THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

VEHICLE ELECTRIFICATION POLICY STUDY

Task 4 Report:

COMPLEMENTARY POLICIES

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EXECUTIVE SUMMARY

ICCT's Vehicle Electrification Policy Study seeks to evaluate policies that can achieve motor vehicle emission reductions beyond those attainable with traditional tailpipe pollution standards. The study is focused on "pure" electric vehicles—battery electric vehicles (BEVs), fuel cell electric vehicles (FCEVs), and combinations thereof—and on the efforts of governments to encourage their adoption. The pending modification of the California Zero Emission Vehicle (ZEV) program, due to be considered by the Air Resources Board in October 2011 in conjunction with the LEV III criteria pollutant and greenhouse gas regulations, is a primary concern of the study.

This study identifies and promotes policies that support vehicle electrification, focusing on the California ZEV program. In light of the history of the ZEV program and its surrounding controversy, however, it is helpful to clearly and carefully define the overall goal of vehicle electrification policy. ICCT believes the goal is to foster a successful long-term transition to zero-carbon electric drive transportation.

The ICCT study is organized around five tasks, with the results of each task presented in a separate policy report. This document reports ICCT analysis and findings regarding Task 4, Complementary Policies. Complementary policies in this context are nonregulatory policies that are intended to support the successful deployment of electric vehicles.

In general, it appears that policies and programs are in place to adequately support the planned initial deployments of BEVs. There will be many challenges, but the pent-up demand from electric vehicle enthusiasts and the ample support from governments and manufacturers appear to be sufficient to carry through the "first wave" of electric vehicle deployment, roughly the next 3 years. It is far from clear, however, that the same can be said for the "second wave" of deployment, roughly 2014 through 2018. It is ICCT's view that policy attention, particularly in California, should focus on how best to support this upcoming second wave.

The electric vehicle–targeted incentive and other programs currently in place can be grouped into three categories according to their intended result: to support and encourage the manufacturing of electric vehicles and key components such as batteries, to increase customer demand for electric vehicles, or to encourage the installation of electric vehicle infrastructure. Electric vehicle deployment is just getting under way, and the various incentives and subsidies being provided have not been in operation long enough to evaluate their results. Nonetheless, some observations can be made regarding the incentive programs currently in place:

- Policies to encourage the introduction of ZEVs must come to grips with a fundamental tradeoff: What is the appropriate balance of research and development versus deployment, and to what extent should this balance change over time?

- The institutional, organizational, and industrial frameworks for a BEV charging infrastructure and a FCEV hydrogen refueling infrastructure are completely different. Despite the lack of a common institutional framework, there are a number of issues that cut across both infrastructure efforts, notably the extent to which the provision of electric drive vehicle infrastructure should be subsidized by other energy users and/or taxpayers.
- Given the high cost of today's electric vehicles, analysts have predicted that the initial buyers of electric vehicles will have higher than average incomes. This has led to concerns in some quarters that subsidies for electric vehicles are inequitable.
- The ongoing economic downturn will continue to put pressure on subsidy programs for the foreseeable future. One key question is whether vehicle costs will decline rapidly enough to offset the loss of subsidies, such that the net cost to the consumer remains the same or declines.

The many existing policies and incentive programs provide a strong base of support for most aspects of the coming initial vehicle rollouts, but there are still areas of concern. FCEVs face important challenges both for vehicle technology and fueling infrastructure. More important, however, is a need for careful planning and mutual commitment among disparate parties to ensure a coordinated rollout of vehicles and stations. Without assurance that adequate refueling will be available, vehicle manufacturers will be reluctant to commit to large-scale vehicle deployment as the technology improves. On the other hand, energy companies are reluctant to make substantial investment in hydrogen refueling infrastructure without assurance of sufficient market demand to earn a return on their investment, and in any event there will be an initial period of losses to sustain before profitability can occur.

Another key question being faced around the world is how fast to install public infrastructure. Interviews with government officials in a variety of jurisdictions generally revealed that most believe that the majority of charging (90% or more) will take place at home. Nonetheless, they have concluded that widespread public infrastructure is needed to mitigate range anxiety on the part of prospective purchasers. As a result, many jurisdictions have aggressive plans under way to install public infrastructure.

In most countries around the world, the initial emphasis for placement of electric vehicles is on fleet purchasers. Fleets are targeted because fleet operators understand the total cost of ownership, they know the duty cycle, and they are more understanding of issues stemming from the deployment of new technology. In the California ZEV program, other than the regulation's encouragement of car-sharing applications, there have not been policies specifically targeted at fleets.

California offers an incentive of $5000 to encourage the purchase of electric vehicles, similar to vehicle purchase incentives offered in other jurisdictions.

However, other jurisdictions have other powerful fiscal incentives in place, notably (in the European Union) much higher fuel taxes. In addition, the French bonus/malus system provides an example of a revenue-neutral way to offer purchase incentives.

At some point, the demand for ZEVs among early adopters will be largely supplied. To move toward widespread commercial acceptance, it will be necessary to appeal to a broader range of customers. Moving toward a mass market raises additional issues beyond those that are relevant for early adopters. Early adopters by definition are more willing to try new technologies and make compromises, and are less concerned about risk. Mainstream customers will need to feel comfortable with their understanding of the technology and how it may or may not meet their needs. Before purchasing an electric vehicle, customers in the broader market will need to have a number of concerns addressed, including "outlier" needs, risk aversion, and the environmental performance of the vehicle.

ICCT recommends several steps to continue to provide for an orderly, sustainable transition to electric-drive vehicles:

- *Research*
  - » Incentives should continue to focus on research and development as well as deployment.
- *Infrastructure*
  - » Work should continue on a variety of approaches to ensure the systematic deployment of hydrogen infrastructure.
  - » The ARB should continue its efforts to forge a mutual commitment among auto companies and fuel providers that vehicle and hydrogen infrastructure deployment will proceed hand in hand.
  - » ICCT agrees with the data-driven approach to electric infrastructure deployment being recommended by the California Plug-In Electric Vehicle Collaborative, and urges caution regarding the pace of installation of additional public infrastructure to avoid stranded assets and overreliance on daytime charging.
  - » The ARB should explore the use of on-bill financing and property-assessed clean energy (PACE) programs to allow loans for infrastructure installation to be tied to the property.
- *Deployment*
  - » The ARB should encourage the development of programs that allow for placement of electric vehicles in community centers or other facilities in low-income neighborhoods to provide some access to these emerging technologies.
  - » The ARB should monitor developments with regard to secondary use of vehicle batteries and determine whether there is a role for state action.

- The ARB should provide additional focus on fleets as an early market for electric vehicle passenger vehicle deployment.
- The ARB should promote the common procurement of a substantial number of electric vehicles in the 2013 time frame.
- The ARB should pursue policies that put a price on carbon, resulting in higher prices for conventional fuels.
- The ARB should pursue adoption of a feebate program that will provide a self-financing ongoing price incentive for low-carbon vehicles.
- The ARB should begin to develop a package of incentives directed at the "second wave" of customers and vehicle deployments, focused on the time frame of 2014 through 2018. Elements of the package should include loaner conventional vehicles, customer trials, customer information, and provision of renewable electricity and hydrogen to electric vehicle owners.

INTRODUCTION

ICCT Vehicle Electrification Policy Study

ICCT has undertaken a Vehicle Electrification Policy Study to evaluate, recommend, and support the adoption of policies that can achieve motor vehicle emission reductions beyond those achieved by traditional tailpipe standards. Although ICCT recognizes the important role that plug-in hybrid electric vehicles (PHEVs) are likely to play in the transition to vehicle electrification, the study is focused on the encouragement of "pure" electric vehicles—battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs). These two major electric-drive technology areas are grouped here and in many international policy efforts because of their electric drivetrain commonality, their diversity of potential upstream energy carriers, and their prospects for long-term, ultra-low energy, and emissions impacts. Throughout this project the term *electric vehicle* refers to both BEVs and FCEVs.

