Research Division
Contractor: Regents of Univiersity of Calif, Davis
Contract # 08-312

FUNDING FISCAL YEAR	FY 08/09	FY 09/10	FY 10/11	
TERM	01/01/09-08/01/10	01/01/09-08/01/10	01/01/09-08/01/10	
PCA	72350	72350	72350	
LINE ITEM/OBJECT	418.20	418.20	418.20	TOTAL
DESCRIPTION	Analyze implementation of feebates			
Contract $	$ 557,649.00	$ 159,328.00	79,664.00	$ 796,641.00
				$ -
				$ -
Total, Contract	$ 557,649.00	$ 159,328.00	$ 79,664.00	$ 796,641.00

Payments to Contractor:

Inv. #	Inv. Date	Ser Per				C/S
83477-1	4/13/2009	01/09 - 03/09	34,754.86		34,754.86	C090128
Total, Payments			$ 34,754.86	$ -	$ -	34,754.86
Balance Available to Pay Contractor			$ 522,894.14	$ 159,328.00	$ 79,664.00	$ 761,886.14
Balance Must Be Spent By:			*6/30/2011*	*6/30/2012*	*6/30/2013*	

Notes:

Contract Manager: Fereidun Feizollahi

1

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W:\Contracts\ARB\FY 08-09\08-312y UCD Regents.xls
11/19/2009

RCVD APR 16 '10

UNIVERSITY OF CALIFORNIA, DAVIS
Accounting & Financial Services Office
Extramural Accounting

Please include the following claim number on your remittance advice:
Claim No. X23024

CONTRACTOR'S INVOICE

INVOICE TO

AIR RESOURCES BOARD
RESEARCH DIVISION
1001 I STREET, 5TH FLOOR
SACRAMENTO, CA 95814
ATTN: EMMA PLASENCIA

Invoice Number: **83477-1**
Date: April 13, 2009
Amount: **$34,754.86**

Direct questions regarding this invoice to **Sheila Lame' at (530) 754-9532 or sllame@ucdavis.edu**

Federal Employer ID # 94-6036494

Contract/Grant/Agreement/Purchase Order **#08-312**

Period Billed	
From	To
01/01/09	**03/31/09**

Project Title: **Potential design, implementation & benefits of a feebate program**
PI /Director: **David Bunch**
Department: **Institute of Transportation Studies**

Description of Services	
PER TERMS OF INTERAGENCY AGREEMENT	
	RCVD AUG 11 2009
Salaries	$24,935.30
Benefits	$1,205.81
Supplies & Expenses	$1,385.39
Indirect Costs @ 10.0%	$2,752.66
Graduate Student Fee Remission (Benefits exempt from Indirect Costs)	$4,475.70
Please Return Invoice Copy with Check **PAY THIS AMOUNT>>>>>**	**$34,754.86**

Remarks:
OUTSTANDING INVOICES:

for James Ringo
Kathleen Hass/sml, Extramural Funds Division Manager

Make Check Payable and Remit To:
The Regents of The University of California
Cashier's Office
P.O. Box 989062
West Sacramento, CA 95798-9062

To the best of my knowledge and belief this report is correct and complete, and all outlays are for the purposes set forth in the award documents.

STATE OF CALIFORNIA
STANDARD AGREEMENT
STD 213 (Rev 06/03)

AGREEMENT NUMBER
08-312
REGISTRATION NUMBER

1. This Agreement is entered into between the State Agency and the Contractor named below:

STATE AGENCY'S NAME
Air Resources Board (ARB or State)

CONTRACTOR'S NAME
The Regents of the University of California, Davis (UCD, University, or Contractor)

2. The term of this Agreement is: January 1, 2009 through August 1, 2010

3. The maximum amount of this Agreement is: **$796,641.00**
(Seven hundred ninety-six thousand six hundred forty-one dollars and no cents)

4. The parties agree to comply with the terms and conditions of the following exhibits which are by this reference made a part of the Agreement.

Exhibit A – Scope of Work	1 Page
Exhibit A - Attachment 1	90 Pages
Exhibit B – Budget Detail and Payment Provisions	2 Pages
Exhibit B – Attachment 1	55 Pages
Exhibit C* – General Terms and Conditions	GTC 307
Check mark one item below as Exhibit D:	
☒ Exhibit - D Special Terms and Conditions (Attached hereto as part of this agreement)	1 Page
☐ Exhibit - D* Special Terms and Conditions	
Exhibit E – Additional Provisions	8 Pages
Exhibit F – Research Report Format	6 Pages

Items shown with an Asterisk (*), are hereby incorporated by reference and made part of this agreement as if attached hereto. These documents can be viewed at www.ols.dgs.ca.gov/Standard+Language

IN WITNESS WHEREOF, this Agreement has been executed by the parties hereto.

CONTRACTOR

CONTRACTOR'S NAME *(if other than an individual, state whether a corporation, partnership, etc.)*
The Regents of the University of California, Davis

BY *(Authorized Signature)*
DATE SIGNED *(Do not type)* DEC 29 2008

PRINTED NAME AND TITLE OF PERSON SIGNING
Ahmad Hakim-Elahi, Ph.D., JD, Director of Sponsored Programs

ADDRESS
Office of Research, Sponsored Programs
18950 Research Park Drive, #300, Davis, CA 95618

STATE OF CALIFORNIA

AGENCY NAME
Air Resources Board

BY *(Authorized Signature)*
DATE SIGNED *(Do not type)* 12/30/08

PRINTED NAME AND TITLE OF PERSON SIGNING
Socorro Watkins, Chief, Business Management Branch

ADDRESS
P.O. Box 2815, Sacramento, CA 95812

California Department of General Services Use Only

APPROVED
DEC 30 2008
DEPT OF GENERAL SERVICES

☐ Exempt per:

EXHIBIT A

SCOPE OF WORK

1. The Regents of the University of California, UCD (UCD, University, or Contractor) agrees to provide the following services for the project entitled "Potential Design, Implementation, and Benefits of a Feebate Program for New Passenger Vehicles in California," which is attached hereto as Attachment 1 and made a part of this Agreement.

2. The project representatives during the term of this agreement will be:

Requesting Agency: ARB	**Providing Agency:**
Name: Fereidun Feizollahi	Name: Drs. David L. Green & David S. Bunch
Research Division	Institute for Transportation Studies
1001 "I" Street	University of California, Davis
Sacramento, CA 95814	One Shields Avenue Davis, California 95616
Phone: (916) 323-1509	Phone: (530) 752-2248
Fax: (916) 322-4357	Fax: (530) 752-2924
Email: ffeizoll@arb.ca.gov	Email: dsbunch@ucdavis.edu

The ARB Contract Administrator is: The University's Contract Administrator is:

Requesting Agency: ARB	**Providing Agency:**
Emma Plasencia	Paula Noble
Research Division	Contract & Grants Analyst
Contracts Analyst	Office of Research, Sponsored Programs
1001 "I" Street, 5th Floor Sacramento, CA 95814	1850 Research Park Drive, Suite 300 Davis, CA 95618
Phone: (916) 323-1524	Phone: (530) 754-8115
Fax: (916) 322-4357	Fax: (530) 754-8229
Email: eplasenc@arb.ca.gov	Email: pnoble@ucdavis.edu

TECHNICAL PROPOSAL

Potential Design, Implementation, and Benefits of a Feebate Program for New Passenger Vehicles in California

Principal Investigators:

Dr. David L. Greene
Visiting Researcher
Institute for Transportation Studies
University of California, Davis
Corporate Fellow
Oak Ridge National Laboratory

and

Professor David S. Bunch
Graduate School of Management
& Institute for Transportation Studies
University of California, Davis

Official Authorized to Bind this Proposal:

_____
Paula Noble, Contracts & Grants Analyst

Prepared for:
State of California Air Resources Board
Research Division
P.O. Box 2815
Sacramento, CA 95812

Prepared by:
University of California, Davis
One Shields Avenue
Davis, California 95616
(530) 752-6548

October 22, 2008

Check if applicable:
Animal subjects_____
Human subjects__X__

TABLE OF CONTENTS

B. TECHNICAL PROPOSAL

I. Technical Proposal

c. Statement of significance....3
d. Abstract....4
e. Project Objectives....5
f. Technical Plan....6
1. Research methods....6
2. Tasks....8
i. Lessons learned....9
ii. Focus Groups and Dealer/Salesperson Interview....9
iii. Policy Formulation....11
iv. Feebate Analysis Model....12
v. Policy Analysis....27
vi. Policy Implications of Program....28
vii. Statewide Survey....32
3. Data management plan....32
4. Human Subjects....33
5. References....35

II. Project Schedule....37

III. Project Management Plan....38
a. Roles and Responsibilities....39
b. Project Management (incl. org. chart)....40
c. Curricula Vitae
David Greene, PhD....41
David Bunch, PhD....61
Yueyue Fan, PhD....63
Christopher Knittel, PhD....66
Tim Lipman, PhD....74
Daniel Kammen, PhD....76
Susan Shaheen, PhD....78
Caroline Rodier, PhD....80
Walter McManus, PhD....82
K.G. Duleep....84

IV. Related Research....87

V. Publications List....88

C. Cost Proposal

I. Budget Submittal Forms (attached as separate Excel file)
II. Cost Breakdown by Task....91

c. Statement of Significance

The Global Warming Solutions Act of 2006 (AB 32) calls for California's greenhouse gas (GHG) emissions to return to 1990 levels by 2020. The transportation sector produces 38% of greenhouse gas emissions in California and passenger vehicles are the source of 74% of the emissions within the sector. Emissions reductions can be achieved through a combination of approaches, including: improved vehicle technology, shifts to alternative fuels, and reduction in vehicle miles traveled. The Air Resources Board (ARB) is charged with the responsibility of evaluating and implementing regulatory policies to bring about these changes. California has passed legislation (Pavley AB 1493) requiring improved vehicle technology to reduce GHGs. California applied for a waiver as required under the Clean Air Act but the application was denied by the EPA. California and other states are challenging a U.S. EPA decision preventing implementation of the Pavley standards and expect to prevail. Yet AB 32 requires that if Pavley does not remain in effect, ARB shall implement alternative regulatory options to achieve equivalent or greater GHG reductions. (HSC §38590) ARB plans to pursue a feebate program to backstop the Pavely regulations if they cannot be implemented or to complement them if additional cost-effective emissions reductions are available. Should the Pavley waiver be granted during the course of this research, it would not affect the assessment of lessons learned or the development of the feebate analysis model. However, it would shift the emphasis of the focus groups, survey and stakeholder interviews to give greater emphasis to feebates as a complement to the Pavley regulations.

Feebates are a market-based policy for encouraging GHG emission reductions from new passenger vehicles by levying fees on relatively high-emitting vehicles and refunding the revenue generated to purchasers of lower-emitting vehicles. Feebates may serve as a complement to California's Pavley standards by providing a continuing economic incentive for manufacturers to adopt technologies that reduce GHG emissions as well as a continuing economic incentive to consumers to purchase cleaner vehicles. Feebates could also serve as a replacement for the Pavley standards in the event that California is unable to obtain a waiver for the Pavley standards under the Clean Air Act because feebates can be designed to achieve cumulative GHG mitigation equivalent to or greater than the Pavley standards.

The purpose of this research project is to provide a comprehensive study of feebates that meets the decision-making needs of ARB by addressing issues essential to the practical design and implementation of a feebate program for California. Specific options for possible California feebate systems will be developed based on previous work and studies in the literature, insights from investigating currently functioning feebate programs, and through consultation with ARB staff. A rigorous, quantitative model of vehicle market behavior will be developed to provide a tool for evaluating alternative feebate programs under various market scenarios. The model will represent manufacturers' decision making with regard to in-use vehicle GHG emissions, estimate the impacts on consumers' decisions about new and used vehicle choices, vehicle ownership and use, and provide the data necessary for calculating the impacts on GHG emissions over time. In addition, implications for revenue flows and management of the feebate programs, administrative costs, potential unintended consequences, equity concerns, and interactions between feebates and other possible AB 32 programs will also be investigated. Federal fuel economy standards as specified by the Energy Independence and Security Act of 2007 and implemented by rulemakings of the National Highway Traffic Safety Administration (NHTSA) will be assumed to be in force. The NHTSA is expected to issue a final rule on passenger car and light truck standards through 2015 by the end of calendar year 2008. Specific designs of feebate systems and specific implementation strategies to be analyzed will be determined after consultation with ARB staff. Market research will be conducted to better understand how consumers, auto dealers, manufacturers and other stakeholders are likely to respond to alternative feebate program designs. Based on these activities, and in consultation with ARB staff, the project will synthesize these research results into an overall evaluation and characterization of candidate feebate program options for ARB's consideration.

d. Abstract

The objective of the California feebate research project is to provide a California specific assessment of two options: (i) a feebate program implemented in place of the Pavley standard to achieve equivalent or greater GHG reductions and (ii) a feebate program in combination with Pavley to achieve additional reductions beyond those expected by the Pavley program. The study will assess options for elements of the design of the feebate program including fee and rebate levels, structure of benchmarks, implementation strategies, point of regulation, consumer and manufacturers responses, and interactions with other AB 32 programs. The information provided will be structured to guide ARB in a potential rulemaking on a feebate system for the State.

Task 1 will infer lessons learned from past and current real world experience with feebate and feebate like systems. The cases evaluated will include France's experience with its current feebate system, the Canadian government's experience with its briefly implemented feebate system, and the Province of Ontario's experience. Other countries reported to have tried feebate (e.g., Denmark and Austria) will be investigate. The U.S. gas guzzler tax (the fee half of a feebate system) will also be examined.

Consumers' perceptions of alternative feebates systems are likely to strongly influence their effectiveness. Task 2 will conduct two sets of focus groups to learn how consumers are likely to react to different feebate programs. The first set will explore consumer's attitudes toward vehicle GHG mitigation policies and feebates in general. The second set will present consumers with specific alternatives.

Feebates can be formulated in many different ways. Task 3 will develop specific formulations to be evaluated by this research project and define the context in which they will be evaluated. The principal investigators will conduct a half-day workshop for ARB staff to explain the key options and their implications, and discuss the pros and cons of alternatives with ARB staff. The outcome will be a set of alternative structures (feebate rates, pivot points and points of regulation) and implementation strategies to be analyzed.

In task 4, a comprehensive feebate analysis model for the present to 2020 will be developed and tested. The model will integrate manufacturer decision making about vehicle design and technology adoption at a national and regional scale with California consumers' decisions about vehicle choice, ownership and use. A detailed, disaggregated model of California households' vehicle choice, ownership and use behavior will be developed to predict the impacts of the feebate systems, given manufacturers' design and product introduction decisions. The model will estimate impacts on new passenger vehicle GHG emissions, changes in the mix of vehicles sold, consumers' surplus by demographic and income group, manufacturers sales and revenues, and feebate revenue flows.

In task 5, the comprehensive feebate model will be used to analyze the impacts of the feebate policies formulated in task 3. The impacts of feebates will be assessed both as a replacement and as a supplement for Pavley. Should the Pavley waiver be granted during the course of the research, greater emphasis will be placed on feebates as a complement to the Pavley regulations. Preliminary results will be presented to ARB staff in a formal briefing by the principal investigators. Final adjustments to the policy strategies will be made, if necessary, and a final assessment completed.

Task 6 will assess policy implications, administrative costs, impacts on state revenues, potential unintended consequences, interactions with other AB 32 measures, and implications for the incidence on different demographic and income groups of program impacts.

Task 7 will carry out a state-wide survey of consumers to determine the perceptions, preferences and concerns of California households with respect to various state feebate programs.

e. Project objectives

The main objective of this project is to provide the ARB with a California-specific assessment of feebate programs for new vehicles as a replacement for the Pavely standards or as a complement to the Pavley standards.

This study of feebates is needed to insure that the maximum feasible and cost-effective reduction of GHG emissions from new passenger vehicles is achieved. In 2004, the ARB approved regulations to reduce the GHG emissions from new passenger vehicles beginning in model year 2009 and phasing in through the 2016 model year. The regulations apply to four GHGs: carbon dioxide, methane, nitrous oxide and hydroflourocarbons. As required by the Clean Air Act, California applied for a waiver before implementing vehicle tailpipe emissions standards but the U.S. EPA denied the waiver. Although California and other states are challenging the denial in court and expect to prevail, AB 32 Section 38590 requires that the State implement alternative measures to achieve equivalent or greater reductions in GHG emissions should Pavley not remain in effect. A feebate program has been identified by ARB as a key alternative measure that could achieve equal or greater reductions in GHG emissions. A feebate program would combine rebates for low-emitting vehicles with fees for high-emitting vehicles. Fees and rebates would be determined based on the difference between a vehicle's emissions rate and a reference rate, or benchmark. The objective of the feebate program would be to cost-effectively achieve GHG reductions equivalent to the Pavley reductions of 31.7 $MMTCO_2E$. ARB is also considering a feebate program as a complement to the Pavley standards to achieve maximum feasible and cost-effective GHG reductions. Should the Pavley waiver be granted, it would still be useful to ARB to understand how a feebate system would function in the absence of the Pavley regulations but with other federal programs in place. The emphasis of the research, however would shift towards understanding the potential role of feebates as a complement to Pavley and determining whether and how much additional reduction in GHG emissions might be cost-effectively achieved by the addition of a feebate program.

Because of the differing contexts, it is very likely that feebate programs to replace Pavley and to complement Pavley would be designed differently. This study will assess options for program design including fee and rebate rates and structures, alternative designs for benchmarks, alternative points of regulation (manufacturer versus consumer/dealer), and alternative implementation strategies. It will extract lessons to be learned from real world experience with feebate and feebate-like programs. Consumers' perception and likely response to alternative feebate systems will be studied. Views of manufacturers, car dealers and other stakeholders will be solicited and considered. Alternative design strategies will be meticulously defined in consultation with ARB. Rigorous analytical tools will be developed to estimate the impacts of alternative designs on new passenger vehicle GHG emissions, consumer welfare, manufacturer sales and revenues, feebate revenue streams (especially achieving revenue neutrality), administrative costs, State finances and economic impacts.

The resulting information will be organized and presented so as to successfully guide ARB in a potential rulemaking on feebate systems for the State.

f. Technical plan

1. Research methods

This research project will comprehensively design and assess two general options for a California GHG feebate program. The first will be a feebate-only program to replace the Pavley standards. The second will be a feebate program implemented in combination with the Pavley standards. In both cases the federal CAFE standards as mandated in the Energy Independence and Security Act of 2007 will be assumed to be in effect. The study will address the design of the feebate system, strategies for implementing it over time, its effects on consumers and automobile manufacturers and their responses to it, and interactions with other AB 32 programs.

The complexity of this research calls for an array of research methods. Determining the lessons to be learned from previous experience with feebate or feebate-like policies will require interviewing the key personnel responsible for designing, implementing and managing the programs, collecting data on program impacts, revenue flows and related information, as well as drawing on evaluation studies.

