure necessary to meet Middle 2020 Vehicle Target

Again considering full BEVs only and using the US Advanced Battery Consortium Goals[9] we estimated that the current ZEV regulations would result in 150 million dollars of revenue to battery suppliers in Phase III.

Energy Storage per Vehicle	40 kWh
Cost of Battery[10]	$150/kWh
Battery pack Costs	$6000
Battery pack Supplier Revenue at 25,000 Vehicles	$150 million
Battery pack Supplier Revenue at 2,500 Vehicles	$15 million

Table 6: Battery pack supplier revenue at different levels of BEV production.

However, the ARB Gold Floor proposal reduces the investment in battery suppliers during Phase III by a factor of ten to $15 million.

This revenue level would make it significantly harder to justify investment in research and manufacturing plants for advanced batteries.

The reduction of the Gold Floor proposed in the ARB ISOR results in an enormous drop in vehicles and revenue for component suppliers. Furthermore, the delay of growth in the pure-ZEVs means that the time to install additional hydrogen and electric production capability along with fueling/charging stations to service 379,000 vehicles by 2020 will be compressed to nine years.

The drastic reduction in the numbers of pure-ZEVs proposed in the ARB ISOR will delay infrastructure development and undermine investment in ZEV technologies. This will dramatically reduce the likelihood of success of pure-ZEV commercialization and the state's greenhouse gas goals.

[9] U.S. Advanced Battery Consortium. 2008. *USABC Goals for Advanced Batteries for EVs.*

New Vision for the ZEV Program

In the seventeen year history of the ZEV program, there have been notable benefits from the program, such as assisting in the development and early market success of "traditional" hybrid vehicles. However, every time the ARB reviews the ZEV regulations, they have consistently delayed the introduction of higher numbers of pure-ZEVs. Given the need to dramatically reduce global warming pollution in the next forty years and the crucial role ZEVs can play, it is time for the ARB to implement a *New Vision* for the ZEV Program.

This *New Vision* would include the following major changes:

- Create a New Vision for the ZEV program which places it on the road to a major role in reaching California's long term global warming, air quality, and petroleum reduction goals, in conjunction with California's other greenhouse gas and air quality regulations.

- Create a near term plan that puts 379,000 pure ZEVs on the road by 2020 while taking into account the need for additional technology development.

- Ensure that any changes to the ZEV program will support research and investment in ZEV technologies and infrastructure.