The study is intended to provide information relevant to the upcoming consideration of modifications to the California Zero Emission Vehicle (ZEV) program, due to be considered by the California Air Resources Board (ARB) in October 2011. The study is organized around five tasks, with the results of each task presented in a policy report:

1. *What is the current status of vehicle and infrastructure technology and what are the current and projected costs?*

   On the basis of a review of existing studies, Task 1 provides an overview of technology status and projected costs for BEVs and FCEVs. The report compiles existing estimates of incremental cost over time, taking into account expected technical development and increased production volume. The report also evaluates global deployment projections and compares the likely California share of those deployments to the targets for the ZEV program under consideration by the California ARB staff.

2. *What metrics should be used to measure progress toward ZEV commercialization?*

   Currently the ZEV program requirements are expressed primarily in terms of the number of vehicles to be offered for sale, with adjustments for different types of technology. This approach has the benefit of being tangible and readily verified because it is based on available sales data. Depending on technology progress over time, however, this approach can lead to over- or underinvestment in the various deployment stages. Other metrics that have been used or recommended include componentry-based approaches (such as vehicle battery capacity), measures of full lifecycle emissions, or the number of zero emission miles traveled. The ideal set of metrics also should incentivize efficiency, which for ZEVs can vary even though all vehicles have zero tailpipe emissions. Task 2 evaluates the key goals that potential metrics should support and the relevance and practicality of various metrics.

3. *What will be the cost in California of the transition to a self-sustaining market, and how long will it take?*

   Building on work that has been undertaken nationally and internationally, this task will quantify to the extent possible the public or private investment needed to get through the proverbial "valley of death" before zero emission electric drive technologies can compete in the market without subsidies. Task 3 will address the magnitude and duration of needed policies under various scenarios. This task is currently in progress.

4. *Which complementary policies (e.g., infrastructure rollout, incentives) are needed to support a transition to an electrified vehicle fleet, and what is the appropriate framework for considering possible policy actions?*

   Task 4 identifies and recommends policies that most effectively support the necessary transition and that are applicable in the California context. The study also assesses the extent to which existing global policies will facilitate this transition, such as global private and public investments in research, development, and demonstration; manufacturing scale-up; and the need for California-specific investments in areas such as infrastructure.

5. *What can we learn from work under way elsewhere in the world?*

   Task 5 (forthcoming) reviews region-specific market niches, infrastructure challenges, and existing policies to identify lessons applicable to California and how they can best be applied in the California context. Although specific insights relevant to the previous tasks are included in those reports as appropriate, this task presents a comprehensive review of global policies. The selection of regions accounts for the targets, goals, and policies in place in each jurisdiction and the existence of market opportunities as evidenced by manufacturer vehicle introductions and interest.

The Task 4 Report

This document presents ICCT findings for Task 4, the evaluation of complementary policies. Complementary policies in this context are nonregulatory policies that are intended to support the successful deployment of electric vehicles. ARB staff have asked for comment on the issues addressed herein, and this document is intended to assist staff in their deliberations.

BACKGROUND

To provide context for the consideration of electric vehicle incentive programs, this section gives a brief overview of near-term deployment plans and projections, with special attention to several issues that will become increasingly important as the market develops.[1]

Current Deployment Status

The scope of current international electric vehicle activity is unprecedented. A number of jurisdictions are encouraging vehicle electrification and have active programs under way. Here in the United States, federal and state incentives for auto manufacturers and parts suppliers [primarily oriented toward plug-in hybrid electric vehicles (PHEVs)] and for infrastructure development, together with matching private funds, have reached about $10 billion.[2] The United Kingdom has announced incentives of £5000 per vehicle,[3] and Transport for London plans to provide 25,000 residential, commercial, and public charging points and procure 1000 fleet vehicles by 2015.[4] France is offering vehicle incentives of €5000, and a consortium of major industries and governmental agencies has committed to order 50,000 vehicles.[5] China has demonstration projects in place in 25 cities, provides subsidies of up to 60,000 yuan for electric vehicles, and plans to invest the equivalent of $15 billion over the next 10 years in electric vehicle development.[6] Demonstrations, incentive programs, and related efforts are under way in Germany, Sweden, Japan, Korea, Canada, and other countries.

Table 1 shows current electric vehicle and PHEV targets for a number of countries. Bear in mind that these targets are ambitious and in general assume the adoption and continuation of aggressive incentive policies and other measures. Nonetheless, they show a substantial commitment.

1 A more detailed discussion and evaluation of deployment projections is provided in the ICCT Technology Innovation Project, Vehicle Electrification Policy Study, Task 1 Report: Technology Status.

2 California ETAAC Advanced Technology Sub-Group, *Advanced technology to meet California's climate goals: Opportunities, barriers & policy solutions* (December 14, 2009), pp. 6-5–6-7; www.theicct.org/pubs/ETAAC_Advanced_Technology_Final_Report_12-14-09.pdf.

3 www.autonews.com/apps/pbcs.dll/article?AID=/20100227/COPY/302279991/1193.

4 http://ecogeek.org/component/content/article/3023.

5 www.euractiv.com/en/climate-environment/france-awaits-clearer-eu-strategy-on-e-cars-news-464836?utm_source=EurActiv+Newsletter&utm_campaign=329ce9af9a-my_google_analytics_key&utm_medium=email.

6 www.businessgreen.com/business-green/news/2271666/china-produce-million-electric.

Table 1. National Electric Vehicle and Plug-In Hybrid Electric Vehicle (PHEV) Deployment Targets[7]

Country	Target
United States	1 million cumulative PHEVs by 2015
Germany	1 million cumulative electric vehicles (BEVs, PHEVs, FCEVs) by 2020, 5 million by 2030
United Kingdom	1.2 million cumulative electric vehicles by 2020, 3 million by 2030
France	2 million cumulative electric vehicles/PHEVs by 2020
China	5 million cumulative EVs/PHEVs by 2020, 1 million electric vehicles/PHEVs annually in 2020, 20% to 30% market share by 2030
Japan	2 million cumulative FCEVs by 2025
South Korea	50,000 cumulative electric vehicles/PHEVs by 2020, 50% of sales by 2030s

BEV = battery electric vehicle, FCEV = fuel cell electric vehicle.

Meanwhile, vehicle manufacturers are aggressively pursuing a variety of advanced technologies to secure their competitive position in the global marketplace. Nissan has become the first large-volume manufacturer to offer an electric vehicle to the general public, and General Motors is beginning the rollout of the Chevrolet Volt PHEV. The Renault-Nissan Alliance has entered into partnerships with cities around the world to promote the installation of infrastructure. General Motors, Honda, Daimler, Hyundai, and Toyota are sponsoring consumer tests of their latest FCEVs. Battery vehicle demonstrations are being sponsored by Ford, BMW, Volkswagen, Mitsubishi, Think, and others. New players such as Tesla are actively marketing vehicles. Thus, there is considerably more activity and investment on the part of manufacturers than in the past.

Several manufacturers have stated their own targets for future deployment. Carlos Ghosn, CEO of Renault and Nissan, is on record as predicting that by 2020 electric vehicles will account for 10% of Renault and Nissan sales.[8] Volkswagen has announced a goal of having electric vehicles represent 3% of its sales in 2018.[9] Along the same lines, a number of fuel cell manufacturers have stated their expectation for collective placements totaling in the hundreds of thousands, beginning in 2015, as well as their intent to offer a commercial FCEV beginning in 2015 in Japan, Korea, Europe, and one U.S. market (provided that sufficient infrastructure is in place).[10] More recently, Hyundai has announced that it will begin to market a production version of a FCEV in 2012.[11]

7 International Energy Agency, *Technology roadmap: Electric and plug-in hybrid electric vehicles* (2009), p. 18; www.iea.org papers/2009/EV_PHEV_Roadmap.pdf.
8 www.cnbc.com/id/33907442/Ghosn_s_Bet_10_of_World_Will_Drive_EV_s_in_10_Years.
9 www.treehugger.com/files/2010/03/volkswagen-plans-sell-300000-electric-cars-year-2018.php.
10 www.h2carblog.com/wp-content/uploads/2009/10/Letter-of-Understanding.pdf.
11 www.allcarselectric.com/blog/1048608_report-hyundai-fuel-cell-electric-vehicle-coming-in-2012.