Developing an understanding of consumers' perceptions of feebate systems will be based primarily on facilitated focus group interviews and a sample size 3,000 (completed) statewide survey using standard methods of market research. Focus group protocols will be carefully designed, pre-tested, and cleared by the University of California Institutional Review Board (IRB)/Office for the Protection of Human Subjects, as will be the statewide survey "instrument." The focus groups will take place in two rounds – early and later in the project – and will be conducted in both English and Spanish.

Modeling manufacturers' and consumers' responses to feebate systems is undoubtedly the most complex research task. Manufacturers seek to maximize profits, given the cost and potential of technology for mitigating vehicle GHG emissions, their own product lines and future product plans, fuel economy and GHG emissions standards, and the financial incentives created by the feebate program. We will employ rigorous methods of mathematical programming, together with detailed data on manufacturers' product offerings and the costs and potentials of mitigation technologies to create a model simulating manufacturers' decisions, over time, in response to a feebate program and related policies. Technology and cost data are available from a number of sources, including the ARB, NESCAFF, EPA, NAS and Energy and Environmental Analysis, ICFI, Inc., a key subcontractor to this project. EEA, ICFI will also supply a detailed database of vehicles offered for sale in the U.S. in the base year, their prices and technical attributes, their expected date of major redesign, and their base-year use of GHG mitigation technologies. Detailed data on vehicle sales for California and GHG emissions rates will be obtained from the ARB, while sales data for the Northeast States and Rest of US will be purchased from R.L. Polk & Co or other reliable source. Manufacturers will be assumed to optimize an objective function subject to technology and regulatory constraints.

Importantly, there will be considerable interaction among key project tasks, particularly including the lessons learned, consumer research, and policy formulation tasks (Tasks 1, 2, 3, and 7). Information from the lessons learned assessment and an early round of focus groups will help to shape both the types of policies that will be examined in the policy formulation task and the design of the statewide survey. The statewide survey results will further inform the final selection of feebate policy structures for the analysis, and then a final round of focus groups will help the team to understand how the "downselected" set of potential feebate policy structures may be perceived by the general public, also based on insights gleaned from the statewide survey results.

With regard to the key market simulation modeling task, past studies have specified objective functions representing cost minimization and consumer, or consumer and producer, surplus maximization. The

manufacturer decision model will require a representation of manufacturers' perception of how consumers will respond to changes in vehicle prices, feebates and induced changes in fuel costs. Previous studies have successfully employed representative consumer nested multinomial logit (NMNL) models to represent consumers' demands in regions with and without feebate systems. Based on what has already been documented in the scholarly literature, we are confident that a multi-period, multi-region manufacturer decision model can be successfully developed that will make credible changes to existing vehicle designs to incorporate proven and near-market-ready GHG mitigation technologies. These changes can be handed off to a model of vehicle choice in California to estimate the impacts of alternative feebate programs in California.

A detailed, disaggregated model of consumers' choices among vehicle types, ownership and use levels is required for assessing the impacts of feebate programs in California. Professors Bunch and Brownstone have extensive experience in specifying and estimating such models in general and for California in particular. The models are rigorously grounded in consumer utility theory and make use of state-of-the-art random utility modeling and econometric estimation methods. Disaggregating households by demographic and income attributes not only enables more precise predictions but also permits impacts on different population groups to be assessed. By integrating vehicle choice with ownership and use, impacts of feebate programs on used vehicle markets and overall vehicle travel can be quantitatively estimated. The representative consumer model for California used in the manufacturer decision model will be calibrated to serve as a reduced form version of the full California vehicle choice model. Representative consumer models for the Northeast states and Rest of US will either be calibrated based on the existing literature on vehicle choice or, if possible, to regional models estimated using the same methods used to develop the California vehicle choice model. The will chiefly depend on the availability of appropriate data for all three regions.

Beyond the sequential decision making approach described above, it may be possible to create an integrated model that simultaneously determines manufacturer design, and production decisions, consumers' choices and market equilibrium prices. However, such a model has not been developed before at the level of detail and complexity required for this study. Several difficult issues remain that may or may not be solvable. For example, profit rates and production costs for individual makes, models and configurations of vehicles are deemed highly proprietary by manufacturers and are therefore generally unavailable. Furthermore, in reality manufacturers do make design decisions two or more years in advance of production, suggesting that a sequential modeling approach may be more realistic. Thus, whether or not it is possible or even desirable to construct a full equilibrium model remains an open research question. The question will be decided in the course of the research based on the adequacy of historical data for calibrating a simultaneous market model for three U.S. regions and the degree to which valid simulations can be made in the absence of information on the cost and profit functions for individual makes, models and configurations.

2. Task Descriptions

The research will be carried out in seven tasks. These are: Task 1: Lessons Learned; Task 2: Focus Groups and Interviews; Task 3: Policy Formulation; Task 4: Feebate Analysis Model; Task 5: Policy Analysis; Task 6: Policy Implications; Task 7: Statewide Survey.

Figure 1, below, shows how tasks will interrelate in the context of the overall project.

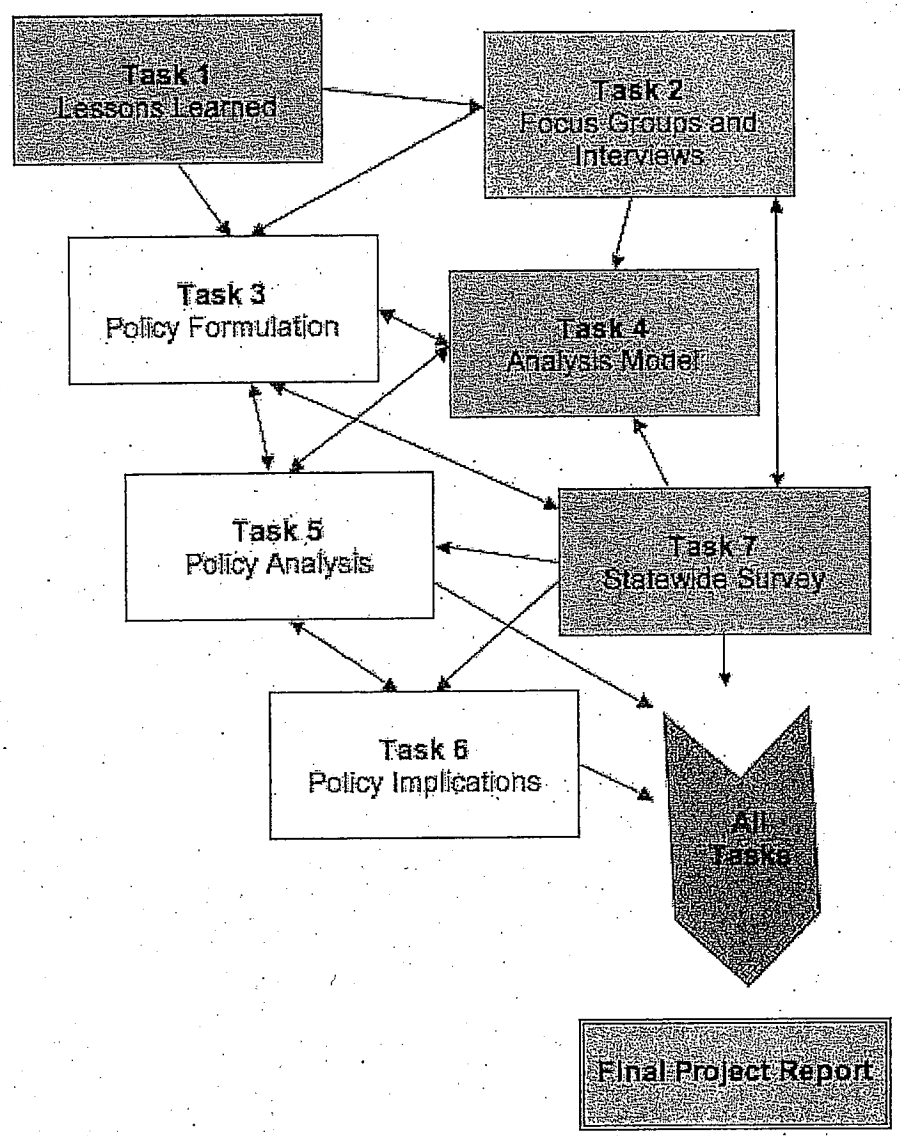


Figure 1: Task Influence Diagram

Task 1: Lessons Learned

This task includes eight to twelve interviews with experts involved in current feebate and "gas guzzler tax" programs around the globe (e.g., in Ontario, Canada; France; Denmark; Norway/Northern EU; etc.), as well as those involved in feebate dialogues in the past in the United States and California (e.g., automobile manufacturers, advocacy groups, governmental agencies, legislature, academics, etc.). Representatives of major auto companies will also be interviewed to get their impressions of how feebate programs and other vehicle pricing strategies have worked in the past, and how they might respond to a new feebate program in California and other states. Published studies and publicly available reports will also be drawn upon. Of particular interest are experts familiar with AB 493 (the California Clean Car Discount bill), which expired without passing in February 2008 and the Drive+ program (ca. 1990) that also failed to pass, despite a great deal of support. A key goal is to understand barriers to feebate deployment and successful implementation, particularly in terms of how the public has reacted to the programs. Additional key areas of investigation will include assessment of the policy and administrative issues and considerations that have come up as the programs have been proposed and implemented, and any lessons that can be learned from past use of differential vehicle registration fees, for example to encourage purchases of cleaner or more efficient vehicles.

The expert and automaker interviews will be conducted primarily by telephone, except where in-person meetings can be arranged within the project travel budget. No international travel is included in this task. This task will be co-led with UC Davis by Dr. Susan Shaheen and Dr. Tim Lipman of UC Berkeley's Transportation Sustainability Research Center (TSRC). Human subject's approval must be granted by both the UC Berkeley and Davis campuses prior to proceeding with the interviews. Results of this task will help to inform the efforts in Task 3 - "Policy Formulation," Task 4 - "Feebate Analysis Model," Task 6 - "Policy Implications of Program," and Task 7 – "Statewide Survey."

Deliverables:
-- Summary report on lessons learned, to be included in the final report.

Task 2: Focus Groups and Dealer/Salesperson Interviews

This task is focused on assessing the potential consumer perceptions and response to the feebate schemes developed in earlier tasks, as well as dealer perceptions. Responses will be studied on potential public support for feebate schemes, if enacted. This task will be led by Dr. Susan Shaheen of UC Berkeley's TSRC. It consists of two key steps: 1) focus groups and 2) interviews with new vehicle dealers and salespersons. Human subject's approval must be granted by both the UC Berkeley and Davis campuses prior to proceeding with these steps.

Focus Groups:
Consumer response to feebates will be explored via a total of twelve (12) focus groups (including four (4) urban, four (4) suburban, and four (4) rural groups). Six exploratory focus groups will be held at the start of the study, and another six will be conducted toward the end of the study to evaluate policy options developed as part of earlier study tasks. Of these, two (2) of the twelve will be conducted in Spanish and ten (10) will be conducted in English.

The six (6) initial study focus groups (including two (2) urban, two (2) suburban, and two (2) rural groups) will be conducted with consumers that intend to purchase a car within the next year or two or have purchased a new car in the past two years. Recruitment for the focus groups will be performed by a well-regarded market research firm, using web-based recruitment tools and other recruitment techniques available to the firm (e.g. existing databases of potential study participants to draw from). Study participants will be offered an incentive of $100 to participate in a focus group.

The focus groups will begin with an overview of GHG emission standards and feebates to provide participants with background information for the discussion. The exploratory discussion will include:

- Vehicle GHG emission standards (Pavley program) vs. feebates;
- Vehicle GHG emission standards (Pavley program) in conjunction with feebates;
- Are feebates viewed as a "tax" or as an opportunity to purchase a cleaner or more desirable (to the buyer) vehicle?
- Manufacturer-level applied feebate vs. consumer level feebate;
- Discussion of additional feebate structures/issues, including feebate per manufacturer fleet or per vehicle class;
- Discussion of clean fuels/advanced technology vehicles in relation to feebates;
- Potential social stigma and "halo" effects resulting from the feebate program; and
- Hypothetical responses to different consumer feebate structures based on input from study tasks (described above).

Initial focus group results, along with lessons learned from expert interviews, will then be used to develop a statewide survey (described below), and to inform the design of feebate policies in task 3.

A second set of six focus groups (including two (2) urban, two (2) suburban, and two (2) rural groups) will be conducted midway to two-thirds of the way through the project, with exact timing to be determined depending on when the researchers feel they would be of most use (i.e., just before or after the statewide survey). This second set of focus groups will also be conducted with consumers that might be about to purchase or have recently purchased a new car to evaluate participant response to feebate policy options.

Interviews with New Vehicle Dealers and Salespersons:
If consumer feebates are implemented, the role of explaining the fee or rebate associated with different vehicle choices will fall primarily to new vehicle dealers/salespersons. Eight to ten interviews will be conducted with new car dealers/salespersons to gain a stronger understanding of their perceptions/opinions regarding feebates, how they think their customers might respond, and what message/language regarding feebates would be useful for consumers. Interviews will be approximately 30 minutes and will likely be conducted via telephone. In-person interviews could be conducted, if appropriate. Note that the success of this research step is dependent on the willingness of car dealers to participate in the interviews. To this end, the researchers will seek the cooperation of the California Automobile Dealers Association in recruiting and scheduling interviews. Interview topics include:

- Awareness of AB 493?
- Overall opinion of feebates (once explained);
- Potential impact on consumer choice of vehicle GHG emission standards (Pavley program) vs. feebates;
- Are feebates likely to be viewed as a tax or as an opportunity to purchase a more desirable vehicle by their customers?
- Anticipated impact on individual sales representatives and the business; and
- Hypothetical responses to different consumer feebate structures based on input from economic analysis.

Deliverables:
-- Summary of focus group results, which will be included in the final report.

-- Summary of interviews with new vehicle dealers and salespersons, which will be included in the final report.

Task 3. Policy Formulation

While design details can vary greatly, all feebate systems share certain structural elements. One key element of any feebate program is the pivot or benchmark point: vehicles with emission rates above the benchmark are subject to fees, whereas vehicles with emission rates below the benchmark obtain rebates. There may be one or many benchmarks (e.g., for different vehicle classes) or benchmarks may defined as a function of vehicle attributes (e.g., weight or footprint). A second critical design element is how fees/rebates vary as a function of distance away from the pivot point. The most commonly analyzed functional form is linear: the fee (or rebate) is equal to a constant multiplied by the difference between the vehicle's emissions rate and the benchmark rate. The feebate rate determines the marginal value of reducing a vehicle's GHG emissions and is therefore the principal driver of manufacturers' responses to a feebate system. A third essential design question is the point at which feebates will be transacted. Feebates may be enforced at the level of the vehicle manufacturer, in which case there will be a small number of parties involved and most "transactions" will be internal to the firm. Under such a system feebates may be reported to car buyers via a label on the vehicle or other means, but the State would deal directly with manufacturers for the payment of rebates or collection of fees. Alternatively, feebates can be made a part of the transaction between dealers and customers. This would greatly increase both the number of transactions and the volume of revenue flows but might possibly have a greater impact on consumer decision making.

There will very likely be differences in the design of a feebate program intended to replace and provide equal or greater GHG reductions than the Pavley standard and a feebate program designed to supplement the Pavley standard. A feebate program replacing Pavley would almost certainly have to be comprehensive and might call for a greater feebate rate than a complementary feebate program. Feebates can be interpreted as a charge on future GHG emissions, capitalized at the time of vehicle purchase. By shifting the incidence of these costs from the future to the present feebates, like emissions standards can remedy failures in the marketplace (e.g., Greene et al., 2009). Employing this insight, feebates as a complement to Pavley could be designed to reflect the price of carbon (equivalent) emissions and could be harmonized with other GHG policies, such as carbon cap-and-trade systems. Other potential design differences between replacement and complementary feebates might also be desirable and will be investigated.

Other practical questions for policy makers include how to manage revenue flows generated by the program and how to adjust the program to cope with the uncertain future energy prices, or changes in the preferences of consumers and use of technology by manufacturers, as well as economic conditions in general.

Design and implementation issues will be examined in depth in a workshop conducted by the University of California research team for ARB staff. The UC research team will present options, pros and cons for each of the following feebate program design issues.

- Specification of benchmark(s)
- Magnitude and functional form of the feebate rate
- Domain of vehicles included in the program
- Point of regulation
- Implementation and management

The policy formulation task will also decide on the general context in which future feebate systems are to be evaluated. This will likely require selecting one or more projections of future population, economic growth, energy prices and other key factors. It will also require deciding on external "surprises" that could alter the effectiveness of the feebate program, the revenue flows it generates or its economic impacts. Surprises could include large changes in the price of oil, severe economic downturns, drastic reorganization of the automobile industry, or more rapid than expected development of key technologies, such as batteries or fuel cells.

Following a thorough discussion of the alternatives, ARB staff and the UC research team will select a feasible number of feebate structures and implementation strategies to evaluate under each of the two policy options (without and with Pavley standards). A memorandum will be prepared by the UC Davis principal investigators documenting the conclusions of the workshop. This task will be led by Dr. Greene.

Deliverables:
-- Workshop and memorandum detailing the policy structures to be analyzed.

Task 4. Feebate Analysis Model

The UC research team will construct a rigorous model of consumers' vehicle choices and manufacturers' decisions concerning the use of technology to reduce vehicular GHG emissions. This task will be led by Dr. Greene and Professor Bunch. The model will be used to analyze feebate alternatives and provide the information needed to guide ARB in a potential rulemaking on a feebate system for California. The model will be capable of representing the constraints imposed on manufacturers by the federal CAFE standards and the California Pavley standards, as well as the incremental impacts of a California feebate system. The model will focus in detail on the state of California but will include separate representations of the Northeast states likely to opt in to California's standards and the rest of the U.S. (3 regions). The model will represent annual decision making by vehicle manufacturers and consumers from the present to 2020. It will be capable of analyzing a wide range of feebate system designs and implementation strategies.

Previous studies provide a variety of insights into how feebates systems and their impacts can be successfully modeled. On the manufacturer decision side, models have been constructed making use of the full detail of EPA's test car list (approximately 1,000 makes, models and drivetrain combinations) and representing every major car manufacturer individually. Vehicle class-specific technology/cost cost models for GHG mitigation as well as fuel economy improvement have been developed. Models have been constructed simultaneously representing different regions with different policies and different preferences. Models have been constructed representing multiperiod decision making, taking into account the normal redesign cycles for individual makes and models. On the consumer side, detailed, disaggregate models of vehicle choice, use and ownership have been developed capable of predicting impacts in new and used car markets and the behavior of and economic impacts on different demographic and income groups. Yet to date, no model has combined all the features necessary to comprehensively evaluate alternative feebate programs and adequately address the requirements for implementing a feebate program in California. However, existing research does demonstrate that such a model can be constructed and can be supported by existing information resources.

Lessons learned from previous research

Existing models of feebate systems have utilized differing but related designs to address a variety of issues (e.g., Greene, 2008; McManus, 2007; Dumas et al., 2007; Johnson, 2006; Greene et al., 2005; Davis et al., 1995). The best model formulation for analyzing a California feebate program will not be

clear until the policies to be analyzed have been specified. However, a great deal has been learned from the models developed by previous studies about how manufacturer decisions can be realistically represented at a high level of detail and how consumers' responses and economic impacts can be estimated.

Nearly all previous studies have considered feebates as a fuel economy rather than greenhouse gas mitigation policy (DRI, 1991 is an exception). Davis et al. (1995) examined a wide variety of definitions and forms of feebates. Their model combined an algorithmic representation of manufacturers' decisions to adopt fuel economy technologies based on their cost-effectiveness with a random utility model of consumers' vehicle choices. The manufacturer decision model ranked technologies by cost-effectiveness and then adopted them sequentially (taking into consideration engineering constraints) until the retail price equivalent of the last technology exceeded the sum of its feebate and fuel savings benefits. Market solutions were found by maximizing the sum of consumers' and producers' surplus. This formulation allowed Davis et al. to simulate market responses to feebates over time, from initial implementation to full impact. The manufacturer decision model used by Davis et al. (1995) assumed that consumers would undervalue fuel savings relative to expected full lifetime discounted present value. In the vehicle choice model, on the other hand, consumers were represented as placing a much higher value on fuel savings. As a consequence, the study found that feebate systems generally increased social surplus.

Greene et al. (2005) developed a model that represented manufacturers' decisions and consumers choices at the level of make, model and drivetrain (approximately 1,000 vehicles) for a single year in the future. Manufacturers were assumed to have the opportunity to redesign all their product lines to respond to the feebate system. Vehicle choice was modeled using a representative consumer nested multinomial logit model. Technology was represented by quadratic cost curves fitted to fuel economy cost data developed by the NRC (2002). Solutions were found by maximizing consumers' surplus. With the high level of vehicle detail, Greene et al. (2005) were able to estimate sales and revenue impacts by manufacturer. The impacts on vehicle manufacturers of a single unified feebate schedule with one pivot point for all vehicles versus feebate systems with pivot points for 2 to 11 vehicle classes were studied. The results indicated that class based systems would produce more equitable impacts on manufacturers. Assuming that consumers undervalued fuel savings, Greene et al. (2005) found that feebate programs would produce a small decline in vehicle sales but a small increase in revenues received by manufacturers. The relative increase in vehicle price exceeded the relative decline in sales because the value of fuel savings offset a portion of the vehicle price increase. If the full lifetime value of fuel savings were taken into account, feebate systems were found to produce net economic benefits even without considering the value of reduced external costs.

Using a methodology similar to Greene et al. (2005) Dumas et al. (2007) considered the impacts of feebates implemented in Canada but not the entire North American car market. The results of the modeling indicated that if only Canada implemented a feebate system the impacts on fuel economy would be smaller than if the same system were implemented throughout North America and a greater proportion of the fuel economy gain (on the order of 50%) would come from sales mix shifts. This appears to be the first study explicitly representing manufacturers' responses when a feebate program is implemented in only a portion of the North American market. HLB (1999) carried out a feebates analysis for Canada but incorrectly changed the technology cost function for the Canada-only program, rather than the demand function faced by manufacturers.

McManus (2007) analyzed the impacts of a feebate program applied to California for the year of 2016, separately and in combination with the Pavley GHG standards. Similar to Greene et al. (2005) McManus' manufacturer decision model assumed manufacturers would make adjustments to a base year (2002) set of product offerings in response to the feebate policy. Consumer demand was modeled using a representative consumer nested multinomial model that included a vehicle class market structure. Makes

and models with similar features were assigned to vehicle classes (e.g., Small Cars, Luxury Cars, Minivans, Midsize SUVs) based on the notion that they are "substitutes," i.e., makes and models within the same vehicle class are more likely to compete with one another than they are with makes and models from other vehicle classes.

McManus' demand model was implemented as a "representative consumer model," i.e., consumers are considered to be part of a population that can be characterized by a common utility function that represents the population's "average" utility for each vehicle, plus a random error term to capture individual differences across consumers. Vehicle choices were assumed to be a function of: vehicle price ($), performance (horsepower per ton), size (weight in pounds), and fuel economy (fuel cost per mile). Fuel economy is assumed to be valued on the basis of miles driven over the lifetime of the vehicle, which in turn relies on specific behavioral assumptions (14 year lifetime, with a decline in miles driven as a function of age, and an assumed discount rate). Substitutability within vehicle classes was captured by assuming that vehicles *within* the same class have random errors representing unobserved (to the analyst) similarities in preference or excluded attributes. Model parameters were estimated using hedonic price regression on aggregated sales data from 2002. Demand elasticities for the vehicle attributes were assumed to vary by vehicle class, and are a function of the correlation parameters.

The supply side was modeled using seven vehicle manufacturers (the six largest, plus a seventh "composite"), and the vehicle choice set included all makes and models offered for that model year. Using the level of detail offered by the EPA Fuel Economy Guide (which represents technological choices affecting fuel economy for vehicle series, but does not include details like trim level), yields approximately 1,000 vehicle choices in any given model year. To perform the simulation, the manufacturers were assumed to offer the same makes and models as in the base year. In response to a regulation scenario, they have two decision variables under their control: the amount of improvement (if any) in emissions for each model, and the price. (The decision of how many vehicles to produce is interdependent with price, as discussed below.) Improvements in emissions control increase the unit cost of a model according to a specified cost curve. Each manufacturer was assumed to minimize costs, subject to any constraints that might be in force (e.g., Pavely). Prices and vehicle emissions characteristics are varied in an iterative process to reach market equilibrium, which in turn determines the quantity manufactured.

Like Davis et al. (1995), McManus' model assumes that manufacturers believe that consumers undervalue fuel economy improvements but that consumers actually fully value the expected, discounted lifetime fuel savings. As a consequence, McManus' model estimates net economic benefits for a feebate program, even excluding the value of reduced external costs.

Greene (2008) studied the effect of manufacturers' redesign schedules for individual makes and models in estimating the application of fuel economy technologies over time in response to a feebate system. Manufacturers were assumed to optimize one year at a time, an acceptable method provided that feebate rates are constant. The results indicated that the impacts of a feebate system change significantly over the first five years, indicating a possible need for a phase-in strategy to address the fact that manufacturers cannot change the design and technological content of all the vehicles they manufacture in a single year.

Other studies have shown that feebate benchmarks can be readily defined as functions of vehicle attributes. Johnson (2006) compared weight-based feebates with single pivot point systems and found strongly differing impacts on manufacturers. Greene (2008) analyzed the feasibility and impacts of a footprint (wheelbase time track width) based feebate system (similar to NHTSA's reformed Corporate Average Fuel Economy {CAFE} system) and found its impacts on manufacturers to be similar to a multiple-class system.

Manufacturer Decision Model

Manufacturers will respond to a feebate program chiefly by incorporating additional GHG mitigation technologies in the vehicles they produce. A realistic representation of manufacturers' responses requires a detailed knowledge of each manufacturers current product lines, future product plans, and technology status, as well as comprehensive information on the costs and potentials of mitigation technologies. Vehicles must therefore be represented at a fine level of detail equivalent to the Environmental Protection Agency's test car list (approximately 1,000 makes, models and drivetrain configurations). The technical potential to reduce GHG emissions will be represented by technology/cost relationships that take into account base year implementation of mitigation technologies as well as future potential applicability. The representation of manufacturer decision making will be dynamic, considering normal redesign cycles and their interaction with the feebate implementation strategy. Manufacturers will be assumed to be designing vehicles for sale in three regions (California, Northeast States and Rest of US) that may have differing GHG policies.

There is considerable experience and success in modeling the uptake of proven technologies to reduce vehicle emissions or improve fuel economy. The ability to predict the introduction of novel technologies, especially at the level of detail required for this study, is lacking. Instead, we propose to use scenarios to specify alternative assumptions about the timing and make/model details of introductions of new technologies such as plug-in hybrid vehicles (PHEVs), battery electric vehicles (BPEVs) and hydrogen fuel cell vehicles (FCVs) over the 2009-2020 timeframe.

For a competitive manufacturer, profit maximization is equivalent to cost minimization, assuming the quality of the product remains constant. When a feebate system is introduced, the manufacturer faces a new market demand that alters the previous relationship between a vehicle's GHG emissions and the cost of manufacturing it. All else equal, reducing a vehicle's GHG emission rate will add to the cost of manufacture, improve its feebate, and very likely reduce it's energy costs. Reducing energy costs, other things equal, increases the value of the product. Assuming a manufacturer can estimate the value of reduced energy costs to its customers, cost minimization is equivalent to minimizing the change in net cost to the consumer. Let $f(e, e_o)$ be the change in feebate associated with a change from emissions rate e_o to emission rate e, let $V(e, e_o)$ be the change in energy costs as perceived by the customer, and let $c(e, e_o)$ be the change in the full cost of the vehicle, including returns to capital (i.e., the retail price equivalent or RPE). As a convention, it is assumed that rebates and fuel savings are negative, fees and prices are positive. For any given vehicle, the manufacturer will maximize its profits by minimizing the following.

Equation 1

$$Min \quad NetCost = c(e, e_o) + f(e, e_o) + V(e, e_o)$$

$$\frac{dc}{de} + \frac{df}{de} + \frac{dV}{de} = 0$$

The first order conditions for optimization shown in equation 1 require that the marginal cost of reducing emissions equal the negative of the sum of the marginal changes in feebates and energy costs. That is, a marginal increase in manufacturing cost to reduce emissions is just offset by the marginal increase in the benefits of an improved feebate and lower energy costs. It is important to note that equation 1 applies independently to each vehicle, assuming a competitive market. That is, a competitive manufacturer's optimal strategy is to minimize the net cost (maximize the net value) of each and every vehicle. This principle applies even though a manufacturer's product lines compete with one another, to some degree. As long as the manufacturer faces other competitive producers, it has no choice but to minimize the net

cost of each and every one of its product lines. In a less than perfectly competitive market this simple rule must be modified. We will address the question of whether or not such deviations from perfect competition could have important implications for feebate policies in real world automotive markets.

Acceleration performance and weight can also be traded-off for fuel economy improvement and GHG emissions reductions. In general, weight reduction via materials substitution (while maintaining the size of a vehicle) is included as a technology in technology/cost curves. Thus, the only opportunity for further weight reduction would be downsizing, which would fundamentally change vehicle design, in effect creating a new make and model. Since a wide range of sizes of makes and models are already available for consumers to choose from, we propose to handle weight reduction by downsizing via sales mix shifts as predicted by the NMNL vehicle choice model. We propose to experiment with including the option to trade-off performance (measured by the ratio of horsepower to weight) for fuel economy. This may or may not be successful due to a lack of consensus in the literature on the value of horsepower and its impact on fuel economy.

Manufacturers have other options they may use to change their product offerings in California. One option is to modify a design currently sold in other countries to meet U.S. and California regulatory requirements. Another is to acquire or merge with a foreign manufacturer to acquire new product lines. With the assistance of EEA, ICFI, Inc. we will explore such options and incorporate them in the analysis as appropriate.

For the manufacturer decision model, we propose to develop an aggregate, representative consumer, vehicle market simulation model, implemented as a non-linear, multi-period optimization model. Market equilibrium solutions will be determined by maximizing social (consumers' plus producers') surplus, thereby simulating a competitive market equilibrium. Vehicle choices will be represented by a nested multinomial logit function of vehicle and consumer attributes. Choice alternatives will be represented in detail, by make, model, engine and transmission type, at a level of detail equivalent to EPA's test car list. This will result in on the order of 1,000 choice alternatives per year. Consumer demand will be represented in three distinct regions: California, the Northeast States and "Rest of U.S." To the maximum extent possible, the aggregate choice model will be calibrated to mimic the behavior of the California Vehicle Market Model described below.

Each regional NMNL vehicle choice model can be calibrated to exactly fit the base year make, model and drivetrain market shares by calculating intercept terms in two steps. First, make and model intercepts (A_{ij}) are calculated using the following equation, in which s_{ij} is the base year share of make and model i, in class j, n_j is the number of makes and models in class j, and N is the number of vehicle classes. These intercepts represent the net utility of each vehicle in the base year, before design changes are made in response to the feebate program. Vehicle classes can be defined in many different ways. The vehicle classes used will depend on the feebate structures to be analyzed, among other factors.

Equation 2

$$A_{ij} = \ln(s_{ij}) - \frac{1}{\sum_{j=1}^{N} n_j} \sum_{j=1}^{N} \sum_{i=1}^{n_j} \ln(s_{ij})$$

Second, vehicle class intercepts (a_j) are calculated, given values for the class price coefficients (B_j) and overall price coefficient (b). Since the class shares, S_j, must sum to one, an arbitrary constraint is required to produce a unique set of coefficients. Assuming that the sum of the class intercepts is zero, the intercept for class 1, a_1, is the following.

Equation 3

$$a_1 = \frac{b}{B_j}\ln\left(\sum_{i=1}^{n_j} e^{A_{ij}}\right) + \frac{1}{N}\left[\sum_{j=1}^{N}\ln\left(\frac{S_1}{S_j}\right) - \sum_{j=1}^{N}\frac{b}{B_j}\ln\left(\sum_{i=1}^{n_j} e^{A_{ij}}\right)\right]$$

In equations 3 and 4 e represents the base of the naperian logarithms. Intercepts for the remaining classes are obtained from the following equation.

Equation 4

$$a_j = a_1 - \ln\left(\frac{S_1}{S_j}\right) + \frac{b}{B_1}\ln\left(\sum_{i=1}^{n_1} e^{A_{ij}}\right) - \frac{b}{B_j}\ln\left(\sum_{i=1}^{n_j} e^{A_{ij}}\right)$$

The above calibration insures that before any GHG mitigation technology can be implemented and before any feebate system is imposed, the model will predict exactly the base year market shares for every class and every make and model, in each of the three regions (California, Northeast States, Rest of US).

Manufacturers' decisions concerning the use of technologies to reduce greenhouse gas emissions will be represented by technology cost curves that estimate the change retail price equivalent (RPE) per vehicle as a function of the relative reduction in GHG emissions. At a minimum, vehicle class-specific cost functions will be used. If possible, we will develop manufacturers and class-specific or even vehicle specific costs curves to more accurately reflect the current status of technology implementation. Manufacturers' planned redesign schedules and announced product introductions will be used through 2016, at least. Curves describing the total cost of fractional improvements in fuel economy from a base level have been constructed by numerous researchers over the past three decades (see, e.g., Greene and DeCicco, 2000, for a review of this the topic). Data developed by EEA, ICFI, Inc. for Transport Canada showed that the same methods can be used with equal effectiveness for GHG mitigation. When technologies are ranked by decreasing cost effectiveness (change in GHG emission rate divided by cost, taking into consideration a logical engineering implementation sequence) total cumulative cost (RPE) as a function of cumulative fractional change in GHG emissions (Δ) can be very closely fitted by a quadratic curve with zero intercept (figure 1).

Equation 5

$$\Delta = \frac{e - e_0}{e_0}$$

$$RPE(\Delta) = b\Delta + c\Delta^2$$

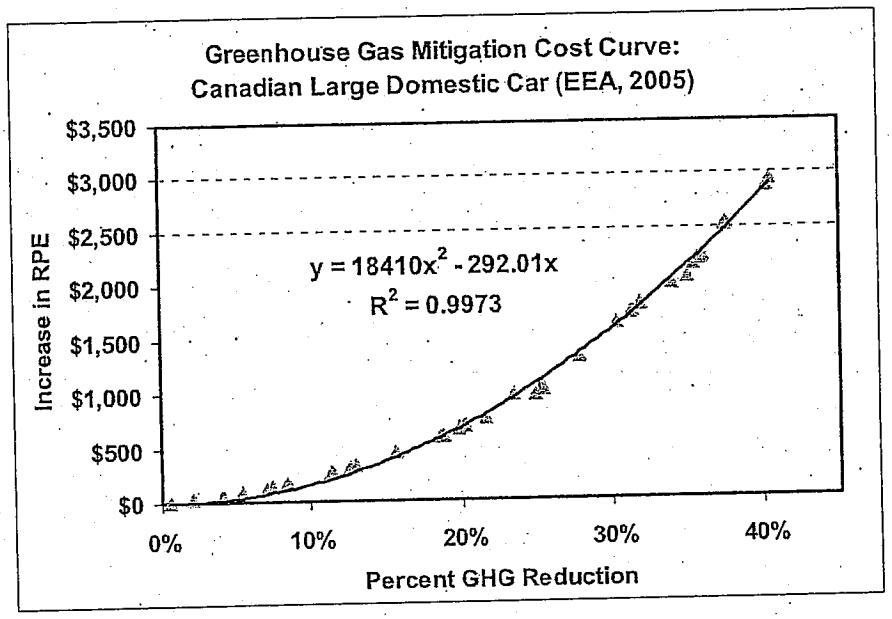


Figure 1. Greenhouse Gas Mitigation Cost Curve for a Large Canadian Domestic Car Derived from Data Presented in table 1-4 in EEA, 2005.

In figure 1 cost is measured in terms of retail price equivalent, an estimate of the incremental price the purchaser of a car would pay based on fully burdened manufacturing costs plus manufacturer's profit and retailing cost and profit.

Many technologies that reduce GHG emissions also improve energy efficiency and fuel economy. Thus, a fuel economy improvement function corresponding to the GHG mitigation cost function must also be created. How consumers are assumed to value fuel economy improvements is key to both the impacts on GHG emissions and economic welfare. Economically rational consumers would measure the value of fuel savings by the expected discounted present value of fuel saved over the full life of the vehicle. There is evidence that very few consumers actually make such quantitative assessments (Turrentine and Kurani, 2007). Greene et al. (2008) show that typical consumer loss aversion combined with the uncertainty of future fuel savings could lead to a significant undervaluing of future fuel savings relative to their expected present value. On the other hand, some econometric studies indicate that car buyers appear to value fuel savings in accord with rational economic principles (e.g., Espey and Nair, 2005). The subject remains controversial and has very significant implications for the costs and benefits to consumers of fuel economy policies (e.g., Fischer, 2007). Reflecting this controversy, the NRC (2002) fuel economy study considered two alternative methods of valuing fuel savings, full lifetime discounted fuel savings (equation 6) and a 3-year simple payback (equation 7). Greene et al. (2008) showed that the 3-year simple payback produces approximately the same effect as loss aversion plus uncertainty.