Emerging Issues

It is clear that enthusiasm for ZEVs is advancing rapidly, with major governmental and manufacturer investment in vehicle technology development and deployment. Analyst estimates, manufacturer plans, and governmental targets all point toward substantial future expansion of the use of electric vehicles. These trends surpass any seen before.

Nonetheless, there is substantial uncertainty regarding commercialization potential. Many studies point toward continued long-term cost penalties for electric drive vehicles.[12] But the existing subsidy programs generally are limited by time and/or cost, and thus they will only be available in the near term. The newly announced Chinese subsidies for electric vehicles and PHEVs, for example, each phase out after a manufacturer has sold 50,000 units. The future status of such subsidies has not been determined, but it appears unlikely that the substantial financial incentives currently being provided can be sustained over an extended number of years, particularly as the number of vehicles being deployed increases beyond the relatively small initial totals. Other incentives, such as preferential parking or access to high-occupancy vehicle lanes, by their very nature cannot be sustained as vehicle numbers reach mainstream levels.

The ongoing economic crisis may also affect the viability of ongoing subsidies. As one example of the pressures facing subsidy programs given current economic distress, the new U.K. coalition government announced its intent to review after 1 year the previously open-ended incentive program proposed by the previous Labor government with rebates of up to £5000 per vehicle, and reduced the overall funding commitment from £230 million to £43 million.[13] Subsequent reports called into question even that level of funding.[14] Such uncertainty seriously undermines manufacturers' ability to develop long-term plans, which will hold back the development of an ongoing market.

At the same time, demand from the ranks of "early adopters," who are eager to drive electric vehicles and are willing to compromise on cost or performance in order to do so, will be increasingly saturated. Moving toward commercialization will require an expanded customer base. Expansion of the customer base will be even more difficult if feedback from early users points to problems with range, reliability, or other critical concerns.

In general, it appears that policies and programs are in place to adequately support the planned initial vehicle deployments of BEVs. There will be many challenges involving dealer training, infrastructure installation, and the typical growing pains encountered in any new endeavor, but the pent-up demand from electric

12 For a more complete discussion of cost projections, see the ICCT Technology Innovation Project, Vehicle Electrification Policy Study, Task 1 Report: Technology Status.

13 www.goauto.com.au/mellor/mellor.nsf/story2/F06EA72AD7690BBCCA25776F0003012E.

14 http://uknews.freshcontentengine.com/uk-government-blocking-green-car-take-up-say-electric-vehicle-makers/.

vehicle enthusiasts and the ample support from governments and manufacturers appear to be sufficient to carry through the "first wave" of electric vehicle deployment—roughly the next 3 years. It is far from clear, however, that the same can be said for the "second wave" of deployment, roughly 2014 through 2018. It is ICCT's view that policy attention, particularly in California, should focus on how best to support this upcoming second wave.

EXISTING COMPLEMENTARY POLICIES

This section provides a brief description of electric vehicle–targeted incentive programs currently in place.[15,16] The various incentives can be grouped into three major categories according to their intended result. Incentive programs seek to do the following:

- Support the manufacturing of electric vehicles or key components such as batteries,
- Increase customer demand for electric vehicles, or
- Encourage the installation of electric vehicle infrastructure.

Although these categories are interrelated (for example, installation of infrastructure helps to increase customer demand), this categorization provides a useful framework for considering the different approaches.

Support for Vehicle and Component Manufacturing

These measures focus on the supply of vehicles into the market and are targeted at vehicle manufacturers rather than customers. Many countries have provided subsidies and loans to vehicle and component manufacturers, often as part of economic recovery or industrial policy measures that seek to support their domestic automobile industry. Other policies that encourage vehicle supply include providing "supercredits" for electric vehicles (as part of the overall passenger vehicle emission regulatory system) and the California ZEV mandate. Table 2 lists existing policies of this type.

15 For another description of international incentives, see Electrification Coalition, *Electrification roadmap: Revolutionizing transportation and achieving energy security* (November 2009), pp. 154–159; www.electrificationcoalition.org/reports/EC-Roadmap-screen.pdf.

16 A forthcoming ICCT report (Review and Comparative Analysis of Fiscal Policies Associated with New Passenger Vehicle CO_2 Emissions) will provide a comprehensive review and evaluation of fiscal policies to reduce CO_2 emissions, some of which are targeted at electric vehicles.

Table 2. Policies That Support Vehicle and Component Manufacturing

Jurisdiction	Description
United States	$2 billion in American Recovery and Reinvestment Act grants to manufacturers of advanced vehicle batteries and systems More than $2.4 billion in U.S. Department of Energy Advanced Technology Vehicle Manufacturing loans to Fisker, Nissan, and Tesla to support plug-in hybriod electric vehicle and electric vehicle factories Electric vehicles assessed 0 g/mi in green house gas fleet average standards*
European Union	Electric vehicle assessed 0 g/mi in greenhouse gas fleet average standards and receive a supercredit through 2016
France	€400 million for reserach, development, and demonstration programs, including a €90 million research fund for vehicles and batteries
Germany	€1.4 billion committed to fuel cell development €500 million for pilot projects and research and development €60 million research and development funding for lithium-ion batteries
United Kingdom	£350 million for research and demonstration projects
China	100 billion yuan ($15 billion) earmarked over 10 years for research and development for new energy vehicles and components
California	Zero Emission Vehicle Mandate

**This exemption applies to the first 200,000 vehicles sold in model years 2012–2016 or 300,000 vehicles for manufacturers that sell 25,000 vehicles or more in model year 2012. For PHEVs, the 0 g/mi value applies only to the percentage of miles driven on grid electricity.*

Encouragement of Vehicle Deployment

There are a broad range of policies in place to encourage electric vehicle deployment. These policies can be further subdivided into those that reduce the first cost (purchase cost) of the vehicle, those that target ongoing operating and maintenance costs or provide other desirable incentives, and vehicle procurement programs. Tables 3 through 5 address each in turn.

Table 3. Policies that Encourage Vehicle Deployment—Reducing First Cost

Jurisdiction	Description
United States	Tax credit for new electric vehicles and PHEVs of $2500 plus $417 for each kWh of battery capacity over 5 kWh, to a maximum of $7500 State-level purchase incentives in California, Colorado, Georgia, Illinois, New Jersey, Maryland, Kansas, Louisiana, Oregon, Rhode Island, Utah, and Oklahoma
France	€5000 rebate for private electric vehicles under bonus/malus (feebate) system
United Kingdom	Starting in 2011, purchasers of electric vehicles and PHEVs will receive a discount of 25% of vehicle list price to a maximum of £5000 First-year registration tax based on CO_2 emission bins
Japan	New electric vehicles and PHEVs exempt from acquisition tax Acquisition tax reduced for used electric vehicles and PHEVs
China	Subsidy for private purchase of electric vehicles and PHEVs of 3000 yuan (~$440) for each kWh of battery capacity, up to 60,000 yuan (~$8800) for electric vehicles and 50,000 yuan (~$7400) for PHEVs No acquisition tax for electric vehicles and PHEVs
India	Subsidy of 20% of the cost of electric vehicles

PHEVs = plug-in hybrid electric vehicles.