Equation 6 Lifetime Discounted Present Value

$$V_L = \int_{t=0}^{L} P(t) M_0 e^{-\delta t} \left(\frac{1}{G_0} - \frac{1}{G_0(1+\varepsilon)} \right) e^{-rt} dt = \frac{1}{\delta + r} \left[1 - e^{-(\delta + r)L} \right] P_0 M_0 \left(\frac{1}{G_0} - \frac{1}{G_0(1+\varepsilon)} \right)$$

Equation 7 Simple 3-year Payback

$$V_3 = 3P_0M_0\left(\frac{1}{G_0} - \frac{1}{G_0(1+\varepsilon)}\right)$$

P(t) = price of fuel, for simplicity of exposition only assumed to be P_0 for all t
M_0 = annual miles traveled for a new vehicle
e = base of naperian logarithms
$-\delta$ = rate of decline in vehicle use per year (-0.04)
G = base year fuel economy
ε = fractional increase in fuel economy
r = consumer discount rate
L = vehicle lifetime, in years

Solving the Manufacturer Decision Model

The manufacturer decision model is solved by maximizing consumers' surplus subject to federal CAFE standards and with and without California Pavley constraints, with the decision variables being the change in GHG emissions for each vehicle eligible for redesign in the year in question. Consumers' surplus in the NMNL model is a function of the calibrated constant terms, the price slopes, and the changes in vehicle price, P, present value of fuel savings, V, and the feebate, f. The utility of vehicle i in class j, u_{ij}, is the sum of its constant A_{ij} and the class j price slope times the changes in P and V, and f.

Equation 8

$$u_{ij} = A_{ij} + B_j\left(\Delta P_{ij} + \Delta V_{ij} + f_{ij}\right)$$

The change in consumers surplus per vehicle (ΔU) is calculated using the expected utilities of each class (u_j) with (u) and without (u^*) the feebate system, and the price slope for choice among vehicle classes, b (equation 8).

Equation 9

$$u_j = \frac{1}{B_j}\ln\left[\sum_{i=1}^{n_j} e^{u_{ij}}\right]$$

$$\Delta U = \frac{1}{b}\ln\left[\frac{\sum_{j=1}^{N} e^{a_j+bu_j}}{\sum_{j=1}^{N} e^{a_j+bu_j^*}}\right]$$

Note that, all else constant, in the absence of the feebate program there would be no motivation to change vehicle designs and so $u^* = A_{ij}$.

The manufacturers' optimization problem is to choose the change in GHG emissions (implying changes in the price, fuel savings and feebate) for each vehicle that maximizes the change in consumers' surplus. Because feebate structures (e.g., rates, benchmarks) may change over time, multi-period optimization will, in general, be required. This will require the researchers to address questions of myopia versus perfect foresight versus various representations of expectations, uncertainty, and discounting of future

costs and benefits. The modeling framework, however, is well suited to multi-period optimization methods.

CAFE standards are represented as equations constraining, by year, the sales-weighted harmonic mean fuel economy (G) of a manufacturers vehicles to be greater than or equal to the required levels (G^*). In equation 10 Q_{ijt} is the number of vehicles of type j sold by manufacturer i in year t. NHTSA's new CAFEE standards are based on a footprint metric, which results in a unique standard for each manufacturer.

Equation 10

$$G = \left[\sum_{j=1}^{N_{it}} \frac{Q_{ijt} / Q_{ji}}{G_{ijt}} \right]^{-1} \geq G_{it}^*$$

The greenhouse gas constraints in California (Pavley standards) require that the sales-weighted mean emissions rate is less than or equal to the standard. Since manufacturers have alternative compliance methods, the actual constraints may be more complex than shown in equation 11. In particular, banking and trading of credits is permitted. Note that in equation 11, e represents an emissions rate.

Equation 11

$$\sum_{j=1}^{N_{it}} \frac{Q_{ijt}}{Q_{it}} e_{ijt} \leq e_t^*$$

The federal gas-guzzler tax also remains in effect and will be represented in the manufacturer decision model.

California Vehicle Market Simulation Model

A major task in this project is the development of a Vehicle Market Simulation Model to support the evaluation and assessment of alternative feebate policy scenarios. The entire premise of a feebate approach is that desired policy outcomes (e.g., reduction in greenhouse gas emissions) can be brought about through the effect of economic incentives on the general market behavior of both consumers and vehicle manufacturers, rather than by, e.g., direct governmental regulation of specific vehicle choice offering performance standards. [Note: Some policy scenarios to be considered in this project involve a combination of both types of regulations. However, the emphasis in this discussion is on the modeling requirements imposed by the goal of addressing feebates.] Evaluating alternative policies therefore requires a means of analyzing the effect of these policies on market behavior. In the case of feebates, the distribution of demand across vehicle types, as well as their emissions characteristics, directly determines the bottom-line effect not only on the desired policy outcome (emissions) but also on the total program budget (total costs from rebates and administration, minus revenues from fees).

As discussed in Bunch and Chen (2008), the choice of specific methods and techniques for vehicle demand modeling are determined by the purpose to which the results will be applied. For example, methods used for short-run decision making by automobile manufacturers will generally be different from those used for medium-to-long run policy analysis by public agencies (although there will be many similarities). Manufacturers will typically be concerned with preferences by consumers for highly detailed vehicle characteristics within any one of a number of segments. In contrast, policy analysts are more concerned with large, general impacts on total fuel consumption and emissions from the entire fleet

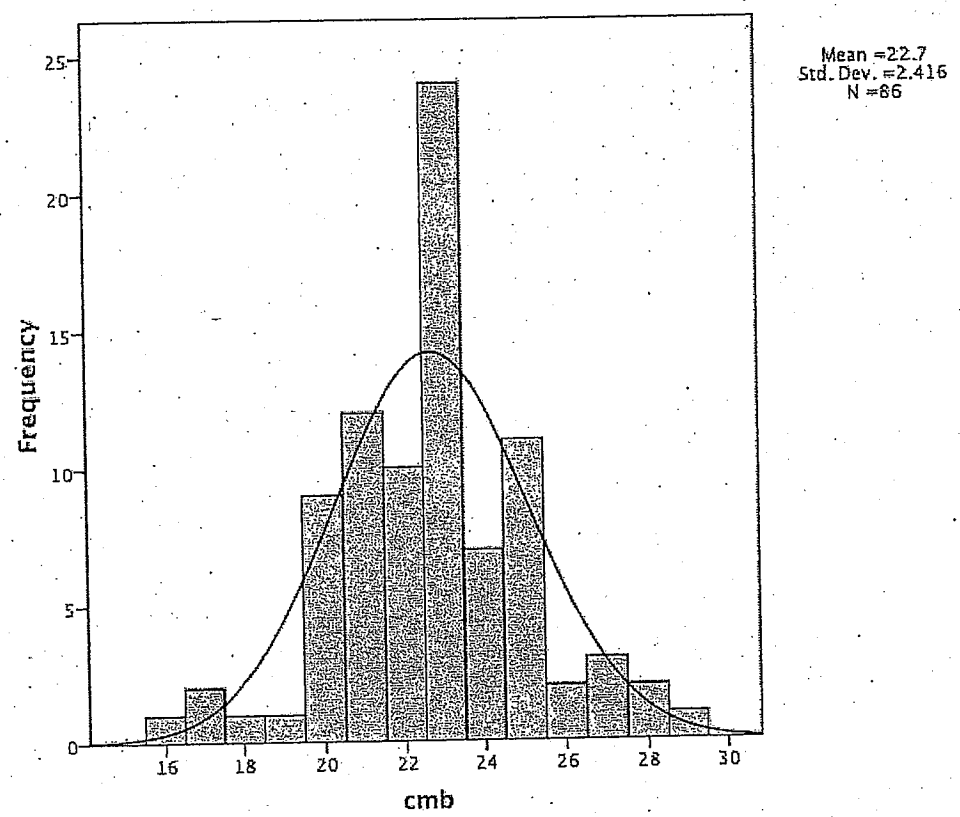
over a medium- to long-term time horizon. Automobile manufacturers are typically focused on *sales* in the new vehicle market, whereas policy analysts are concerned with the full life cycle and distribution of the entire fleet, as well as how the vehicles are actually driven, since these are the direct determinants of fuel use and emissions. Policy makers may also be concerned with the impact of their decisions (both economic and environmental) on specific demographics groups (e.g., low income households). To provide context, we briefly review two different types of modeling approaches to illustrate previous discussion, and then discuss in more detail the requirements for this project.

The first type of approach relies on aggregate-level demand models of the type described in the previous section. McManus (2007) is such an example. The model includes a high level of detail in product offerings (i.e., down to the make-model level), which would seem to be a requirement because under feebate programs consumers would face tradeoffs for purchase price versus emissions characteristics when choosing among vehicles in the same vehicle class (e.g., subcompact cars). However, this approach focuses exclusively on the new vehicle market, and analyzes manufacturer decisions based on a one-period simulation and optimization. This ignores two potentially important effects, namely, the interaction between the new and used vehicle market, and how these affects affect both sales and manufacturer decision making over time (as discussed in more detail below).

By way of contrast, many policy analyses use models with a different set of features. Two examples are the CalCars model of the California Energy Commission, and CARBITS of the Air Resources Board. These models are different than the McManus (2007) approach in the following respects:

1. The models simulate market behavior over a many multi-year time horizon, and attempt to incorporate dynamic effects (to the degree possible).
2. Consumer choice models are formulated at the individual household level, and are estimated using actual household choices and behavioral data collected using large-scale surveys. Utility functions are based on behavioral theory that posits a more detailed set of preference effects, including those due to demographic differences across households (e.g., income, age, household size).
3. As part of the market simulation, temporal changes in the demographic makeup of the market can also be incorporated if necessary. These typically rely on demographic forecasts from a sanctioned source.
4. Models simulate household-level choices for the entire vehicle fleet, including how many vehicles to own, which types, and how much to drive them. The models include choice of both new and used vehicles. In some cases, vehicle scrappage effects are also modeled.
5. Vehicle choices are characterized at the vehicle *class* level of detail (e.g., subcompact cars, large SUVs), i.e., choices are not simulated at the individual make and model level. New vehicle offerings (and their characteristics) are treated as exogenous and are part of the evaluation scenario to be determined by the analyst.

The above two examples illustrate various potential requirements for a vehicle market simulation model to evaluate feebate policies. For example, in order to adequately model consumer response to feebates, choice of new vehicles may require a level of detail similar to McManus (2007), so the level of detail typically included in vehicle-class-based models such as CalCars and CARBITS may be inadequate. As further illustration, the following histogram shows the distribution of EPA combined fuel economy (combined MPG, or cmb on the x-axis below) for Compact Cars in 2003:



There are 86 data points representing available vehicle technologies at the level of make-series-engine–transmission-drive train. Specifically, for a give make-series (e.g., Toyota Corolla), details that affect fuel economy and performance for a series are included, but details related to trim package are not. Fuel economy for this vehicle class covers a relatively wide range (from 16 to 29 MPG), roughly corresponding to a range of 550 grams-per-mile to 300 grams-per-mile CO_2 equivalent. This is comparable to the ranges used as examples by McManus (2007, section 2.4), where lower bound could incur a fee of, e.g., $2,500, and the upper bound a rebate of, e.g., $1,300. In other words, a typical feebate program would seek to influence vehicle demand over ranges that currently fall entirely *within* a typical vehicle class. In this instance, the McManus (2007) approach includes the required level of detail in the consumer model, whereas a vehicle class-based model does not.

At the same time, features of CalCars/CARBITS models are also potentially important. The McManus (2007) focuses only on new car purchases, and performs a myopic one-period market simulation. Such an approach cannot capture the total effect of a policy for an evolving vehicle market in which last year's new vehicles become this year's used vehicles. The effect of the policy on the entire market is extremely important, and ignoring the dynamic effects for the entire market system could lead to erroneous results. The vehicle market simulation model for this project must adequately address all of these issues.

With this as background, we now formulate a mathematical framework for vehicle market simulation that will form the basis for developing a model for this project. Note that the framework is intended to be rather general: For any specific model implementation certain elements may be simplified or eliminated, depending on the nature of the assumptions. The basic issues are: Modeling consumer demand given available vehicles, and modeling the decisions made by automobile manufacturers. In what follows, we make use of the following notation:

m is an index of manufacturers from 1 to M
s is an index of household/consumer segments from 1 to S
Z_s is a vector of consumer characteristics for segment s
Z $= \{Z_s, s = 1, \ldots, S\}$ = the collection of characteristics for all segments
j is an index of vehicle *models* (for a given make) from 1 to J_m
y is a time-related index used to denote a vehicle *model year*
t is a time-related index used to denote a *calendar year*
jy denotes a vehicle type of model j and model year y
O_{my} denotes the set of vehicle models offered by manufacturer m for model year y
W_{st} is the size of consumer segment s at time t
W_t $= \{W_{st}, s = 1, \ldots, S\}$ = the collection of segment weights for time t
X_{jy} denotes vehicle attributes for vehicle jy
e_{jy} is the emission rate for vehicle jy (and is therefore one of the X_{jy}'s)
c_{jy} is the marginal cost for producing jy (generally not observable)
$c_j(e, e_0)$ is an incremental cost function.
= the cost of improving a vehicle model's emission rate from e_0 to e.
$p_{jy,t}$ is the market price for vehicle jy in calendar year t
(so $p_{jy,y}$ is the new vehicle price)
$Q_{jy,t}$ is the *quantity* of vehicle jy in the market during year t (a.k.a., vehicle stock)
(so $Q_{jy,y}$ is the number of new model j vehicles manufactured in year y)

Using the above notation, we denote a vehicle choice model by

$H(jy \mid P, X, Z_s)$ = the expected demand for vehicle type jy by a household belonging to segment s in a market defined by the matrix of vehicle characteristics X and price vector P (where we have suppressed the subscript t).

The aggregate demand for vehicle type jy by the consumers in segment s is given is therefore given by

$$W_s H(jy \mid P, X, Z_s) .$$

This general form can support a range of model types. In the simplest case, there would be one segment ($S=1$) corresponding to a representative consumer model with a vector of preference parameters and no actual consumer characteristic variables (e.g., demographics). If the market definition were limited to the new vehicle market, this would correspond to an aggregate level demand model of the type used in McManus (2007), where the weight (W) would be the market size. Alternatively, in a policy analysis model such as CalCars, there might be a limited number of segments that are specifically defined by demographic variables such as income, household size, etc. Each segment would be defined by its own set of variables (Z_s). The definition of each segment would not change during the course of a market simulation; however, weights could be changed based on demographic forecasts to represent changes in the population. In the most extreme case the vehicle market could be modeled using pure micro simulation, so that S is large and the Z_s would represent a random draw from a distribution. The distribution could involve demographic variables and/or unobserved heterogeneity in consumer preferences. In this case (depending on the details of the model) the weights might all be equal, and their sum would equal the market size.

Adding in the time dimension t, the total market demand for jy during calendar year y is given by

$$D_{jy,t}(P_t, X_t, Z_t, W_t) = \sum_{s=1}^{S} W_{st} H(jy \mid P_t, X_t, Z_s)$$

From the perspective of a manufacturer, total profit during calendar year y is given by

$$\pi_{my} = \sum_{j \in O_{my}} (p_{jy} - c_{jy}) D_{jy,y}(P_y, X_y, W_y) = \sum_{j \in O_{my}} (p_{jy} - c_{jy}) \sum_{s=1}^{S} W_{st} H(jy \mid P_y, X_y, W_y)$$

The standard behavioral assumption is that manufacturers make decisions based on profit maximization, subject to any relevant constraints. However, there are many issues that can affect the details of how models are estimated and used in practice. For example, in many cases it is difficult to obtain accurate data on proprietary items such as costs (e.g., c_{jy}). This issue has been addressed in a variety of ways, as discussed elsewhere. Other cost-related issues include such affects as economies of scale, and synergies across product lines within the same company.

The timeframe raises additional issues. In the short term, manufacturers are constrained to making price changes only, whereas over a longer time frame they can change their vehicle designs. In considering a longer time frame, market dynamics and the role of the used vehicle market can be important issues.

In For a dynamic market simulation, define the vehicle stock of vehicle type $jr\,jv$ during calendar year y by $Q_{jr,yv}$ for $r\,v = y - wv, \ldots, y$, where v denotes vehicle vintage.. For this example, let $v\,w$ denote a parameter used to define the window of allowable vehicle vintages, so that $Q_{jvr,y} = 0$ for $r\,v < y - vw$, i.e., all vehicles w+1 years old or older are assumed disappear completely from the market. (Depending on the details of the model, vehicles may be scrapped prior to this, but the window is included to create a well-defined lower bound.) . If we assume that the market is in equilibrium in year t so that supply equals demand, then the following must hold:

$$Q_{jv,t} = D_{jv,t}(P_t, X_t, W_t), \quad \text{for } v = y - w, \ldots, y.$$

For new vehicle purchases, vehicle stock is the same as the demand defined above. For used vehicles, the evolution of vehicle stock can be modeled in a number of ways. However, in a closed system the following must be true: The vehicle stock for a given model year must decline over time (e.g., it cannot go down, and then go back up). It is generally assumed that the used vehicle stock for year t is determined by the vehicle stock from year t-1, minus some scrappage quantity.

This framework provides a basis for discussing the following research issues to be addressed by this project. The following were identified in the pre-proposal:

1. Representation of Market Structure
    a. Role of California within a national market
    b. Role of States that "opt in" to the California feebate program
    c. Framework for manufacturer decision-making as a function of market structure
    d. Importance of differentiation of consumer market

2. Consumer Demand
    a. How consumers value vehicle attributes
    b. Nature of demand for fuel economy
    c. Role of heterogeneity
    d. Functional requirements for vehicle choice modeling
    e. Data requirements

3. Manufacturer Decision Making
    a. Role of timing in designing and offering new vehicles
    b. Strategic choices on offering products to a total market system

c. Vehicle technology adoption decisions
d. Manufacturer assumptions regarding consumer response

One challenge in discussing these issues is that they are not independent from one another, as will become apparent.

To begin, consider a "simplified" case where a group of manufacturers is serving a single market, and we seek to evaluate alternative regulation scenarios applied to this market. To support additional discussion about methods and data, assume that the market is California. Also for purposes of discussion, assume that we are modeling household vehicle holdings decisions, that these holding "choices" are made on an annual basis, that every household holds at least one vehicle, but may hold no more than three. In this case, the household-level demand model depicted above:

$$H(jy \mid P, X, Z_s)$$

gives the "expected number" of vehicles of type *jy* held by a household with characteristics Z_s. Note that these are not choice probabilities that sum to one. One research task will be to formulate more detailed "submodels" that are subsumed under *H*. For a holdings model, the vehicle choices involve the choice of (i) how many vehicles to own, and (ii) which vehicles to own, which can be depicted by a tree structure. As noted above, a household's expected choices will be a function of the attributes (X'SX's) of all vehicles available in the market, their prices (P's), and the household's characteristics (already mentioned).