Table 4. Policies that Encourage Vehicle Deployment—Other Incentives

Jurisdiction	Description
Germany	Electric vehicles exempt from vehicle taxes for the first 5 years after purchase Electric vehicles have free inner-city parking
United Kingdom	Electric vehicles exempt from annual circulation tax Company Electric vehicles exempt from company car tax for first 5 years after purchase Electric vehicles exempt from London congestion charge Free parking for electric vehicles in many London areas
United States	Free access to High Occupancy Vehicle lanes in California, New York, Colorado, Florida, Utah, and Virginia Free parking for electric vehicles in numerous cities
Japan	Electric vehicles exempt from annual tonnage tax

Table 5. Policies that Encourage Vehicle Deployment—Vehicle Procurement

Jurisdiction	Description
United States	$300 million for federal purchase of EVs and HEVs
France	Planned mass order of 50,000 EVs by public and private entities under state-sponsored group purchase program
United Kingdom	£20 million for government purchase of electric vans

Encouragement of Infrastructure Deployment

The third major focus of electric vehicle complementary policies is infrastructure deployment. Table 6 lists programs of this type. There is also a growing movement to supplement infrastructure deployment with other measures to simultaneously address multiple aspects of electric vehicle deployment in concentrated pilot/demonstration programs. The Electrification Coalition uses the term "electrification ecosystems" to describe programs of this type.[17]

Table 6. Policies that Encourage Infrastructure Deployment

Jurisdiction	Description
United States	$400 million for demonstration projects and evaluation of plug-in hybrid and electric infrastructure The EV Project (ECOtality) installing 15,000 charging stations in 16 cities Charge Point America (Coulomb) project installing 4600 charging stations in 9 cities Project Get Ready initiative (Rocky Mountain Institute) is working on EV readiness with regional coalitions in Tampa Bay, Florida, central Florida, Rhode Island, and the cities of Denver, Indianapolis, Portland, Houston, Kansas City, and Raleigh Other jurisdictions with active regional programs include Los Angeles, the San Francisco Bay Area, New York City, and Richmond 31 hydrogen fueling stations built or under construction pursuant to the California Hydrogen Highway program $53 million over several years for hydrogen infrastructure under the California AB 118 program $5 million from Bay Area Air Quality Management District (California) for electric infrastructure deployment California Energy Commission grants for electric charging infrastructure in Los Angeles, San Francisco, and Sacramento areas
Germany	Clean Energy Partnership installing hydrogen infrastructure €500 million for infrastructure €115 for eight test/demonstration projects
France	€107 million for infrastructure demonstration projects
United Kingdom	£30 million for Plugged in Places project installing infrastructure in three regions Goal of £20 million procurement program for 25,000 charging points in London
China	5 billion yuan ($730 million) over 10 years for infrastructure 30 billion yuan ($4.4 billion) over 10 years for pilot projects Tens of Cities, Thousands of Vehicles project under way, expanded to 20 cities
Canada	Project Get Ready regional activities in Vancouver and Toronto

17 Electrification Coalition, *Electrification roadmap*, op. cit., pp. 140–143.

COMPLEMENTARY POLICY ISSUES

Electric vehicle deployment is just getting under way, and the various incentives and subsidies being provided have not been in operation long enough to meaningfully evaluate their results. Substantial information will be gained in the next year or two as the Nissan Leaf, Chevrolet Volt, Mitsubishi iMiev and other vehicles come to market. Nonetheless, some observations can be made regarding the policies and incentive programs currently in place. This section outlines several key issues relevant to electric vehicle complementary policies.

Finding the Balance—Production Volume Versus Technical Development

Policies to encourage the introduction of ZEVs must come to grips with a fundamental tradeoff: What is the appropriate balance of research and development versus deployment, and to what extent should this balance change over time? Until the technology matures, there will always be a need for additional research and development through several iterative generations of technology, and each successive generation will cost substantially less. On the other hand, increased production volume also reduces unit cost. Finding an appropriate policy balance between these two objectives is an important challenge.

This point was addressed in a May 2010 article in GreenBiz[18] reporting on an interview with Matt Mattila and Tripp Hyde, who are managers for the Project Get Ready initiative sponsored by the Rocky Mountain Institute. The article noted,

> Consumer cash may be a quick fix, but money spent further upstream—on better design, more efficient processes and more cost-effective materials—could result in a much lower vehicle cost which would ultimately be passed on to EV [electric vehicle] buyers. "A vehicle designed to be lighter requires less energy to move, smaller batteries to power, and, ultimately, less money to manufacture," Hyde said. "These savings are passed straight to the consumer by bringing down the MSRP and ideally making the vehicle a more attractive option."

This tradeoff is discussed in more detail in the ICCT Task 1 report on Technology Status, in the context of future deployment targets under the ZEV regulation. In that report ICCT recommends that targets be set with caution, bearing in mind the need to allow time for technology to mature.

Implementation Framework for Electricity and Hydrogen Infrastructure

The California institutional, organizational, and industrial frameworks for electricity and hydrogen refueling infrastructure are completely different. The provision of electricity takes place in a well-established policy-making environment involving the utility companies, third-party providers, and regulatory bodies such as the California Public Utilities Commission. Although there are a number of difficult issues to be resolved (such as cost allocation), the regulatory process

18 www.rmi.org/rmi/Making+Every+Dollar+Count+for+Evs.

provides a consistent forum for addressing them. No such preexisting implementation framework exists for hydrogen infrastructure. The California Fuel Cell Partnership has stepped into this policy space to attempt to provide a forum for achieving consensus and a strategic plan for moving forward.[19] In addition, as noted later, the California ARB staff is moving forward to identify options to ensure the provision of hydrogen infrastructure in California.

Despite the lack of a common institutional framework, there are a number of issues that cut across both infrastructure efforts, notably the extent to which the provision of electric vehicle infrastructure should be subsidized by other energy users or taxpayers. If this question is answered in different ways for electricity and hydrogen, it could have the effect of favoring one technology over the other. Although this may be appropriate, given the differing needs of a primarily decentralized electricity charging network versus a primarily centralized hydrogen distribution network, such issues need to be carefully considered.

Equity

Given the high cost of today's electric vehicles, analysts have predicted that the initial buyers of electric vehicles will have higher than average incomes.[20],[21] This has led to concerns in some quarters that subsidies for electric vehicles are inequitable, or, as stated in a recent article in Slate, "Where does the federal government get off spending the average person's tax dollars to help better-off-than-average Americans buy expensive new cars?"[22] Although the use of electric vehicles will lead to community air quality benefits in neighborhoods near freeways, low-income drivers are unlikely to be able to afford electric vehicles for quite some time. This issue will be mitigated as electric vehicle costs come down, but in the meantime it has the potential to cause resentment and potentially restrict the nature or amount of future subsidies.

Sustainability over Time

The federal tax credits for electric vehicles are available for the first 200,000 vehicles per manufacturer[23] and then phase out over a period of 1 year. Projected deployments indicate that this should cover demand for a number of years for most manufacturers. Nonetheless, the ongoing economic downturn will continue to put pressure on subsidy programs for the foreseeable future. One key question is whether vehicle costs will decline rapidly enough to offset the loss of subsidies, such that the net cost to the consumer remains the same or declines.

19 See, for example, California Fuel Cell Partnership, *Hydrogen fuel cell vehicle and station deployment plan: A strategy for meeting the challenge ahead—Progress and next steps* (April 2010); www.cafcp.org/sites/files/FINALProgressReport.pdf.

20 Deloitte Consulting LLP, *Gaining traction: A customer view of electric vehicle mass adoption in the U.S. automotive market* (2010); www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/us_automotive_Gaining%20Traction%20FINAL_061710.pdf.

21 www.businessweek.com/blogs/europeinsight/archives/2009/01/luxury_buyers_ready_for_e-cars_bain_says.html.

22 www.slate.com/id/2262229/.

23 www.energy.gov/taxbreaks.htm.

In this environment, programs that do not require governmental outlays will be easier to sustain. For example, self-financing feebate programs can provide incentives over the longer term (although the cross-subsidization involved could still trigger equity concerns similar to those noted earlier). Similarly, tax incentives that do not require a direct governmental appropriation may be more attractive politically than cash subsidies, even though the fiscal consequences to the government are the same. Finally, there is merit in pursuing approaches that seek to leverage private-sector investment.

ADDITIONAL MEASURES FOR THE EARLY-ADOPTER PERIOD

The many existing policies and incentive programs provide a strong base of support for most aspects of the initial vehicle rollouts, but there are still areas of concern. This section outlines several areas where additional attention is warranted in the near term.

Hydrogen Infrastructure

Careful planning and mutual commitment among disparate parties are needed to ensure a coordinated rollout of FCEVs and hydrogen refueling stations. Without assurance that adequate refueling will be available, vehicle manufacturers will be reluctant to commit to large-scale vehicle deployments as the technology improves. On the other hand, energy companies are reluctant to make substantial investment in hydrogen refueling infrastructure without assurance of sufficient market demand to earn a return on their investment, and in any event there will be an initial period of losses to sustain before profitability can occur.

This latter point was emphasized in a recent study conducted by a European consortium of companies and organizations. The study evaluated various power trains that could meet EU long-term GHG reduction goals; in the case of hydrogen, it noted that "Infrastructure providers . . . bear a first-mover risk, making a heavy upfront outlay to build a retail station network that will not be fully utilised for some years; the unit cost reduces over time simply because the fixed capital expenditure is used by an increasing number of FCEVs."[24] Similarly, modeling at the University of California, Davis has shown that although hydrogen infrastructure can be a profitable long-term private-sector investment, it faces negative returns in the short term.[25]

These issues are well recognized, and work to address them is under way in California and elsewhere. Researchers at UC Davis are investigating how best to serve initial "clusters" of vehicles near where they are owned, provide some connecting stations to support longer trips, and then ramp up the number of stations over time. This approach helps to address the rollout issue by targeting limited initial vehicle and infrastructure deployments in specific initial geographic areas, and then

24 *A portfolio of power-trains for Europe: A fact-based analysis. The role of battery electric vehicles, plug-in hybrids and fuel cell electric vehicles*. Available at: www.zeroemissionvehicles.eu/uploads/Power_trains_for_Europe.pdf

25 http://hydrogen.its.ucdavis.edu/research/track2/index_html, p. 23.

scaling up over time. Along similar lines, the California Fuel Cell Partnership has prepared a strategic plan for moving forward.[26] There are currently 20 hydrogen fueling stations in California, with 10 more in the planning phase.[27] Work is proceeding in California, nationally, and internationally on codes and standards and on related administrative and logistical issues.

There are a number of technical pathways to provide hydrogen through the use of natural gas or biofuels (as feedstock), industrial process gases, or electricity to convert water to hydrogen. Hydrogen can be produced on-site or centrally, to be distributed via truck or pipeline. The cost effectiveness of the various production technologies, the extent to which hydrogen is generated locally versus centrally, and the ability to recoup the fixed costs of pipeline delivery all will likely depend on the future costs of the various options as well as on production volumes.

In the near term in California, existing public funding along with some private funding can support infrastructure for demonstration-phase vehicle deployments. Currently committed public funding may fall short of needs around 2014 to 2015, as vehicle deployments ramp up to early commercialization with tens of thousands of vehicles expected in the 2015–2017 window.[28] This gap could reach more than 40,000 kg of hydrogen per day by 2017, assuming roughly 1 kg of hydrogen per vehicle per day.[29] The development of solutions will need to focus on creating private-sector business models that can be self-sustaining in the long run as public investment phases out.

UC Davis researchers have estimated the cost of a 19-year hydrogen infrastructure growth scenario for the Los Angeles Basin, concluding that "for an infrastructure of 42 hydrogen stations in the LA Basin that supports 25,000 FCVs by 2017, a $200 million total investment would be required ($170 million to build the stations and $30 million to operate them)."[30] On a larger scale, the Power-trains for Europe study estimates that the cost of installing sufficient initial hydrogen refueling network coverage for the first decade for a region such as Germany would be about €3 billion,[31] but goes on to note that this sum is a small fraction of the overall cost of FCEV deployment:

> One could argue that it is inefficient to build an additional vehicle refueling infrastructure on top of existing infrastructures. However, the additional costs of a hydrogen infrastructure are relatively low compared to the total costs of FCEVs and comparable to other fuels and technologies, such as a charging infrastructure for BEVs and PHEVs. Costs for a hydrogen distribution and retail infrastructure are around 5% of the overall cost of FCEVs—the vast majority lies in the purchase price.[32]

26 California Fuel Cell Partnership, op. cit.
27 www.cafcp.org/stationmap.
28 CARB, *New directions for the Clean Fuels Outlet regulation* (April 1, 2010); www.arb.ca.gov/fuels/altfuels/cf-outlets/meetings/04_01_10pres.pdf.
29 Ibid.
30 California Fuel Cell Partnership, op. cit., p. 6.
31 *A portfolio of power-trains for Europe,* op. cit., p. 7.
32 Ibid.

The California Fuel Cell Partnership has identified a number of options for government and the private sector to help bridge the infrastructure funding gap:[33]

- Continuing state funding for initial stations in addition to some private funding during the demonstration phase
- Exploring low-cost private financing options
- Collecting and distributing technical and market data to help the development of successful private-sector business models
- Continued learning from other countries such as Germany, Japan, and South Korea

Other options that should be evaluated include the following:

- Recycling a portion of the value of greenhouse gas cap-and-trade allowances for the transportation sector into hydrogen station funding. The total value of California cap-and-trade allowances is likely to exceed $400 million annually when upstream emissions are covered in 2012 and $2 billion annually when on-road transportation fuels are added in 2015.[34]
- Lowering vehicle thresholds for the Clean Fuels Outlet program to trigger a requirement that fuel providers install hydrogen infrastructure. Challenges to this approach include the fact that most retail fueling stations are independently owned, and oil companies are more interested in large-volume markets rather than the emerging H_2 market.
- Evaluating the effectiveness of favorable tax treatment and tax exemptions in encouraging the deployment of hydrogen infrastructure while that market is still emerging.[35]
- Making public or private land available for fueling stations.

In addition, work is needed to better understand the value of ultraclean fuels within the Low Carbon Fuel Standard (LCFS). As currently structured, the LCFS provides credits for hydrogen fuel, but the value of such credits is uncertain and may be more relevant as the LCFS 2020 goals approach rather than in the 2015 time frame. Depending on the results of such a review, it may then be appropriate to evaluate the use of increased near-term credits for hydrogen and electricity to help support infrastructure deployment.

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33 California Fuel Cell Partnership, op. cit.

34 Under current plans, beginning in 2012 more than 40 million metric tons per year of upstream GHG emissions from transportation-sector petroleum production and refining will be included in the California cap-and-trade program. The transportation-sector share is likely to reach about 200 million metric tons per year in 2015 when on-road transportation fuels are included. Estimates are based on ARB's climate change inventory and projections, assuming that roughly half of the oil and natural gas production category can be attributed to transportation fuels and that moderate reductions occur in the transportation sector by 2015. See www.arb.ca.gov/cc/inventory/archive/tables/ghg_inventory_sector_90-04_sum_2007-11-19.pdf and www.arb.ca.gov/cc/inventory/data/forecast.htm.

35 California Fuel Cell Partnership, op. cit. See also U.S. EPA, NHTSA, and CARB, *Interim joint technical assessment report: Light-duty vehicle greenhouse gas emission standards and Corporate Average Fuel Economy standards for model years 2017–2025* (September 2010), chapter 4; www.epa.gov/otaq/climate/regulations/ldv-ghg-tar.pdf.

Above all, what is needed is a mutual commitment among auto companies and fuel providers that vehicle and infrastructure deployment will proceed hand in hand. Examples of mechanisms to establish such a commitment include the California Fuel Cell Partnership process, a state-sponsored Memorandum of Understanding among the relevant parties, or a market launch plan similar to that being developed by the Power-trains for Europe coalition.[36]

Electricity Infrastructure

Another key question being faced around the world is how fast to install public infrastructure. Interviews with government officials in a variety of jurisdictions revealed that most believe that the majority of charging (90% or more) will take place at home. But they have nonetheless concluded that widespread public infrastructure is needed to mitigate range anxiety on the part of prospective purchasers. As a result, many jurisdictions have aggressive plans under way to install public infrastructure.

There is disagreement among auto manufacturers on the desired pace of public infrastructure installation. Manufacturers that are marketing BEVs argue for substantial public infrastructure with fast charging capability, whereas manufacturers marketing PHEVs in general do not see such a need (although, as noted later, GM recommends 0.3 public chargers per vehicle).

In California, the installation of infrastructure for passenger electric vehicles is under way. The California Energy Commission AB 118 Investment Plan notes that "California currently has 413 stations with 1300 public access electric charge points."[37] The Bay Area Air Quality Management District grants noted in Table 6 will support 3000 home chargers, 2000 public chargers, and 50 highway fast chargers. San Diego is installing 1000 residential, 1300 commercial, and 60 level-3 chargers.