The market consists of available used vehicles from the collected market activities of earlier years, plus the new vehicles that are introduced in the current year by the manufacturers. For every model year, each manufacturer must decide:

1. Which vehicles to offer
2. What characteristics (X's) they should have
3. What price to charge
4. How many to manufacturer

For an operational model using the above framework, the behavior of both consumers and manufacturers must be specified in some manner. Generally speaking, the methods for developing and estimating quantitative behavioral models are much more highly developed for consumer demand than they are for manufacturers. With regard to consumer models, the team will apply its expertise in choice modeling to develop an appropriate model to meet the needs of the project. Using California as an example, developing and estimating choice models makes use of multiple types of data. The following is a list of categories, and our preliminary assessment of specific data sets that can be used.

1. Detailed historical database on Vehicle Technology (X's).
   a. Chrome data on vehicle characteristics.
   b. National Automobile Dealers Association historical data on used and new vehicle prices (broken down by region).
   c. Wards Automotive data on vehicle characteristics
   d. EPA and NHTSA data.
   e. Historical vehicle technology data from KG Duleep.
2. Projections of Vehicle Technology scenarios for future vehicle markets.
   a. Data tables and consulting with KG Duleep.
3. Household-level survey data on vehicle holdings.
   a. 2001 Caltrans Travel Survey

   b. NHTS Travel Surveys
   c. Consumer Expenditure Survey (CES) data
   d. California Vehicle Survey (CVS) data from California Energy Commission
4. Aggregate level sales data for estimation and calibration purposes.
   a. Sales estimates from processing historical data from California DMV
   b. Data from RL Polk (for non-California sales)
   c. Smog Check data?
5. Stated preference data from households on hypothetical future vehicles.
   a. 2001-2002, 2006, and 2008-2009 California Vehicle Survey (CVS) data from California Energy Commission

These data represent the required collection of information on consumer choices (H), characteristics (Z), market demand (D), vehicle characteristics (X), and prices (P) to support estimation of choice models.

With regard to the decisions of manufacturers, quantitative approaches based on maximizing the profit function, subject to constraints, have already appeared in the literature. For example, one such constraint would be that the sales -weighted mix of vehicles meets CAFÉ CAFE requirements. See, e.g., Goldberg (1998), Bento, et al. (2006), and Jacobsen (2006). These approaches require structural assumptions about market equilibrium between supply and demand in order to simultaneously estimate the parameters of both the consumer demand model and the manufacturer decision model.

However, as mentioned previously, quantitative modeling of manufacturer decisions is much less developed and faces a number of challenges. For example, one problem is the availability of accurate data. Attempting to model manufacturers as profit maximizers nominally requires knowledge of each manufacturer's variable cost of production, but accurate cost data are proprietary and difficult to obtain. This problem has been addressed by the literature in a number of ways, but remains a concern.

A bigger challenge is that the needs of this project go well beyond price and quantity decisions, as evidenced by the list provided above. Issues include the timing and nature of design decisions, the role of multiple markets, etc. For purposes of this project the overall approach to specifying the manufacturers' decision processes was presented in the previous section, and reflects the most current experience available. Our initial approach will be to develop a high-level model of the entire new vehicle market (defined to include the entire United States, comprised of up to three region-based segments) that captures manufacturers' design and pricing decisions over time. Aggregate-level market models will be used for this purpose. The solution of the high-level model will define the market environment scenario to be used as an input to a more detailed model of the California vehicle market. The more detailed model allows a sharper focus on policy-related outcomes such as sales of specific vehicle types in the new vehicle market, the impact on the used vehicle market, vehicle usage, and the affect on emissions. Economic impacts on demographic segments of the consumer market can also be assessed.

The approach is practical, and will support the needs of the project. At the same time, the development of consumer choice models and the implementation of vehicle market simulation for this project provide an opportunity to test and pursue potential new approaches. We Specifically, we plan to explore the possibility of using the above framework to extend the simulation model by including a quantitative, integrated model of manufacturer decision making.

Model outputs

The feebate analysis model will produce estimates of feebate impacts on a wide array of variables at a fine level of detail. Impacts on vehicle GHG emissions rates for both new vehicles and the vehicle fleet, as well as total, on-road light-duty vehicle GHG emissions will be estimated. ARB estimates of

emissions rates per vehicle as defined for the Pavley standards will be used. In general, impacts on vehicles will be estimated at the level of make, model, engine and transmission. In addition to GHG emissions, these impacts will include estimated changes in the retail prices of vehicles, their fuel economy and the feebates they will incur. Estimates of manufacturers' changes to vehicle design will be produced for each of the three regions (California, Northeast States, and Rest of U.S.). This will permit estimation of impacts on national and California total light-dut vehicle sales, sales distributions by make and model, changes in manufacturer revenues, and revenue impacts on notional automobile dealerships characterized by brand and sales volume. Estimates of impacts on California consumers will be produced by demographic and income group. All the output variables listed below will be generated for each calendar year.

- New passenger vehicle GHG emissions rates by year, by individual make and model, by manufacturer, by vehicle class and for the new vehicle fleet as a whole
- Vehicle price and fuel economy changes for all subcategories
- Passenger vehicle sales by manufacturer, vehicle class by model year
- Manufacturer sales revenues by vehicle class and model year
- Sales revenue impacts on notional automobile dealerships
- Changes in consumers' surplus by model year and by manufacturer
- Impacts on used vehicle prices and transactions by vehicle class
- Fees and rebate flows, and net revenue to the State
- Total GHG emissions by passenger vehicles in California by calendar year, and cumulative emissions impact
- Passenger vehicle travel, energy use and petroleum consumption by calendar year.

These outputs will provide a comprehensive and detailed basis for policy analysis.

Deliverables:
-- Working, tested model of manufacturer decision responses to feebate systems in an appropriate computer language, with documentation.
-- Working, tested model of vehicle choice, use and ownership for California with documentation.
-- Databases used in model development and calibration, as permitted by data acquisition agreements.

Task 5. Policy Analysis

The design of a feebate system affects its efficacy in reducing GHG emissions, its economic efficiency, its distributional impacts, its administrative complexity, and its revenue risks. Moreover, the number of possible feebate designs is infinite. Feebate systems can be discrete, assigning the same fee or rebate to classes of vehicles, or continuous, basing the fee or rebate on a metric such as grams of CO_2 equivalent emissions per mile. There can be a single benchmark, different benchmarks for different classes of vehicles, or benchmarks defined by a continuous vehicle attribute, such as footprint or weight. The feebate rate parameter can be a constant or can be any number of different functions of distance from the pivot point. Feebates can apply to all light-duty vehicles or only certain vehicles, for example to only the most and least efficient. Based on the results of task 2, Policy Formulation, several alterative feebate strategies will be analyzed using the Feebate Analysis Model. These will embody different assumptions about the key elements of feebate design:

- Functional form: discrete or continuous
- Benchmark definition: single, vehicle class, or attribute-based benchmarks
- Value of emissions: constant or varying $/gm-per-mi feebate rate, and level
- Coverage: universal or segments of vehicle market

- Implementation strategy: changes in rates, benchmarks or coverage over time

Continuous feebate systems avoid boundary effects that could reduce the impact of the system on GHG emissions and also increase uncertainty about revenue streams. Nonetheless, France implemented a discrete feebate system and some argue that such systems may have a greater psychological impact on consumers' purchase decisions by identifying certain vehicles as "the right choice" (Peters et al., 2008). For a given feebate rate, a single benchmark system is likely to have the greatest impact on the mix of vehicles sold, but multiple and attribute-based feebate systems can mitigate inequitable impacts on vehicle manufacturers (Greene et al., 2005). If all vehicles were driven the same number of miles per year, a constant feebate rate ($/gm-per-mi) would insure that every gram of CO_2 equivalent GHG emitted was valued the same, satisfying a key condition for economic efficiency. On the other hand, varying feebate rates can be used to mitigate potentially extreme payments for unusual vehicles or to create special incentives or disincentives. Including all vehicles in the feebate system insures maximum impact on GHG emissions but exempting some vehicles, especially during a phase-in period, can reduce economic costs and revenue flows and may affect public perception of the policy.

The implementation and management of feebate systems has received too little attention from researchers. This is important because feebate systems are likely to have different immediate and long-term impacts. Past analyses indicate that for nationwide feebate systems, 90% or more of the impact on energy use or GHG emissions is likely to come from technology and design decisions made by manufacturers and 10% or less from changes in the mix of vehicles sold (e.g., Davis, et al., 1995; Greene et al., 2005). When the system applies to only a portion of the market, however, salesmix effects can account for half or more of the total impacts (Dumas, Bourbeau and Greene, 2006). Still, manufacturers' engineering decisions are of major importance. In the first year of a feebate system, manufacturers will be able to redesign only 10% to 20% of their product lines. Thus, early on, a greater proportion of the feebate impacts will come from salesmix shifts (Greene, 2008).

Once a feebate system has been implemented, management will be required not only to handle revenue flows but also to adapt to changing market conditions. Sudden, large changes in the price of oil, for example, can significantly change the economics of the feebate program. The scenarios and surprises identified in task 3 will be used to estimate the impacts of important external events on the feebate program. Once impacts have been estimated, strategies for adjusting to changed revenue flows or GHG impacts will be proposed and tested to determine which feebate formulations are most robust to external challenges.

Utilizing the feebate analysis model, the policy analysis task will estimate the impacts of the feebate strategies defined in task 3 on vehicle emissions rates and total GHG emissions from passenger vehicles in California annually and cumulatively from the present to 2020. It will assess the impacts on the mix of vehicles sold in California, on vehicle prices, on fuel savings, and the impacts on consumers' surplus by income and demographic group. Effects on vehicle sales in total and by manufacturer, and impacts on manufacturers' average vehicle prices and total sales revenues will be estimated, as will gross and net revenue flows.

Dr. Greene and Professor Bunch will lead this task.

Deliverables:

- Workshop presenting intermediate results of policy analysis with opportunity for stakeholder comments.
- Draft report on policy analysis of a feebate program for California.

Task 6: Policy Implications of Program

This task is focused on assessing the policy implications and social responses to the feebate program structures and features developed in earlier tasks. This task will be led by Dr. Tim Lipman and Prof. Dan Kammen of UC Berkeley's TSRC, with the assistance of Dr. Walter McManus and other UC Berkeley and Davis team members. The task consists of several key aspects, including assessment of:

- Program social incidence/consumer welfare shift analysis;
- Potential program VMT interaction effects and effects on trip-making behavior;
- Program administration costs and secondary effects;
- Possible unintended program consequences to be considered; and
- Potential interaction with other AB 32 measures.

This task would be informed by the results of Task 1 – "Lessons Learned," in terms of drawing in considerations from previous feebate program experiences. The results of this task will help to inform the efforts in Task 3 – "Policy Formulation" and Task 5 – "Policy Analysis."

Social Incidence/Consumer Welfare Shift Analysis

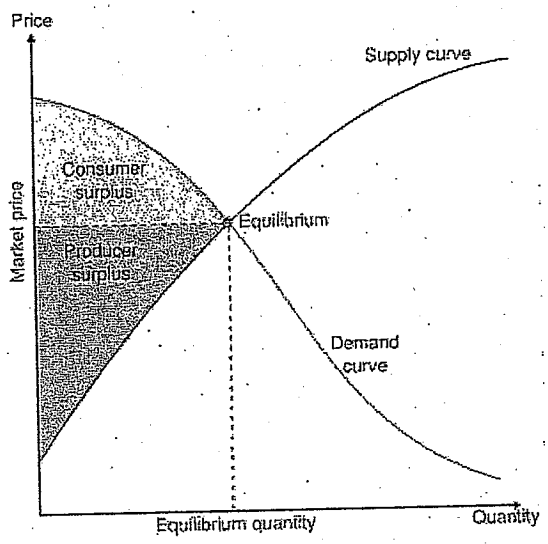
This task will consist of examining the potential shifts in consumer welfare from the feebate program (i.e., Who 'wins' and who 'loses'?), based on the results from the feebate analysis model (Task 4) activity. This task would be led by Walter McManus and Tim Lipman at UC Berkeley's TSRC, with assistance from other team members including David Greene and Dan Kammen.

A key question for any feebate program is the effect that the program will have on vehicle purchasers of different income groups, including potential interactions through the used vehicle market. Discussions among the project team with regard to the type of assessment that will be possible of feebate program social incidence/welfare issue, have concluded that incorporating demographic data into the main feebate program analysis / market equilibrium assessment is vital, so that social welfare shifts can be included. However, the complexity of that analysis limits the number of socio-economic or other demographic strata that can be considered.

In this investigation, the project team proposes to include three to four divisions by household income, and to assess consumer welfare changes that occur through the implementation of the feebate program. The research team will also consider social welfare shift effects within California, including: 1) regional effects on more rural and more urban areas; 2) potential adverse effects on elderly populations; and 3) potential social welfare shifts associated with the implementation of feebate program structures.

As the model output data from Task 4: "Feebate Model" will be highly resolved with regard to vehicle make, model, engine/transmission, etc., and will have an annualized representation in the vehicle stock model, detailed analysis of the consumer welfare shifts between income groups as a result of the potential introduction of a feebate program will be possible. This analysis will also make possible careful assessment of the local and state sales tax and revenue shifts associated with potential feebate program designs, resulting from changes in vehicle sales patterns.

Figure 3: Consumer and Producer Surplus in Microeconomic Theory



The consumer surplus effects of the feebate program within and between income groups can then be assessed by then assessing the inter-group shifts in social welfare when the vehicle purchase data are disaggregated. The team will also include assumptions about whether or not the government derives any government surplus from the feebate program, which would be minimized if the program were designed to be "revenue neutral" but which may be desired to some extent, for example to cover the administrative costs of the program.

There are various methods for aggregating the total social welfare gains and losses associated with this potential economic intervention in the vehicle markets in CA and other states that may adopt California regulations, and the merits of these will assessed early in the project and a more detailed methodology will be developed. Options include a traditional "closed form" representation of consumer welfare, as well as more innovative approaches based on the more detailed understanding that is expected to emerge from this specific market equilibrium modeling exercise. The team also will include the impacts of changes in prices of vehicles in the used car market and/or availability of certain models in the used car market that also would entail gains or losses in consumer welfare by certain groups. This could be particularly important with regard to impacts on lower household income groups, as they purchase new vehicles relatively less frequently and more often on the used vehicle market.

In evaluating the incidence of the feebates program we will distinguish between the effects of changing the marginal "price" of clean vehicles to consumers and the income effects of the feebates themselves. This will tell us how much of the change is due to changing the slope of the feebate curve and how much is due to changing the total spending by the household. This is accomplished with a simulation by "returning" the fee or "taking back" the rebate, but in the form of an income change.

The research team also proposes to engage Catherine Wolfram, PhD, from the UC Berkeley Haas School and UC Energy Institute, to help advise this task activity. The team will involve Dr. Wolfram, who has expressed interest in the project, initially on an informal basis but also will work on a side proposal to generate funding for a more formal collaboration, e.g. to the UC Transportation Center or UC Energy

Institute. This would allow for additional aspects of the consumer welfare implications of the feebate program, and potentially other economic impacts of the program, to be investigated somewhat more extensively.

VMT Interaction and Trip-Making Behavior

The assessment of potential shifts in vehicle miles traveled (VMT) and trip-making behavior will examine the potential "rebound effects" that may occur as vehicle consumers were shifting to lower GHG-emission and more fuel-efficient vehicles. This effort would be led by Tim Lipman and Walter McManus, with assistance from Caroline Rodier, Susan Shaheen, and other project team members.

With regard to potential VMT shifts in response to a lower GHG-emission (and higher fuel economy) vehicle stock, a recent study by Small and van Dender (2005; 2007) found that price elasticities for fuel consumption with regard to fuel price have declined over time due to rising incomes, and the progressively smaller contribution of fuel costs to overall purchasing power. In a study of 1966-2004 data, Small and van Dender found a short-term elasticity for changes in fuel consumption relative to fuel prices of -0.074 in the full period from 1966-2004, but only a -0.041 elasticity from the most recent 2000-2004 period. Provided that the trend of increasing wealth continues, this trend might be expected to continue, but with the impact of fluctuating fuel prices (in real terms, relative to real incomes and purchasing power) complicating the story.

Furthermore, shifts to some types of lower GHG emission vehicles, such as electric and natural gas vehicles, may involve shifts to vehicles that have different attributes that could affect how they are used. For example, battery electric or plug-in hybrid vehicles may be attractive choices for some consumers, especially if they can link them with the supplementary use of transit.

This task would assess these two potential implications of the feebate program, by using elasticity values derived from previous studies and examining the effects of VMT increases as a function of decreasing effective fuel prices for consumers, developing ranges of potential VMT rebound effects and potential transit system interactions, and then assessing the impacts of those effects on feebate program effectiveness, public perception/response, and overall AB 32 program goals. The results of the investigation will help to inform the broader assessment of potential program effectiveness, as well as potential side benefits or detriments from the program.

Tax Revenue Impacts and Effects on Auto Dealers

In addition to potential impacts on consumers, this task would consist of assessing the impacts of feebate programs on tax revenues as well as potential impacts on automotive dealers. Based on output from the market equilibrium model, shifts in vehicle sales will be assessed with regard to the number of sales on an annual basis and the values of the vehicle sold. These data will then be used to assess sales tax revenue changes and potential effects on the revenues generated by auto dealers. The auto dealer effects will be assessed for several "generic" auto dealers of different sizes and with different offerings of vehicle models, to get a sense of the types of impacts that can be anticipated. Assessing the impacts on specific auto dealerships (there are approximately 2,000 in California alone) would be outside the scope of the project.

Program Administration Costs and Secondary Effects

This aspect of Task 6 would consist of estimating the administration costs of the feebate program, as implemented in different ways, as well as potential additional secondary effects or "unintended consequences." For example, the administrative costs would be significantly different if the feebate were applied at the manufacturer or dealership level, and this could also affect a key secondary effect – the level of positive or negative public reaction to the program. This effort will be led by Tim Lipman and

Walter McManus, with assistance from Rachel Finson, Susan Shaheen, David Greene, and other members of the project team.

In assessing the potential program administration costs, information would be drawn from the Task 1 – "Lessons Learned" activity, as well as additional information specific to a California policy setting. This would include examination of estimates of the potential administrative costs of the proposed *AB 493* legislation, as well as consultations with the California Legislative Analysts Office (LAO). Factors considered will be the structure of the feebate program, options for administering it through different state agencies, costs of public education campaigns to make sure the program is understood by the public, etc.