There is not yet enough experience to determine how many chargers are needed. The AB 118 Investment Plan is instructive in this regard, stating that:[38]

> Charging infrastructure deployment also needs to consider an "appropriate" number of public and workplace charging stations to encourage public adoption of PEVs and support the development of a competitive market for public charging services. For example, the CPUC estimates that one home charging and 0.5 public charging capacity is needed for each vehicle. Nissan, Ford, GM and Chrysler similarly estimate that there is a need for one home charger and 0.3 public chargers per vehicle. However, these ratios are very speculative and without strong empirical foundation. Recent studies in Germany and Japan suggest that range anxiety may not be as significant an issue for new PEV drivers and that public charging infrastructure may experience only moderate use.[39] More analysis is needed to better understand PEV owner driving and charging patterns as the vehicles enter the market.

36 *A portfolio of power-trains for Europe*, op. cit., pp. 52–53.
37 www.energy.ca.gov/2010publications/CEC-600-2010-001/CEC-600-2010-001-CTF.PDF, p. 36.
38 Ibid., p. 40.
39 2010 Plug-In Conference, July 27, 2010, San Jose. Presentation by CHAdeMO Association/Tokyo Electric Power Co.

> Further, until PEVs gain some level of market share, private sector investments in public charging will be quite limited due to the uncertainties of utilization and revenue potential. If 75 percent to 90 percent of the charging occurs at home, each public charger will average only 30 to 72 minutes of use per day. This is unlikely to be profitable for private financing on the basis of revenue for charging only.[40]

The *Power-Trains for Europe* study estimates that the cost of electrical infrastructure is comparable to that for hydrogen, stating that "[c]urrent costs for an electric charging infrastructure range from €1,500–€2,500 per vehicle. The higher end of the range assumes 50% home charging (investment of €200–€400 per charging station) and 50% public charging at €5,000 for a charging station that serves two cars (€10,000 in the first years)."[41]

As previously noted in the discussion of hydrogen infrastructure, one potential source of funding for infrastructure is credits generated under the Low Carbon Fuel Standard, which requires a 10% reduction in transportation fuel carbon intensity by 2020. Home charging that is separately metered will result in credits for utilities. LCFS revenue directed to utilities could be used as an incentive for infrastructure. LCFS credits will be an ongoing revenue stream that will scale up as the market increases.

The California Electric Transportation Coalition and several state agencies, in cooperation with the UC Davis Plug-in Hybrid and Electric Vehicle Research Center and numerous stakeholders, have established the California Plug-In Electric Vehicle Collaborative Council. The council has developed a roadmap for implementation of plug-in electric vehicles in California,[42] released in December 2010, which calls for a "data-driven" approach to infrastructure installation.[43] Such an approach would use an iterative research process to better understand vehicle usage patterns and consumer response to vehicles, in order to carefully coordinate vehicle and infrastructure rollout, avoid inefficient charger locations, and provide an optimal network to drivers as the market grows. In addition, the California Public Utilities Commission has opened an Alternative-Fueled Vehicle Rulemaking, which is investigating a number of issues related to plug-in infrastructure, potential impacts on the utility grid, and the appropriate role of the electric utilities and other infrastructure providers. One key question is whether infrastructure cost upgrades on the utility side of the meter that are shared among customers will be billed up front to electric vehicle purchasers or recovered over time through general cost recovery mechanisms.

Several methods are being explored to help consumers finance the installation of home charging infrastructure. Through on-bill financing, a utility company would make a loan to the consumer to be repaid over time through utility bills. A mechanism known as PACE (property-assessed clean energy) allows municipalities to

40 CPUC, Preliminary Staff response to PEV charging criteria questions, June 14, 2010.
41 *A portfolio of power-trains for Europe*, op. cit., p. 7.
42 Taking Charge—Establishing California Leadership in the Plug-In Electric Vehicle Marketplace, www.evcollaborative.org/evcpev123/wp-content/uploads/2010/07/Taking_Charge_final2.pdf.
43 Ibid., p. 28.

make loans that are repaid through increased property taxes. Both of these mechanisms allow loans to be tied to the property and not the borrower, thus allowing for more convenient loan rates and lengths.[44] Both approaches are currently being explored in the California context.

Capturing the Value of Additional Battery Applications

Motor vehicle propulsion is an extremely challenging application for batteries. Batteries that are no longer up to the task will still retain value in other less demanding uses. One battery manufacturer interviewed[45] described three possible stages of battery life:

- Initial use in the vehicle (until 70% capacity remains)
- Secondary use for energy storage (until 60% capacity remains)
- Tertiary use for lighting and uninterruptible power supply (until end of useful life)

Various mechanisms have been proposed to capture this remaining value for the benefit of the initial vehicle purchaser, and thereby reduce the first cost of the vehicle. The National Renewable Energy Laboratory has compiled information on projects under way to investigate secondary use[46] and has undertaken a three-phase project[47] to "(1) assess the merit of secondary-use applications and strategies, (2) verify performance and economic projections, and (3) facilitate the implementation of secondary-use programs." Initial modeling work under this project has concluded that capturing the value of secondary use may reduce the initial cost of the battery to the consumer by up to 28%. Nissan is looking for ways to capture the value of partially depleted batteries from the Leaf, and in October 2010 announced a joint venture with Sumitomo to " 'Reuse, Resell, Refabricate and Recycle' lithium-ion batteries previously used in electric cars, giving them a 'second life' as energy-storage solutions in markets worldwide."[48] The ARB should monitor these developments and determine whether there is a role for state action.

In addition, plug-in vehicle batteries can also support electric utility operations. As one near-term option, the state, in partnership with utilities, automakers, and other stakeholders, should explore optimizing the timing of electric vehicle charging to facilitate the use of variable renewable energy sources such as wind.[49] In the future, more sophisticated vehicle-to-grid interaction could allow electric vehicle batteries to be used to provide spinning reserves, smooth out short-term power fluctuations, and perhaps also provide energy storage services.

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44 http://cleanenergysol.com/news/BPs%20-%20Financing%20Options%20(8-16-10).pdf.
45 Unpublished comments provided during consultant participation in World Bank study mission, Beijing, China, June 2010.
46 www.nrel.gov/docs/fy10osti/48872.pdf.
47 J. Neubauer & A. Pesaran, *NREL's PHEV/EV Li-ion Battery Secondary-Use Project*, presented at the Advanced Automotive Batteries Conference (AABC) 2010, Orlando, Florida, May 17–21, 2010; www.nrel.gov/vehiclesandfuels/energystorage/pdfs/48042.pdf.
48 www.nissan-global.com/EN/NEWS/2009/_STORY/091020-03-e.html.
49 docs.cpuc.ca.gov/cyberdocs/WebQuickstart.asp?DOC_ID=E37071

Focus on Fleets

In most countries around the world, the initial emphasis for placement of electric vehicles is on fleet purchasers. The rationale for this focus, as outlined by policymakers in the European Union and China, is that fleet operators understand the total cost of ownership, they know the duty cycle, and they are more understanding of issues stemming from the deployment of new technology. A recent in-depth U.S. analysis by the Electrification Coalition[50] highlighted a number of characteristics of fleet operators and fleet management companies that "make them more likely than typical consumers to take on the potential risks of electric drive ownership in anticipation of reaping financial benefits down the road," including the following:

- Total-cost-of-ownership approach to acquisition
- Route predictability
- High vehicle utilization rates
- Use of central parking facilities
- Importance of maintenance and service costs
- Lower electricity rates
- Availability of alternative business models
- Corporate sustainability initiatives

The study also identified challenges faced by fleets in moving to electric drive, such as the following:

- Technology costs
- Capital expenditures versus operating expenses
- Fleet infrastructure issues
- Utility impact of dense charge networks
- Market perceptions

On balance, the study found significant potential for deployment of electric vehicles in U.S. fleets, and concluded that

> Based on total cost of ownership modeling conducted for this report, commercial and government fleets could contribute substantial volume commitments in the early development phases of the GEV [grid electric vehicle] market. The economic attractiveness of electric drive vehicles in certain applications—coupled with operational enhancements and targeted use of public policy levers—could drive grid-enabled vehicle penetration in U.S. commercial and government fleets to as much as 7 percent of new acquisitions by 2015. In aggregate, the market for EVs and PHEVs in fleet

50 Electrification Coalition, *Fleet electrification roadmap: Revolutionizing transportation and achieving energy security* (November 2010), p. 11; www.electrificationcoalition.org/reports/EC-Fleet-Roadmap-screen.pdf.