In addition to the potential VMT rebound effect and transit system interaction assessments discussed above, additional secondary impacts of the feebate program would also be examined and assessed. These include:

- How to predict and potentially calibrate incentive levels to ensure revenue neutrality?
- Fluctuating gas prices and the resulting uncertainty in program effectiveness and impacts;
- Interactions with the used vehicle market and the resulting impacts on society;
- Impacts on different automakers, foreign and domestic, and the resulting economic implications for California and the U.S.; and
- Interaction with other *AB 32* measures:
  - Low carbon fuel standard (LCFS)
  - Cap and trade program
  - SB 375 – land use and planning restrictions
  - Electricity sector interactions with BEV/PHEV
  - Potential double counting issues
  - How to assess feebate program effectiveness relative to other programs
- Manufacturer gaming/vehicle shuffling, emissions leakage

These issues will be investigated with discussions with feebate stakeholder groups and ARB staff, discussions among the project team, and consultation with other knowledgeable individuals. UC Berkeley and UC Davis have several complementary assessments completed or underway around various aspects of *AB 32* program implementation that will help to inform the efforts of this task.

Deliverables:
-- Several report sections that document the findings of each element of the assessment of the policy implications of potential feebate programs

Task 7: Statewide Survey

Based on the focus group results and expert interview (lessons learned), researchers will develop a telephone survey that addresses the following questions (at a minimum):

- Are feebates viewed as a tax or as an opportunity to purchase a more desirable vehicle?
- Do respondents prefer a manufacturer feebate vs. consumer feebate?
- Equity concerns regarding feebate approach;
- Interest in clean fuels/advanced technology vehicles in relation to feebates; and
- Hypothetical responses to different consumer feebate structures based on input from economic analysis.

The objective is to obtain 3,000 residential interviews completed by a telephone survey of 15 minutes in length throughout the state of California (e.g., five key regions including Sacramento, Bay Area, San

Diego, Central Valley, and Los Angeles). A random digit dialing sample will be used. The large sample size will enable the results to be disaggregated by location and by demographic groups with a 95% confidence interval. The sample will be stratified to reflect the population characteristics of the five key regions of the state, allowing the sample to be broadly representative of the state as a whole. An outside organization will administer the survey. Researchers will collaborate on the content and implementation of the survey to ensure that the project objectives are met. Researchers will analyze survey results and report findings.

Deliverables:
-- Report section with synopsis of statewide survey results and interpretation/analysis of results

3. Data Management Plan

There are four types of data that will be collected as part of this project. The methods for managing and handling the data will vary for the four types. The data to be collected are:

1) Data from focus groups;
2) Data from interviews with experts and vehicle dealers/salespeople;
3) Technical, economic, and demographic data for the feebate analysis model; and
4) Data from the statewide phone survey.

In general, all sensitive data with study participant confidentiality concerns will be encrypted using a software program called TrueCrypt. This is a free, open-source, on-the-fly encryption program. It allows users to create volumes, which are files of any size that get temporarily mounted as extra disk drives. Sensitive information, such as focus group and interview notes, survey data, etc. can be written to the drive as if it was a USB drive. The data are only accessible to those using the computer when the drive is mounted. It becomes unintelligible once the drive is dismounted. Volumes are typically encrypted with either a 256 or 512 bit key. Data stored within TrueCrypt volumes are not readable without the volume password.

Focus Group Data
The focus groups will be held in twelve individual groups, with 10-12 focus group participants at each session. The focus groups will be audio taped and written and/or typed notes will also be taken, but the sessions will not be videotaped due to human subject's considerations. The audiotapes and notes will be stored according to approved Institutional Review Board (IRB) guidelines to safeguard the confidentiality of the focus group participants.

Interview Data
Interview data will also be carefully stored and encrypted as required, again according to IRB guidelines and subject to IRB approval of the specific study protocols. In all cases, the identities of the interviewed parties will be kept separate from the written records of the interviews to help assure the privacy rights of the subjects. The identities of any of the interviewees and any linkages between them and the findings written up in the project report will not be included or divulged. The organizations represented by the interviewees can be identified in the report.

Technical, Economic, and Demographic Data for the Feebate Analysis Model
These data will generally not be of a sensitive nature with regard to confidentiality of study participants, and no specific data handling procedures are therefore required. However, these technical and economic data will be carefully stored and handled, with any necessary security safeguards if any sensitive data (e.g., confidential data supplied by manufacturers) are obtained.

Statewide Phone Survey Data
The phone survey will be conducted by a subcontractor, who will then provide the completed survey results data to the project team. There will be no identifiable links between participants (e.g., phone number) and the data. These data will be encrypted. Once received, these data will be carefully handled to assure participant confidentiality per IRB guidelines (i.e., encryption). Again, the university team will not know the exact identities of any of the phone survey participants, and the results will be supplied on an anonymous basis with only general demographic data (e.g., age, gender, household income, etc.) and no personally-identifiable information attached to the individual study responses.

4. Human Subjects

Human subjects will be formally questioned during three aspects of the project – the focus groups, the interviews, and the statewide phone survey. This means that the project will require IRB approval, where data collection and handling methods, survey/interview/focus group protocols, recruitment protocols, potential risks to and safeguards for study participants, and other participant confidentiality issues, must all be addressed and approved by IRB committees on both campuses.

Focus Groups
There will be approximately 144 focus group participants. These participants will be recruited through IRB-approved procedures by the study subcontractor, using primarily web-based techniques (e.g., "Craig's List"). The full protocols for recruiting and conducting the focus groups will require IRB approval by the UC IRB committee.

Interviews
Approximately 20-25 participants will be interviewed. Interviews will be conducted in an organized manner with both experts in the field of feebates and with automotive dealers and salespeople, thereby also triggering the requirement for IRB approval for interview protocols and data confidentiality/security measures.

Statewide Phone Survey
Three thousand completed participant telephone surveys will be collected. The statewide phone survey will be conducted by the project subcontractor, using IRB approved protocols. The results will be analyzed by the UC project team. The survey will be conducted using random-digit dialing to reach a cross-sectional representation in the study sample that can be stratified in statistically valid ways. Care will be taken in the study design to separate any personally identifiable information from the data set of survey results, again to assure participant confidentiality per IRB guidelines, along with data encryption. Again, this project activity would be subject to IRB review and approval before the survey task can commence.

Accurate data on vehicle sales, vehicle emissions and other relevant attributes are essential to this study. The following data sources are proposed:

- Detailed vehicle attributes by make model and configuration, including fuel type, fuel economy, scheduled date for redesign, retail price (MSRP), energy technologies applied to vehicle (these data can be supplied by EEA).

- Data on vehicles purchased and owned by households in California and vehicle and household attributes (UC Davis researchers have already compiled these data). Also the new survey results that will become available from CEC after the contract begins in spring 2009
- Data on vehicle sales at the make, model and configuration level for the Northeast States and rest of U.S. (EEA will supply total U.S. sales, data for Northeast states specifically may need to be purchased from a reliable source such as R.L. Polk & Co.)
- Data on GHG emissions reduction technologies and their costs will be obtained from a variety of sources (e.g., ARB, US EPA, EEA, Inc., NAS, etc.).
- Greenhouse gas emissions rates (or methodology for calculating rates) for make, model and configuration, for vehicles in California will be obtained from the ARB.

Proprietary data, such as data purchased from R.L. Polk and Co. will need to be held secure and disseminated only in accordance with the restrictions imposed on its purchase. Proprietary data obtained from EEA, ICFI, Inc. will be shared with ARB but further distribution will be restricted by agreement with EEA, ICFI, Inc.

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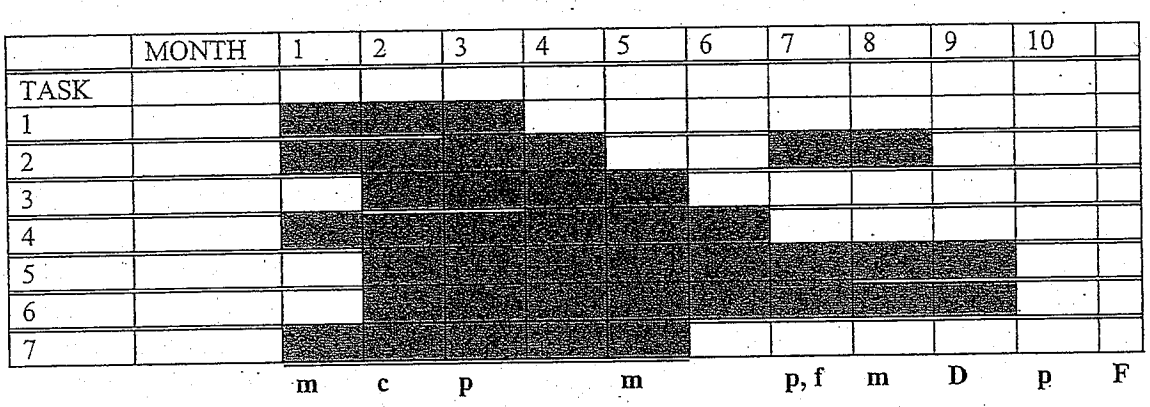
II. Project Schedule

A kick-off meeting at ARB will be held prior to the initiation of the project. The scheduling of Tasks 1-7 is shown in figure N below in terms of months from the start of the contract. The major product of this research project will be a final report describing the research methods and data, and presenting the results of the feebate analyses described above. The computer model developed by this research project and the data used (to the extent that the data are not proprietary) will be documented in detail in an appendix to the final report, and the model and data will be provided to the ARB for use by their staff. A draft final report will be delivered not more than 10 months after the start of the project. The project principal investigators from Davis and Berkeley will present a full reporting on the project at a Chairman's Seminar at the conclusion of the project.

Task 1: Lessons Learned
Task 2: Focus Groups and Interviews
Task 3: Policy Formulation
Task 4: Feebate Analysis Model
Task 5: Policy Analysis
Task 6: Policy Implications
Task 7: Statewide Survey



m = Meeting with ARB staff
c = **Public consultation meeting to discuss policy formulation**
p = Quarterly progress report
f = **Presentation of interim study findings**
D = Deliver draft final report
F = Deliver draft final report and Chairman's Seminar

The project leaders (and senior researchers as needed) will meet with ARB staff to report on the progress of the research on three occasions during the course of the research, at specific times and places to be jointly agreed. Progress reports will be submitted in the third, seventh, and tenth month of the project. A public consultation will be held in the second month of the project to present a preliminary plan and options for structuring the policy analysis and to obtain input. Interim study findings will be presented at the end of the seventh month in an appropriate venue to be determined by the ARB staff The draft final report will be submitted for formal review. A final project briefing will also be made no later than 10 months after the start of the project as a Chairman's Seminar.

III. Project management plan

The UC Research Team has extensive experience in analyzing policies for transportation greenhouse gas mitigation at state, national and international levels, and in conducting surveys of consumer attitudes and perceptions. Personnel are professors, researchers and graduate students in the UC system with the exception of K.G. Duleep, an internationally renowned expert on automotive technology, cost and energy efficiency potential. Members of the research team have constructed feebate analysis models similar to the one that will be built for this study, have carried out numerous consumer research efforts, and have published extensively on these subjects in the peer-reviewed literature. The team possesses strong expertise in modeling and policy analysis of motor vehicle and environmental policy issues in California and the United States.

U.C. Davis

Dr. David L. Greene, Visiting Researcher, U.C. Davis ITS and Corporate Fellow, Oak Ridge National Laboratory
Professor David Bunch, Graduate School of Management, U.C. Davis
Professor Yueyue Fan, Dept. of Civil Engineering, U.C. Davis
Professor Christopher Knittel, Department of Economics, U.C. Davis

U.C. Berkeley

Tim Lipman, PhD, Co-Director, Transportation Sustainability Research Center
Susan Shaheen, PhD, Co-Director, Transportation Sustainability Research Center
Professor Dan Kammen, Energy and Resources Group and TSRC Director
Walter McManus, PhD, Visiting Scholar from University of Michigan Transportation Research Institute
Caroline Rodier, PhD, Transportation Sustainability Research Center
Rachel Finson, Transportation Sustainability Research Center
Denise Allen, Transportation Sustainability Research Center
Kim Strasburg, Transportation Sustainability Research Center
Ewald & Wasserman Research Consultants, LLC, Project subcontractor

U.C. Irvine

Professor David Brownstone, Department of Economics

EEA, ICFI, Inc.

Mr. K.G. Duleep, Managing Director, Energy and Environmental Analysis

a. Project Roles and Responsibilities

UC Davis Team

David Greene, PhD: Project Co-Principal Investigator, Lead for Task 3 and co-lead for Tasks 4 and 5, support for Task 6

Prof. David Bunch: Project Co-Principal Investigator, co-lead for Task 4 and support for Task 3.

Assoc. Prof. Chris Knittel: Support for Tasks 3, 4, and 5.

Assoc. Prof. Yueyue Fan: Support for Tasks 4 and 5.

KG Duleep: Support for Task 4: Feebate Analysis Model (subcontractor)

UC Berkeley Team

Tim Lipman, PhD: Principal investigator for UC Berkeley subaward; Lead for Task 6: Policy Implications of Program; Co-lead for Task 1: Lessons Learned; Support roles for Task 3: Policy Formulation, Task 4: Feebate Analysis Model, and Task 5: Policy Analysis

Susan Shaheen, PhD: Co-lead for Task 1: Lessons Learned; Lead for Task 2: Focus Groups and Inteviews; and Lead for Task 7: Statewide Survey

Prof. Dan Kammen: Co-lead for Task 6: Policy Implications of Program; Support role for Task 3: Policy Formulation and Task 5: Policy Analysis

Walter McManus: Co-lead for Task 6: Policy Implications of Program; Support for Task 3: Pro??

Caroline Rodier: Project management; human subjects (IRB) review; support for Task 6: Policy Implications of Program

Rachel Finson: Project management; human subjects (IRB) review; Task 1: Lessons Learned support; Task 2: Focus Groups and Interviews support Task 6: Policy Implications task support

Denise Allen: Human subjects (IRB) review

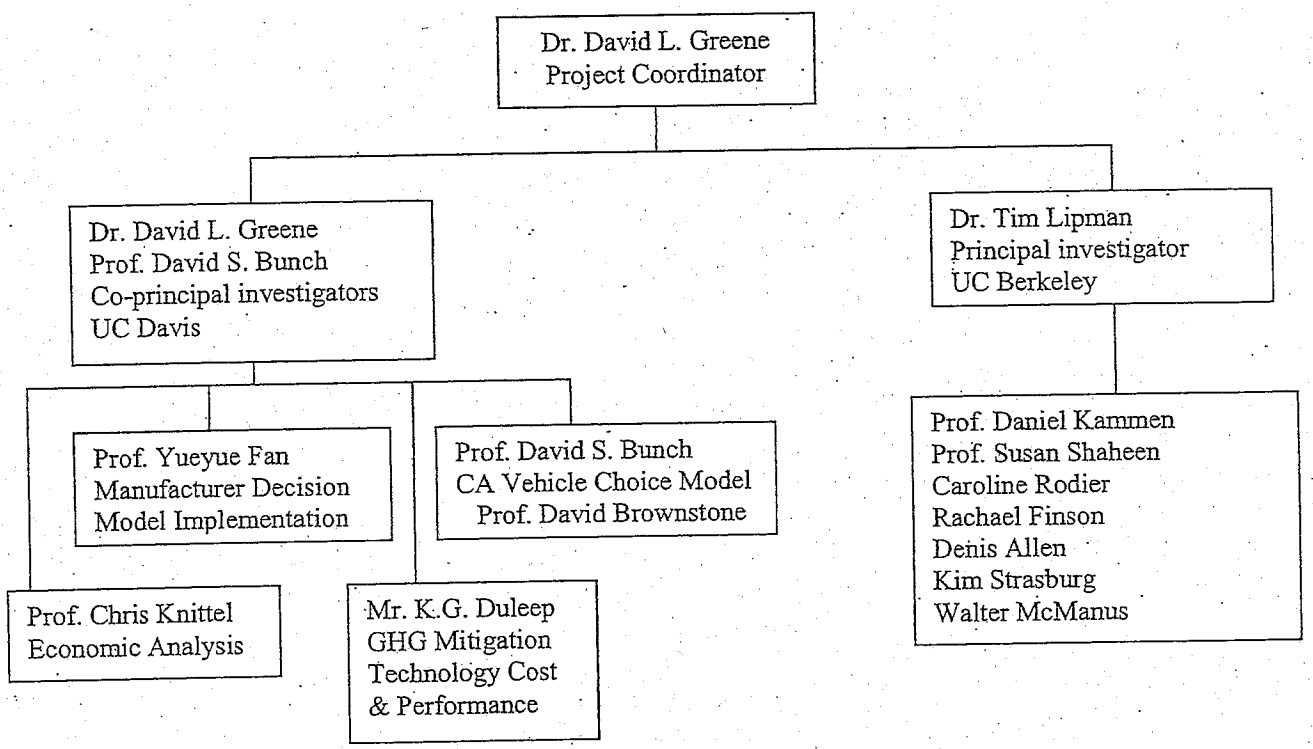
Kim Strasburg: Project management and human subjects (IRB) review

Ewald & Wasserman Research Consultants, LLC: Focus group recruitment and statewide survey recruitment and survey administration (subcontractor)

b. Project Management

The project will be managed carefully due to the need for close coordination for the conduct of the various project tasks. Monthly project meetings will be held for all key project personnel, alternating locations between Davis and Berkeley, with internal project meetings to the UC Davis and Berkeley teams held every two weeks. Two project meetings will be held with ARB staff, either in Sacramento or Davis, along with supplemental phone conversations and email exchanges.

David Greene will be the overall project coordinator, working closely with Tim Lipman who will be the overall manager for the UC Berkeley efforts under the sub-award. Additional project management responsibilities will be held by David Bunch, Dan Kammen, Susan Shaheen, and Rachel Finson.



c. Curricula Vitae

DAVID L. GREENE

Home: 212 Way Station Trail • Farragut, Tennessee 37922 • (865) 966-0891
Work: Oak Ridge National Laboratory • National Transportation Research Center • 2360 Cherahala Boulevard • Knoxville, Tennessee 37932 • (865) 946-1310

PERSONAL

Born: November 18, 1949, New York, New York
Married, two children

EDUCATION

THE JOHNS HOPKINS UNIVERSITY
Ph.D., Geography and Environmental Engineering, 1973–78

UNIVERSITY OF OREGON
M.A., 1972–73

COLUMBIA UNIVERSITY
B.A., 1967–71

EMPLOYMENT

OAK RIDGE NATIONAL LABORATORY (ORNL) 1977–PRESENT

1999–Present *Corporate Fellow, Oak Ridge National Laboratory*
1989–1999 *Senior Research Staff Member II and Manager of Energy Policy Research Programs, Center for Transportation Analysis*
1988–1989 *Senior Research Analyst, Office of Policy Integration, U.S. Department of Energy (On assignment from ORNL)*
1987–1988 *Head, Transportation Research Section*
1984–1987 *Senior Research Staff Member I*
1982–1984 *Research Staff Member*
1980–1982 *Leader, Transportation Energy Group*
1977–1980 *Research Associate*

AWARDS AND HONORS

2008 Science Communicator Award, UT-Battelle
2007 Department of Energy Hydrogen Program R&D Award (with P.N. Leiby)
Society of Automotive Engineers, Barry D. McNutt Award for Excellence in Automotive Policy Analysis, 2007
Member Emeritus, Transportation Research Board Committee on Alternative Fuels, 2006
Barry D. McNutt Award for best paper of 2004, Energy Committee, Transportation Res. Board
Lifetime National Associate of the National Academies, 2002

UT-Battelle Award for Excellence in Science and Technology, 2001
Oak Ridge National Laboratory Significant Event Award, 2001
Designated Corporate Fellow of Oak Ridge National Laboratory, 1999
Outstanding Paper of 1999, *The Energy Journal*, International Association for Energy Economics
Lockheed-Martin Significant Event Award, 1999
Member Emeritus, Transportation Research Board Committee on Transportation Energy, 1998
Lockheed-Martin Significant Event Award, 1996
Distinguished Service Certificate, Transportation Research Board, 1993
ORNL Special Achievement Award, 1991
Distinguished Service Certificate, Transportation Research Board, 1989
Energy Specialty Group Paper Award, Association of American Geographers, 1986
ORNL Special Recognition Award, Oak Ridge National Laboratory, 1986
Technical Achievement Award, Martin Marietta Energy Systems, 1985
Pyke Johnson Award, Transportation Research Board, 1984

PROFESSIONAL ACTIVITIES

- Editorial Advisory Board, *Transportation Research Part D*, 1996–2006
- Editorial Board Member, *Energy Policy*, 2001–present
- Editorial Board Member, *Journal of Transportation and Statistics*, 2001–2006
- Editorial Board Member, *Transportation Quarterly*, 1999–2005
- Editor-in-Chief, *Journal of Transportation and Statistics*, 1997–2000
- Editorial Board Member, Macmillan Encyclopedia of Energy, 1998–2001
- Editorial Advisory Board, *Transportation Research A*, 1986–1997
- National Research Council
  - Transportation Research Board Standing Committees:
    - Committee on Transportation and Sustainability, Member, 2006–present
    - Committee on Energy, A1F01, Chairman 1983–1986, 1986–1990; Member, 1993-1998; Member Emeritus, 1999–present
    - Subcommittee on Forecasting Transportation Energy Demand, A1F01(2), Chairman, 1982–1983
    - Section F, Energy and Environmental Concerns, Chairman, 1990–1992
    - Committee on Alternative Fuels, A1F05, Member, 1993–present, Member Emeritus, 2006–present
    - Task Force on Freight Transportation Data, A1B51, Secretary, 1989–1996
    - Committee on Transportation Information Systems and Data Requirements, Member, 1983–1986, 1986–1989
  - Ad Hoc Committees:
    - Special Task Force on Energy and Climate Change, 2008–2011
    - Committee on Fuel Economy of Light-Duty Vehicles, 2007–2008
    - Planning Group for Workshop on Issues Related to Peaking of Global Oil Production, 2005
    - Committee on State Practices in Setting Mobile Source Emissions Standards, 2004–2006
    - Chair, Committee for the Symposium on Introducing Sustainability into Surface Transportation Planning, 2003–2004
    - Panel on Combating Global Warming through Sustainable Surface Transportation Policy, TCRP Project Panel H-21A, 2002–2005
    - Committee on Effectiveness and Impacts of Corporate Average Fuel Economy (CAFE) Standards, 2001

Committee for the Study of the Impacts of Highway Capacity Improvements on Air Quality and Energy Consumption, 1993–1994
Committee on Fuel Economy of Automobiles and Light Trucks, Energy Engineering Board, Commission on Engineering and Technical Systems, 1991–1992
Committee for the Study of High-Speed Surface Transportation in the United States, 1990
Planning Group on Strategic Issues in Domestic Freight Transportation, 1990
Steering Committee for Conference on Transportation, Urban Form, and the Environment, 1990
National Cooperative Highway Research Program, Panel on "Evaluating Alternative Methods of Highway Finance," 1991–1992

- Intergovernmental Panel on Climate Change
  - Lead Author, Working Group III, Fourth Assessment Report, 2007
  - Lead Author, Working Group III, Third Assessment, 2001
  - Lead Author, Working Group III, Aviation and the Global Atmosphere, 1999
  - Principal Lead Author, Working Group II, Second Assessment Report, 1995
- Association of American Geographers
  - Board of Directors, Transportation Specialty Group, 1989–1991
  - Secretary-Treasurer, Transportation Geography Specialty Group, 1980–1982
  - Editor, *Transportation Geography Newsletter*, 1980–1982
- Society of Automotive Engineers, member, 1985–present
- International Association for Energy Economics, member
- Consulting
  - International Transport Forum, 2007
  - Addx Corporation, 2007
  - United Nations Framework Convention on Climate Change, 2007
  - Securing America's Future Energy, 2007
  - Center for Clean Air Policy, 2007
  - Pollution Probe Canada, 2006-2007
  - The Energy Foundation China Project, 2005—present
  - The Pew Center on Global Climate Change, 2004—present
  - Eno Transportation Foundation, 1991–1996
  - Transportation Research Board, 1996–1997

BOOKS

and D.W. Jones and Mark Delucchi, eds., *The Full Costs and Benefits of Transportation*, Springer-Verlag, Heidelberg, 1997.

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"Survey Evidence on the Importance of Fuel Availability to Choice of Alternative Fuels and Vehicles," *Energy Studies Review*, vol. 8, no. 3, pp. 215–231, 1998.

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Driver Energy Conservation Awareness Training: Review and Recommendations, ORNL/TM-9897, Oak Ridge National Laboratory, Oak Ridge, Tennessee, May 1986.

R.L. Graves, D.L. Greene, E.W. Gregory, II, *Application of the Adiabatic Diesel to Heavy Trucks: A Technology Assessment*, ORNL/TM-9554, Oak Ridge National Laboratory, Oak Ridge, Tennessee, March 1986.

and R. Kowalski and F. Southworth, *The Transportation Sector in Costa Rica and Opportunities for Energy Conservation*, a report of the Energy Conservation Services Program, U.S. Agency for International Development, Office of Energy, Washington, DC, May 1985.

P.S. Hu, D.L. Greene and L.E. Till, *Motor Vehicle MPG and Market Shares Report: First Six Months of Model Year 1984*, ORNL/TM-9391, Oak Ridge National Laboratory, Oak Ridge, Tennessee, October 1984.

and P.S. Hu and A.B. Rose, *Transportation Energy Use and Efficiency in Tunisia*, ORNL-6066, Oak Ridge National Laboratory, Oak Ridge, Tennessee, August 1984.

"Highway Fuel Use: Trends and Factors," *Proceedings of the Energy Information Administration Symposium on Petroleum Information*, DOE/EIA-0425, Energy Information Administration, Washington, DC, September 1983.

G.F. Roberts and D.L. Greene, *Trends in Heavy Truck Energy Use and Efficiency*, ORNL/TM-8843, Oak Ridge National Laboratory, Oak Ridge, Tennessee, October 1983.

et al., *An Overview of the Wharton School Assessments of the Short-Term Integrated Forecasting System*, DOE/NBB-0046, Energy Information Administration, Office of Statistical Standards, Washington, DC, July 1983.

"Regional Demand Implications for Gasoline Supply Shortages," in T.R. Lakshmanan and P. Nijkamp, eds., *Systems and Models for Energy and Environmental Analysis*, Gower, UK, pp. 206–233, 1983.

and E. Hirst, J. Soderstrom and J. Trimble, *Estimating the Total Impact on Energy Consumption of Department of Energy Conservation Programs*, ORNL-5925, Oak Ridge National Laboratory, Oak Ridge, Tennessee, November 1982.

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and G. Kulp, G.H. Walton and D.B. Shonka, *Transportation Energy Use 1973–80: Changes, Trends, and Causes*, ORNL/TM-7953, Oak Ridge National Laboratory, Oak Ridge, Tennessee, April 1982.

G. Samuels, A.B. Rose, D.L. Greene and J.N. Hooker, "Energy Conservation in Transportation," a chapter in Vol. III of *Advances in Energy Systems and Technology*, Peter Auer, ed., Academic Press, New York, 1982.

E. Hirst, D.L. Greene et al., *Energy Use from 1973 to 1980: The Role of Improved Energy Efficiency*, ORNL/CON-79, Oak Ridge National Laboratory, Oak Ridge, Tennessee, December 1981.

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J.N. Hooker, A.B. Rose and D.L. Greene, *End Use Energy Consumption Data Base: Transportation Sector*, DOE/EIA/CR-7405-01, U.S. Department of Energy, Washington, DC, February 1980.

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G. Kulp, D.L. Greene et al., *Regional Analyses of Highway Energy Use*, ORNL-5587, Oak Ridge National Laboratory, Oak Ridge, Tennessee, December 1979.

"A Regional Stock System Model of Highway Gasoline Demand," in *Changing Energy Use Futures, Volume 1*, Proceedings of the Second International Conference on Energy Use Management, Los Angeles, California, October 22–26, 1979.

and T.P. O'Conner, P.D. Patterson, A.B. Rose and D.B. Shonka, *Regional Transportation Energy Conservation Data Book*, ORNL-5435, Oak Ridge National Laboratory, Oak Ridge, Tennessee, September 1978.

Econometric Analysis of the Demand for Gasoline at the State Level, ORNL/TM-6326, Oak Ridge National Laboratory, Oak Ridge, Tennessee, July 1978.

An Investigation of the Variability of Gasoline Consumption among States, ORNL-5391, Oak Ridge National Laboratory, Oak Ridge, Tennessee, April 1978.

R.R. Schmitt and D.L. Greene, "Evaluating Transportation Innovations with the Intervening Opportunities Model," *Proceedings of the Northeast American Institute for Decision Sciences*, April 1977.

M.G. Wolman, D.L. Greene and N.L. Froomer, *An Analysis of the Physical Characteristics of the Shanandoah River Which Affects Its Navigability* and *An Analysis of the Physical Characteristics of the Potomac River Which Affects Its Navigability*, prepared for the Baltimore District, U.S. Army Corps of Engineers, Chesapeake Research Consortium, pub. nos. 37S and 38S, resp., March 1975.

G. Power, M.G. Wolman et al., *Report on the Shenandoah River: An Investigation to Determine Navigability* and *Report on the Potomac River: An Investigation to Determine Navigability*, prepared for the Baltimore District, U.S. Army Corps of Engineers, Chesapeake Research Consortium, pub. nos. 37 and 38, resp., March 1975.

FORTHCOMING PUBLICATIONS

"Feebates, Footprints and Highway Safety", forthcoming, *Transportation Research D*.

"Vehicles and E85 Stations Needed to Achieve Ethanol Goals," forthcoming, *Transportation Research Record*, Transportation Research Board, Washington, DC.

"Measuring Energy Security: Can the United States Achieve Oil Independence?", forthcoming, *Energy Policy*.

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Short Biography – October 2008

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David Bunch is Professor of Management, Graduate School of Management at UC Davis. Professor Bunch is known for his work in identification and estimation of discrete choice models, stated choice experiments, and combining stated and revealed preference data for modeling and forecasting consumer market behavior. Application areas for his research and teaching include marketing research, e-commerce and Internet marketing, product management, and transportation systems (through his affiliation with the UC Davis Institute of Transportation Studies since its inception). Professor Bunch was a principle in conceiving and directing a large multi-year program to develop comprehensive forecasting models and systems for vehicle purchase and usage behavior in California, designed to include future alternative-fuel vehicles (e.g., electric cars). More recently, Professor Bunch developed the CARBITS model for use by the California Air Resources Board in its work to establish regulations on greenhouse gas emissions in California.

Education Ph. D., Rice University, 1985 (Mathematical Sciences); Master in Applied Mathematical Sciences, Rice University, 1981; M. S., Northwestern University, 1979 (Chemistry); B. A. (cum laude), Rice University, 1978 (Chemistry)

Selected Publications

"Behavioral Frontiers in Choice Modeling," (with W. Adamowicz, T. A. Cameron, B. G. B. C. Dellaert, M. Hanneman, M. Keane, J. Louviere, R. Meyer, T. Steenburgh and J. Swait), Marketing Letters, In Press (2008).

California Air Resources Board –Institute of Transportation Studies (CARBITS) Vehicle Market Microsimulation Model for California, June 8, 2004. Prepared for California Air Resources Board under contract 02-310.

"Automobile Demand and Type Choice," (with B. Chen), Handbook of Transport Modeling, Second Edition, David A. Hensher and Kenneth J. Button, editors, Pergamon (2008), pp. 541-556.

"Hybrid Choice Models: Progress and Challenges," (with Moshe Ben-Akiva, Daniel McFadden, Kenneth Train, Joan Walker, Chandra Bhat, Michel Bierlaire, Denis Bolduc, Axel Borsch-Supan, David Brownstone, Andrew Daly, Andre de Palma, Dinesh Gopinath, Anders Karlstrom, Marcela A. Munizaga), Marketing Letters, 13(3): pp. 163-175 (August 2002).

"Joint Mixed Logit Models of Stated and Revealed Preferences for Alternative-fuel Vehicles" (with David Brownstone and Kenneth Train). Transportation Research B, Volume 34, Issue 5 (June 2000), pp. 315-449.

"Combining Sources of Preference Data for Modeling Complex Decision Processes" (with Jordan J. Louviere, Robert J. Meyer, Richard Carson, Benedict Delleart, W. Michael Hanemann, David Hensher, and Julie Irwin). Marketing Letters, Volume 10, Issue 3 (August 1999), pp. 205-217.

"Determinants of Alternative Fuel Vehicle Choice in the Continental United States" (with Melanie Tompkins, Danilo Santini, Mark Bradley, Anant Vyas, and David Poyer), Transportation Research Record, Number 1641, Energy and Environment: Energy Air Quality, and Fuels 1998, Transportation Research Board, National Research Council.

"Commercial Fleet Demand for Alternative-fuel Vehicles," (with Thomas F. Golob, Jane Torous, David Brownstone, Soheila Crane, and Mark Bradley), Transportation Research A Vol. 31A (1997): 219-233.

"A Vehicle Usage Forecasting Model Based on Revealed and Stated Vehicle Type Choice and Utilization Data," (with Thomas F. Golob and David Brownstone), Journal of Transport Economics and Policy Vol. 31 (1997): 69-92.

"A Dynamic Forecasting System for Vehicle Markets with Clean-Fuel Vehicles," (with David Brownstone and Thomas F. Golob). In D. A. Hensher, J. King, and T. H Oum eds., World Transport Research, Volume 1 (1996): 189-203.

"A Vehicle Transactions Choice Model for Use in Forecasting Demand for Alternative-Fuel Vehicles," (with David Brownstone, Thomas F. Golob, and Weiping Ren), Research in Transportation Economics, Vol. 4 (1996): 87-129.

"Demand for Clean-Fuel Vehicles in California: A Discrete-Choice Stated Preference Survey" (with Mark Bradley, Thomas F. Golob, Ryuichi Kitamura, Gareth P. Occhiuzzo). Transportation Research A, Vol. 27A, No. 3, pp. 237-253, 1993.

"Predicting the Market Penetration of Electric and Clean-fuel Vehicles" (with Thomas F. Golob, Ryuichi Kitamura, and Mark Bradley), The Science of the Total Environment, 134 (1993) pp. 371-381.

"Estimability in the Multinomial Probit Model," Transportation Research B, 1991, Vol 25B(1), pp. 1-12.

"Heterogeneity and State Dependence in Household Car Ownership: A Panel Analysis Using Ordered-Response Probit Models with Error Components," 11th International Symposium on Transportation and Traffic Theory, Elsevier, July 1990 (with Ryuichi Kitamura).

Curriculum Vitae

Name: Yueyue Fan **Phone:** 530-754-6408
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RESEARCH INTERESTS:

Applied mathematics and computation focusing on transportation and energy systems modeling and optimization: large-scale network optimization and real-time adaptive network routing, stochastic transportation and energy infrastructure system optimization, and risk management of transportation networks subject to seismic or other natural hazards.

EDUCATION:

May 2003 Doctor of Philosophy in Civil and Environmental Engineering, University of Southern California.

EMPLOYMENT:

July 2003 - present Assistant Professor, Department of Civil and Environmental Engineering, University of California, Davis

JOURNAL PUBLICATIONS:

[Dynamic Programming Applied to Linear, Quadratic, and Optimal Control Problems]

1. Y. Fan and R. Kalaba, Dynamic Programming and Pseudo-inverses, *Applied Mathematics and Computation*, Volume 139, Pages 323-342, 2003.
2. Y. Fan and R. Kalaba, A General Linear Quadratic Problem, *Journal of Optimization Theory and Applications,* Volume 127, Page 485-496, 2005.
3. Y. Fan, H. Bhargava, H. Natsuyama, Dynamic Pricing via Dynamic Programming, *Journal of Optimization Theory and Applications,* Volume 127, Page 565-577, 2005.

[Adaptive Network Routing]

4. Y. Fan, R. Kalaba, and J. Moore, Optimal Routing through Networks with Correlated Link Travel Times, *Computers and Mathematics with Applications*, Volume 49, Pages 1549-1564, 2005.
5. Y. Fan, R. Kalaba, and J. Moore, Arriving on Time, *Journal of Optimization Theory and Applications*, Volume 127, Page 497-513, 2005.
6. Y. Nie, and Y. Fan, The Arriving-On-Time Problem: A Discrete Algorithm that Ensures Convergence, *Transportation Research Record,* No. 1964, pp. 193-200, 2006.
7. Y. Fan and Y. Nie, Optimal Routing for Maximizing the Travel Time Reliability, *Journal of Networks and Spatial Economics*, Vol. 6, pp. 333-344, 2006.

[Transportation and Energy Infrastructure System Planning]

8. A. Kiremidjian, J. Moore, Y. Fan, O. Yazlali, N. Basoz, M. Williams, Seismic Risk Assessment of Transportation Network Systems, *Journal of Earthquake Engineering*, Volume 11, Issue 3, pages 371 – 382, 2007.

9. Y.X. Huang, Y. Fan, and R.L. Cheu, Optimal Allocation of Multiple Emergency Service Resources for Critical Transportation Infrastructure Protection, *Transportation Research Record*, No. 2022, pp1-8, 2007.

10. R.P. Naga and Y. Fan, Quick Estimation of Network Performance Measures Using Associative Memory Techniques, to appear in *Transportation Research Record* (Network Modeling Committee).