> applications could lead to cumulative unit commitments of more than 200,000 EVs and PHEVs between 2011 and 2015.[51]

The Electrification Coalition study found that there were about 16.3 million vehicles of all types in U.S. public and private fleets in 2009, of which 4.8 million were automobiles.[52] (Other vehicle classifications are also amenable to electrification in certain applications but are not relevant to the ZEV requirement.) Using the rule of thumb that California accounts for about 10% of the national total, this implies about 480,000 fleet-based automobiles in service in California.

In the California ZEV program, other than the regulation's encouragement of car-sharing applications there have not been policies specifically targeted at fleets. Concern has been expressed by some environmental groups that linking electric vehicles with fleet ownership in the public mind could undercut the image and desirability of electric vehicles. Moreover, past efforts to introduce alternative-fuel vehicles into the U.S. marketplace by focusing on fleets have not been successful. In ICCT's view, these concerns are outweighed by the advantages noted previously, and the ARB should pursue opportunities to introduce ZEVs into fleet applications. One specific suggestion is discussed in more detail in the following sections.

Although this project is focused on passenger vehicles, ICCT notes that battery electric and fuel cell electric zero-emission buses are also receiving considerable attention worldwide,[53] and progress in those applications will help to support increased deployment in the passenger vehicle arena.

Common Procurement

One way to catalyze fleet purchases is to work with businesses and environmental and local government stakeholders to establish specifications for a group purchase of a substantial number of electric vehicles and encourage private-sector institutions to participate. This approach is modeled after the group purchase of 50,000 electric vehicles that is being arranged by the French national government.[54] The recent announcement by General Electric that it plans to procure 25,000 plug-in vehicles by 2015[55] shows the potential for large purchases of this type.

The following description of the French initiative is taken from the Green Car Congress Web site.[56]

> The French central purchasing authority UGAP (l'Union des groupements d'achats publics) has issued a call for tenders for the grouped purchase of approximately 50,000 electric vehicles, announced earlier by Jean-Louis Borloo,

51 Ibid.
52 Ibid., p. 50.
53 See www.arb.ca.gov/msprog/bus/zeb/fcbdemos.pdf.
54 Green Car Congress, "UGAP launches call for tenders for purchase of 50,000 electric vehicles" (April 26, 2010); www.greencarcongress.com/2010/04/ugap-20100426.html.
55 www.businessweek.com/news/2010-11-11/ge-to-purchase-25-000-electric-vehicles-from-gm-rivals-by-2015.html.
56 Green Car Congress, "UGAP launches call for tenders," op. cit.

Minister for Ecology, Energy, Sustainable Development and Marine Affairs; and Christian Estrosi, Minister of Industry.

UGAP is coordinating the grouping of orders for 20 public and private stakeholders, including, in addition to itself, ADP, Air France, Areva, Bouygues, EDF, ERDF, Eiffage, Orange France Telecom, GDF Suez, GRT Gaz, GrDF, La Poste, RATP, SAUR, SNCF, SPIE, Suez Environment, Vinci, and Veolia. Three types of vehicles are being sought:

- A light commercial van with a load capacity of about 3 m^3;
- A two-seater compact van with a load capacity of approximately 1 m^3; and
- A passenger car with four or five seats.

The vehicles must be able to reach 110 km/h (68 mph) with maximum payload, and have a range of at least 150 km (93 miles) at the end of the warrantied battery life. One option is a recovery of 50 km (31 miles) of range after a 15-minute charge.

Vehicles must have an on-board charger and 5m cable, and support being connected to a standard electrical network (230 A/50 V/16 Hz single phase). Charge time must be less than 8 hours.

UGAP is calling the initial tender process a "competitive dialogue"; i.e., an exchange with each candidate on all aspects of the project. The purpose of the dialogue focuses on identifying and defining the means to best meet the needs of the group: the technology, the economic arrangements, after-sales services, and so on.

At the end of this phase of discussion, on the basis of proposals made, applicants will have to establish their final offer. Candidates will then deliver samples of each vehicle for testing. UGAP estimates a total value for the project of about €1 billion (US$1.3 billion) over four years.

The French energy agency (ADEME) has reported that the government hopes to build upon this program for an additional purchase of 100,000 electric vehicles in 2014. If adopted in California, this mechanism offers a way to harness private-sector resources to help sustain electric vehicle demand. In addition, to the extent that vehicles built in California meet customer needs and could be procured under the California program, such a policy would support California jobs. Private-sector participants in the program would benefit from a reduced purchase price for electric vehicles and would gain valuable publicity for their sustainability efforts.

Fuel Prices and Feebate Program

California offers an incentive of $5000 to encourage the purchase of electric vehicles, similar to vehicle purchase incentives offered in other jurisdictions. However, other jurisdictions have powerful fiscal incentives in place, notably (in the European Union) much higher fuel taxes. In addition, the French bonus/malus system provides an example of a revenue-neutral way to offer purchase incentives. Although

automakers have publicly supported an increase in the gas tax,[57] there are political obstacles to raising taxes. Nonetheless, it is clear that an increase in gasoline prices would markedly improve the electric vehicle total cost of ownership relative to conventional vehicles and thereby help to increase customer demand. Inclusion of transportation fuels in the cap-and-trade program is another way to provide an appropriate price for carbon.

Similarly, although recent legislative efforts have not been successful, the ARB should continue to work on the establishment of a California and/or national feebate program to provide a self-financing source of vehicle purchase incentives.[58]

BEYOND EARLY ADOPTERS—INCENTIVES FOR THE SECOND WAVE

At some point, the demand for ZEVs among early adopters will be fully satisfied. To move toward commercialization, it will be necessary to appeal to a broader range of customers. As noted in the Task 1 report, a recent study by Deloitte Consulting[59] identified a number of characteristics intended to single out those "most likely to buy immediately after the early adopter wave," including the following:

- Higher-than-average income ($114,000)
- Urban or suburban residence
- Private garage with electrical power
- Low weekly mileage (100 mi)
- Environmental sensitivity
- Concern about dependence on foreign oil
- Political activity
- Willingness to pay for convenience

Applying these filters to the U.S. population, the consultants estimated that a total of about 1.3 million people fall into this segment, which they dubbed the "early majority."

Additional Customer Concerns

The Deloitte study went on to note several barriers that electric vehicles face in appealing to this larger audience:

- Familiarity
- Brand identification

57 See, for example, http://money.cnn.com/2010/01/11/news/companies/lutz_gastax/index.htm.
58 For additional discussion of ARB feebate work, see www.arb.ca.gov/research/econprog/feebates/feebates.htm.
59 Deloitte Consulting, op. cit.

- Range
- Charging time
- Infrastructure availability
- Price and cost of ownership

Although range, charging time, infrastructure availability, and cost are familiar issues facing electric vehicles, it is important to note that moving toward a mass market raises additional issues beyond those that are relevant for early adopters. Many of these new concerns are related to the "familiarity" dimension identified by Deloitte. Early adopters by definition are more willing to try new technologies and make compromises, and are less concerned about risk. Mainstream customers will need to feel comfortable with their understanding of the technology and how it may or may not meet their needs. Before purchasing an electric vehicle, customers in the broader market will need to have a number of concerns addressed. Such concerns include:

1. *"Outlier" Needs.* Many families could easily switch to a second car with more limited range. But purchase decisions are often made on the basis of the "maximum" rather than the "average" functional need. Customers will be reluctant to purchase a vehicle that may not meet all of their needs.

2. *Risk.* Another important issue is risk aversion. Until the market matures and there is a history of operating experience, there will be a host of uncertainties associated with BEVs and PHEVs in customers' minds, including the fuel cost savings to be achieved, the cost of home charging equipment, how safe and convenient it will be to plug in the vehicle, the life of the battery, the reliability of the vehicle, the availability of service and repair, and the resale value.

   Few customers other than early adopters are immersed in the details of technology, so it will take a long time for the average consumer to become comfortable with his or her understanding of these issues. The ARB could serve as a trusted third-party source of information on relevant issues.

3. *Environmental Performance.* One of the fundamental customer appeals of electric vehicles and PHEVs is their "green" reputation as vehicles that minimize and potentially eliminate greenhouse gas and criteria pollutant emissions. However, because of the many pathways by which electricity and hydrogen can be produced, the real-world environmental impact of electric vehicles and PHEVs can vary markedly, and in any event is difficult for the average customer to determine. Although electric vehicle deployment in California clearly reduces emissions,[60,61] studies undertaken in other jurisdictions have come up with less

60 See ICCT Technology Innovation Project, Vehicle Electrification Policy Study, Task 1 Report: Technology Status.
61 http://articles.sfgate.com/2010-07-19/business/21988864_1_electric-cars-electric-vehicle-greenhouse-gas-emissions.

positive results,[62,63,64] and the U.K. Advertising Standards Authority has banned advertisements by Nissan and BMW that refer to "zero emissions."[65] Uncertainty or controversy over the environmental consequences of vehicle electrification will undercut the desirability of the vehicles in the eyes of mainstream customers. This issue is currently being considered in the context of the fuel economy/emissions label to be affixed to electric vehicles in California[66] and under the federal program.[67]

Possible Second-Wave Incentives

In addition to traditional incentives that address vehicle cost, new approaches will be needed to mitigate the issues noted earlier. Such incentives could be administered by vehicle manufacturers or dealers, but governmental agencies could help to initiate and support the effort. Possible approaches may include one or more of the following:

- *Loaner Conventional Vehicles:* To minimize the fear that an electric vehicle might not meet all needs, customers could be provided with vouchers for a predetermined number of loans of a conventional vehicle. Purchasers would be assured that the occasional need for a vehicle with greater range could be met. According to press reports, Nissan is considering a program of this type.[68]
- *Customer Trials:* Letting customers use the vehicles in their own circumstances is one good way to address a number of questions and concerns. Such trials could also include or be supplemented by a consumer education and outreach effort by government, auto manufacturers, dealers, utility companies, and other interested parties.
- *Customer Information:* Although the marketing of electric vehicles is the responsibility of the manufacturer, the ARB could provide a trusted source of third-party information regarding vehicle performance, durability, emissions, and other factors.
- *Guaranteed Resale Value:* Some manufacturers are planning to emphasize lease rather than sale of electric vehicles to minimize risk to the consumer. For customers who wish to purchase the vehicle, an up-front guarantee of resale value would help to mitigate concerns about buying a technology that may rapidly become obsolete as newer and better versions emerge. Note, however, that if this guarantee is provided by the government, it could provide a perverse incentive for manufacturers to ignore durability concerns.
- *Enhanced Warranty Coverage:* Providing better-than-usual warranty coverage

62 www.wheels.ca/reviews/article/784439.
63 www.theregister.co.uk/2010/08/31/battery_cars_destroy_the_world/.
64 www.guardian.co.uk/environment/2010/may/25/electric-cars-carbon-emissions.
65 www.brandrepublic.com/news/1018827/bmw-zero-emissions-ad-banned/.
66 www.arb.ca.gov/msprog/levprog/leviii/meetings/111610/eplabel_11_10.pdf.
67 http://epa.gov/fueleconomy/label/420f10048.pdf.
68 www.autorifi.com/story/nissan-to-possibly-loan-conventional-vehicles-to-leaf-buyers-at-no-cost.

would help to address uncertainties regarding vehicle reliability and durability. One variation on this theme that has been recommended is the formation of a "Federal Battery Guarantee Corporation" to provide insurance on battery life for the duration of the vehicle warranty.[69] This concept would best be applied at the federal level, but a state-level approach could be explored in the absence of federal action. The Electrification Coalition report on fleet deployment contains a detailed proposal for a similar mechanism, and also recommends as an alternative or supplemental approach the establishment of a tax credit to offset 33% of any losses incurred by an insurer or reinsurer who insures or reinsures the residual value of vehicle batteries.[70] As noted by the authors of the Federal Battery Guarantee Corporation concept, such a guarantee would have the same "moral hazard" issues that would arise with a guarantee of resale value: Does too much of a safety net inadvertently reduce manufacturers' diligence in their performance engineering? The authors argue that on balance the policy is worth pursuing; in ICCT's view this idea is worthy of further study, but not currently recommended because of the potential to undercut manufacturers' incentive to provide durable vehicles.

- *Renewable Electricity and Hydrogen:* Various mechanisms could be explored to facilitate access to renewable energy by automakers and third-party electric vehicle service providers. Purchasers of electric vehicles and PHEVs could then be provided with renewable electricity at their home, perhaps at no additional cost, which would confer a marketing advantage as well as provide environmental benefits. "Direct access" to wholesale generation is strictly limited in California, so other approaches should be considered, including on-site generation and "renewable electricity credits" that comply with the California Renewable Electricity Standard (RES). Mechanisms will be needed to address providers of public charging services and to ensure that electric vehicles are indeed procuring additional renewable generation rather than just reshuffling existing resources.

69 B. Hendricks & B. Goldstein, Federal policy options to support early electric vehicle deployment by reducing financial and technological risks. In D. B. Sandalow, Ed., *Plug-in electric vehicles: What role for Washington?* (Brookings Institution Press, Washington, DC, 2009).

70 Electrification Coalition, *Fleet electrification roadmap*, op. cit., p. 135.

RECOMMENDATIONS

In light of the foregoing discussion, ICCT recommends the following:

- *Research*
  - » Incentives should continue to focus on research and development as well as deployment. Given that a number of major vehicle manufacturers have begun to offer new electric vehicle designs, it may be tempting to conclude that the technical issues have been resolved. As was noted in the Task 1 report, however, important technical challenges remain and investment in ongoing development is still warranted.
- *Infrastructure*
  - » Work should continue on a variety of approaches to ensure the systematic deployment of hydrogen infrastructure, including continuation of state funding for initial stations during the demonstration phase, exploring low-cost financing options, collecting and distributing technical and market data through the California Fuel Cell Partnership, recycling a portion of the value of cap-and-trade program allowances, evaluating favorable tax treatment, providing lower thresholds for the Clean Fuels Outlet, ensuring land availability, and evaluating how the Low Carbon Fuel Standard can best support ultraclean fuels.
  - » The ARB should continue its efforts to forge a mutual commitment among auto companies and fuel providers that vehicle and infrastructure deployment will proceed hand in hand.
  - » The data-driven approach to electric infrastructure deployment recommended by the California Plug-In Electric Vehicle Collaborative should continue to be pursued by the appropriate state agencies. In general, ICCT urges caution regarding the pace of installation of additional public infrastructure to reduce the potential for stranded assets and overreliance on daytime charging.
  - » The ARB should explore the use of on-bill financing and property-assessed clean energy (PACE) to allow loans for infrastructure installation to be tied to the property, thus allowing for longer loan terms.
- *Deployment*
  - » The ARB should encourage the development of programs that allow for placement of electric vehicles in community centers or other facilities in low-income neighborhoods to provide some access to these emerging technologies.
  - » The ARB should monitor developments with regard to additional uses of vehicle batteries and determine whether there is a role for state action.

- The ARB should provide additional focus on fleets as an early market for electric vehicle passenger vehicle deployment.
- The ARB should promote the common procurement of a substantial number of electric vehicles in the 2013 time frame.
- The ARB should pursue policies that put a price on carbon, resulting in higher prices for conventional fuels.
- The ARB should pursue adoption of a feebate program that will provide a self-financing ongoing price incentive for low-carbon vehicles.
- The ARB should begin to develop a package of incentives directed at the "second wave" of customers and vehicle deployments, focused on the time frame of 2014 through 2018. Elements of the package should include loaner conventional vehicles, customer trials, customer information, and provision of renewable electricity and hydrogen to vehicle owners.
- Two other possible approaches—guaranteed resale value and enhanced warranty coverage—are worthy of further study, but these are not currently recommended because of the potential to undercut manufacturers' incentive to provide durable vehicles.

The International Council on Clean Transportation is an independent nonprofit organization that works directly with regulatory agencies and policymakers to control greenhouse gas emissions and conventional pollution in the transportation sector. The ICCT provides scientifically sound, technically rigorous analysis to inform the design, implementation, and enforcement of vehicle efficiency and fuel standards in countries accounting for 80 percent of the global automotive market, including China, the European Union, the United States, India, Brazil, South Korea, and Mexico.

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