11. C.Z. Liu, Y. Fan, and F. Ordonez, A two-stage stochastic programming model for transportation network protection, to appear in *Computers and Operations Research.*

12. Y. Fan and C.Z. Liu, Solving Stochastic Transportation Network Protection Problem using the Progressive Hedging-Based Method, to appear in *Networks and Spatial Economics*.

13. Z. Lin, J. Ogden, Y. Fan, C.W. Chen, The Fuel-Travel-Back Approach to Hydrogen Station Siting, to appear in *Journal of Hydrogen Energy*.

14. Z. Lin, C.W. Chen, J. Ogden, Y. Fan, The Least-cost Hydrogen for Southern California, to appear in *Journal of Hydrogen Energy*.

15. N. Parker, J. Ogden, Y. Fan, The role of biomass in California's hydrogen economy, to appear in *Journal of Energy Policy*.

[Dynamic Mechanical Systems]

16. Y. Fan, R. Kalaba, H. Natsuyama, and F. Udwadia, Reflections on the Gauss's Principle of Least Constraint, *Journal of Optimization Theory and Applications*, Vol. 127, pp. 475-484, 2005.

17. F. Udwadia, R. Kalaba, and Y. Fan, Is Analytical Dynamics a Theoretical or An Experimental Science? *Journal of Nonlinear Analysis,* Vol. 63, pp. 692-698, 2005.

SELECTED CONFERENCE PRESENTATIONS AND SEMINARS

"Adaptive network routing for maximum reliability of on-time-arrival", UC Berkeley ITS Seminar, Berkeley, CA, 2004.

"Finding the best routing strategies for on-time arrival in stochastic networks", 2nd International Symposium on Transportation Network Reliability, Christchurch, New Zealand, 2004.

"Solving the constrained motion problem using the GI method", the 10th International Symposium on Artificial Life and Robotics, Oita, Japan, 2005.

"Revisiting arriving on time problem", INFORMS Annual Meeting, San Francisco, CA, 2005.

"Optimal allocation of emergency service resources for critical transportation Infrastructure protection", Transportation Research Broad Annual Meeting, Washington D.C., 2006.

"Stochastic network retrofit with recourse", INFORMS Annual Meeting, Pittsburgh, PA, 2006.

"Optimal network routing under emergency", Workshop on Network Analysis Applications to Homeland Security, Naval Postgraduate School, Monterey, CA, 2006.

"A two-stage stochastic programming model for transportation network protection", UC Berkeley ITS Seminar, Berkeley, CA, 2007.

"Reinforcement learning in post-disaster management and response", INFORMS Annual Meeting, Seattle, WA, 2007.

"Converting HOV to HOT: Efficiency, Profit, and Equity", INFORMS Annual Meeting, Seattle, WA, 2007.

"From Waste to Hydrogen: An Optimal Design of Energy Production and Distribution Network", National Urban Freight Conference, Long Beach, CA, 2007.

"Highway network retrofit under seismic hazard", 10th International Conference on Application of Advanced Technologies in Transportation, Athens, Greece, 2008.

RESEARCH GRANTS

Transportation Network Design under Earthquake Hazards, supported by Pacific Earthquake Engineering Research Center, $214,800, 2004-2007 (single PI).

An Integrated Multi-pathway Biofuel System Design under Uncertainties, supported by Chevron Technology Ventures, LLC, $299,082, 2007-2009, (PI: Yueyue Fan; Co-PI: Joan Ogden).

Optimal Design for A Self-sustainable HOT Network, supported by Sustainable Transportation Center at UC Davis, $ 59912.33, 2007-2008 (single PI).

National Biorefinery Siting Model, supported by Department of Energy Office of Biomass Program, $145,000, 2008-2009 (PI: Bryan Jenkins; Co-PI: Yueyue Fan and Joan Ogden).

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CURRENT APPOINTMENTS:

2006-present, Associate Professor of Economics, University of California, Davis

2008-present, Chancellor's Fellow, University of California, Davis

2007-present, Research Associate, National Bureau of Economic Research. Groups: Environmental Economics and Energy, Industrial Organization, and Productivity

2003-present, Visiting Research Fellow, University of California Energy Institute

2005-present, Faculty Affiliate, Institute of Transportation Studies, UC Davis

2006-present, Strategy and Policy Thread Leader for STEPS

2006-present, Associate Editor, *The Journal of Industrial Economics*

2007-present, Associate Editor, *American Economic Journal – Economic Policy*

2007-present, Associate Editor, *The Journal of Energy Markets*

PREVIOUS APPOINTMENTS:

2002-2006, Assistant Professor of Economics, University of California, Davis

2004-2007, Faculty Research Fellow, National Bureau of Economic Research. Groups: Environmental Economics and Energy, Industrial Organization, and Productivity

1999-2002, Assistant Professor of Finance and Economics, School of Management, Boston University

1996-1999, Research Assistant, University of California Energy Institute

1994-1996, Teaching Assistant, University of California, Davis

EDUCATION:

Ph.D., University of California, Berkeley, 1999 (Economics)

M.A., University of California, Davis, 1996 (Economics)

B.A., California State University, Stanislaus, *summa cum laude*, 1994 (Economics and Political Science)

PUBLICATIONS:

- Holland, Stephen P., Jonathan E. Hughes and Christopher R. Knittel. "Greenhouse Gas Reductions under Low Carbon Fuel Standards?," forthcoming in ***The American Economic Journal – Economic Policy***.
- Knittel, Christopher R. and Victor Stango. "How Does Incompatibility Affect Prices?: Evidence from ATMs," forthcoming in ***The Journal of Industrial Economics***.
- Borenstein, Severin, James Bushnell, Christopher R. Knittel and Catherine Wolfram. "Trading Inefficiencies in California's Electricity Markets," ***The Journal of Industrial Economics***, LVI(2), June 2008, pp. 347-378.
- Feenstra, Robert and Christopher R. Knittel. "Re-Assessing the Quality Adjustment to Computer Prices: Do U.S. Procedures Overstate the Gains?," forthcoming ***Price Index Concepts and Measurement***, NBER and the Chicago Press.
- Knittel, Christopher R. and Konstantinos Metaxoglou. "Diagnosing Unilateral Market Power in Electricity Reserves Market," ***The Journal of Energy Markets***, 1(1), Spring 2008.
- Knittel, Christopher R. and Victor Stango. "Incompatibility, Product Attributes and Consumer Welfare: Evidence from ATMs," ***The BE Journal of Economic Analysis & Policy, Advances***, 8(1), January 2008. Available at: http://www.bepress.com/bejeap/vol8/iss1/art1.
- Hughes, Jonathan E., Christopher R. Knittel and Daniel Sperling. "Evidence of a Shift in the Short-Run Price Elasticity of Gasoline." ***The Energy Journal***, 29(1), January 2008.
- Heisler, Jeffrey, Christopher R. Knittel, John J. Neumann and Scott Stewart. "Why Do Institutional Plan Sponsors Hire and Fire their Investment Managers?" Best Paper Award for the 31st NBEA Conference. ***The Journal of Business and Economics Studies***, 13(1), Spring 2007, pp. 88-116.
- Kim, Dae-Wook and Christopher R. Knittel "Biases in Static Oligopoly Models? Evidence from the California Electricity Market," ***The Journal of Industrial Economics***, LIV(4), December 2006, pp. 451-470.
- Knittel, Christopher R. "The Adoption of State Electricity Regulation: The Role of Interest Groups," ***The Journal of Industrial Economics***, LIV(2), June 2006.
- Knittel, Christopher R. and Michael R. Roberts. "Financial Models of Deregulated Electricity Prices: An Application to the California Market," ***Energy Economics***, 27(5), September 2005, pp. 791-817.
- Knittel, Christopher R. "Regulatory Restructuring and Incumbent Price Dynamics: The Case of Local Telephone Markets," ***Review of Economics and Statistics,*** 86(2), May 2004, pp. 614-625.
- Knittel, Christopher R. and Victor Stango. "Price Ceilings as Focal Points for Tacit Collusion: Evidence from the Credit Card Market," ***The American Economic Review***, 93(5), December 2003, pp. 1703-1729.
- Knittel, Christopher R. "Market Structure and the Pricing of Electricity and Natural Gas," ***The Journal of Industrial Economics***, LI(2), June 2003, pp. 167-191.
- Knittel, Christopher R. "Alternative Regulatory Methods and Firm Efficiency: Stochastic Frontier Evidence the US Electricity Industry," ***Review of Economics and Statistics***, 84(3), August 2002, pp. 530-540.

- Borenstein, Severin, James Bushnell, and Christopher R. Knittel. "Market Power in Electricity Markets: Beyond Concentration Measures," ***The Energy Journal,*** 20(4), October 1999, pp. 65-88.
- Knittel, Christopher R. "Long Distance Rates: Search Costs, Switching Costs, and Market Power," ***Review of Industrial Organization***, 12(4), August 1997, pp. 519-536.

WORKING PAPERS:

- Knittel, Christopher R. and Jason J. Lepore. "Tacit Collusion in the Presence of Cyclical Demand and Endogenous Capacity Levels." Revised and resubmitted to ***The International Journal of Industrial Organization.***
- Knittel, Christopher R. and Victor Stango. "Strategic Incompatibility in ATMs." Revisions requested from ***The International Journal of Industrial Organization.***
- Knittel, Christopher R. and Konstantinos Metaxoglou. "Estimation of Random Coefficient Demand Models: Challenges, Difficulties and Warnings"
- Fowlie, Meredith, Christopher R. Knittel and Catherine Wolfram. "Sacred Cars: Optimal Regulation of Stationary and Non-stationary Pollution Sources."
- Knittel, Christopher R. and Victor Stango. "The Productivity Benefits of IT Outsourcing"
- Heisler, Jeffrey, Christopher R. Knittel, John J. Neumann and Scott Stewart. "An Analysis of Re-Allocation Decision by Institutional Plan Sponsors" mimeo, UC Davis. Distinguished Paper for the 2006 Academy of Finance.

WORK IN PROGRESS:

- Consumer Expectations, Gasoline Prices and Vehicle Choice (with Meghan Busse and Florian Zettelmeyer)
- IT Outsourcing, Mergers and Industry Exit (with Victor Stango)
- Pharmaceuticals, Patents and Health Outcomes (with Peter Huckfeldt)
- Traffic and Infant Health (with Douglas Miller and Nick Sanders)
- Price Ceilings in Electricity Markets (with Victor Stango)
- Industry Dynamics in ATM Network Markets (with Victor Stango)
- Electricity Regulatory Restructuring: Efficiency Gains and Executive Pay (with Dae-Wook Kim)
- Durables and Changes in Software: Implications for Price Indexes and Software Firm Incentives (with Robert Feenstra)

AWARDS, HONORS, AND GRANTS:

- Barry D. McNutt Award for Excellence in Automotive Policy Analysis (with Jonathan Hughes and Dan Sperling), 2008
- National Science Foundation Grant (with Victor Stango), 2008-2010, $240,000
- Chevron Bio-Fuel Research Grant, 2007-2008, $127,000
- Chevron Bio-Fuel Research Grant, 2007-2008, $77,000
- Chevron Bio-Fuel Research Grant (Co-PI), 2007-2009, $370,000
- Woods Institute for the Environment Leadership Scholar Training, 2007
- Distinguished Paper, 2006 Academy of Finance
- University of California Energy Institute Research Grant, 2005-2006, $50,000

- Best Paper Award for the 31st NBEA Conference
- ASUCD Excellence in Teaching Award, 2004
- University of California Energy Institute Research Grant, 2003
- Faculty Research Grant, UC Davis, 2002, 2003, 20004, 2005, 2006
- Institute of Governmental Affairs Junior Faculty Grant, 2002, 2003, 2004, 2005
- Junior Faculty Research Grant, Boston University, 2001
- Graduate Fellowship, University of California, Berkeley, 1997–1999
- Graduate Fellowship, University of California, Davis, 1994–1996
- Institute of Transportation Fellow, University of California, Davis, 1995–1996
- Student Commencement Speaker, California State University, Stanislaus, 1994

REFEREE SERVICES:

Agricultural Economics, American Economic Review, Bulletin of Economic Research, Census Bureau, *Econometrica, Economic Inquiry, The Economic Journal, Economics Letters, Energy Economics, The Energy Journal, Energy Studies Review, European Economic Review, International Journal of Industrial Organization, International Journal of Power and Energy Systems, Journal of Banking and Finance, The Journal of Business, Journal of Business and Economic Statistics, Journal of Economic Behavior and Organization, Journal of Economic Education, Journal of Economics and Management Strategy, Journal of Futures Markets, Journal of Industrial Economics, Journal Institutional and Theoretical Economics, Journal of Law and Economics, Politics and Economics, Quarterly Journal of Economics, Rand Journal of Economics, Resource and Energy Economics, Review of Economic Studies, Review of Economics and Statistics, Review of Industrial Organization, Review of Network Economics, Southern Economic Journal, Socio-Economic Planning Sciences, Utilities Policy,* University of California Energy Institute Grant Program, NSF Grant Program

INVITED PRESENTATIONS:

"Climate Change and Economics"
- University Retirement Community, February 2008

"Carbon Taxes versus Cap and Trade"
- New American Foundation, February 2008
- Tainjin Chinese Delegation at UC Davis

"Carbon Policies for Transport"
- UCEI Policy Conference, December 2007

"Greenhouse Gas Reductions under Low Carbon Fuel Standards?"
- University of California Energy Institute, July 2007

"Sacred Cars: Optimal Regulation of Stationary and Non-stationary Pollution Sources."
- University of California at Davis, Institute of Transportation Studies, October 2007
- NBER Environmental Economics and Energy Summer Institute, July 2007
- 9th Occasional Workshop on Environmental and Resource Economics, Santa Barbara, November 2006

"Estimation of Random Coefficient Demand Models: Challenges, Difficulties and Warnings""

- University of California at Berkeley, Department of Economics, November 2007
- University of Alberta and Calgary University Industrial Organization Conference, October 2007

"Strategic Incompatibility in ATM Markets"

- Federal Trade Commission, November 2006
- University of California at Los Angeles, Department of Economics, October 2006

"Evidence of a Shift in the Short-Run Price Elasticity of Gasoline."

- CSEM Gasoline Conference, December 2006
- 9th Occasional Workshop on Environmental and Resource Economics, Santa Barbara, November 2006
- University of California Energy Institute, October 2006

"Incompatibility and Consumer Demand: Evidence from ATMs"

- Washington University, Olin School of Business, November 2007
- The Net Institute Conference, New York University, April 2005.
- University of California at Santa Cruz, Department of Economics, December 2004
- University of California at San Diego, Department of Economics, November 2004
- Penn State, Department of Economics, October 2004.
- NBER Summer Institute, Productivity/IO Meetings, July 2004.
- University of California, Berkeley, Haas School of Management, January 2004.
- American Economic Association Meetings, January 2004.

"Compatibility and Pricing with Indirect Network Effects: Evidence from ATMs,"

- NBER Summer Institute, Productivity/CRIW Meetings, July 2004.

"Re-Assessing the Quality Adjustment to Computer Prices: Do U.S. Procedures Overstate the Gains?"

- NBER/CRIW Conference, Vancouver, June 2004

"Biases in Static Oligopoly Models?"

- University of California Energy Institute, November 2003.

"Price Ceilings as Focal Points for Tacit Collusion: Evidence from the Credit Card Market"

- Boston University, Department of Finance and Economics, April 2002.
- University of California, Irvine, Department of Economics, January 2002.
- University of California, Davis, Department of Economics, January 2002.
- University Arizona, Department of Economics, January 2002.
- Northwestern University, Kellogg School of Management, November 2001.
- University of Maryland, Department of Economics, November 2001.
- NBER Summer Institute, Industrial Organization Meetings, August 2001.

"Trading Inefficiencies in California's Electricity Markets"

- NBER Summer Institute, Industrial Organization Meetings, July 2003.
- University of California, Davis, Department of Economics, October 2002.
- Boston University, Finance Seminar Series, November 2000.
- Harvard University, Industrial Organization Seminar Series, November 2000.
- POWER 5th Annual Electricity Conference, UC Berkeley, March 2000.

"Regulatory Restructuring and Incumbent Price Dynamics: The Case of Local Telephone Restructuring"

- NBER Summer Institute, Industrial Organization Meetings, August 2000.
- NBER Productivity Lunch, October 1999.
- INSEAD, Economics Seminar Series, May 1999.
- Boston University, Finance and Economics Seminar Series, May 1999.
- University of Western Ontario, Microeconomics Seminar Series, May 1999.
- University of California, Berkeley, Industrial Organization Seminar Series, August 1999.
- Georgetown University, Strategy Seminar Series, April 1999.
- University of California, Davis, Applied Microeconomics Seminar Series, April 1999.
- SMU, Applied Microeconomics Seminar Series, April 1999.
- Federal Reserve Board of Governors, Economics Seminar Series, April 1999.

"Does Incentive Regulation Provide the Correct Incentives?: Stochastic Frontier Evidence the US Electricity Industry"

- University of California, Berkeley, October 1998, Econometrics Seminar Series.
- INFORMS – Seattle, September 1999, Summer Conference.

"The Origins of State Electricity Regulation: Revisiting an Unsettled Topic"

- University of California Energy Institute, December 1997, UCEI Seminar Series.

Discussant, 2005 TPUG/ASSA Meetings, Philadelphia
Discussant, 2004 UCEI Annual Energy Conference, Berkeley
Discussant, 2003 UCEI Annual Energy Conference, Berkeley
Discussant, 2003 TPUG/ASSA Meetings, Washington D.C.
Discussant, 2000 Stanford University Strategy Meetings.
Discussant, 2000 NBER Winter IO Meetings, Stanford University

REGULATORY FILINGS:

- Arons, S.M., A.R. Brandt, M.A. Delucchi, A. Eggert, A.E. Farrell, B.K. Haya, J. Hughes, B.M. Jenkins, A.D. Jones, D.M. Kammen, S.R. Kaffka, C.R. Knittel, D.M. Lemoine, E.W. Martin, M.W. Melaina, J.M. Ogden, R.J. Plevin, D. Sperling, B.T. Turner, R.B. Williams, C. Yang, 2007. "A Low-Carbon Fuel Standard for California, Part 1: Technical Analysis." Available Online: http://www.lcfs.ucdavis.edu.

- Brandt, A.R., A.E. Farrell, B.K. Haya, J. Hughes, B.M. Jenkins, A.D. Jones, D.M. Kammen, C.R. Knittel, M.W. Melaina, M. O'Hare, R.J. Plevin, D. Sperling, 2007. "A

Low-Carbon Fuel Standard for California, Part 2: Policy Analysis." Available Online: http://www.lcfs.ucdavis.edu.

- Peer Review Comments on AB 1493, California Environmental Protection Agency Air Resource Board, September 2004.

- "Comments on the Use of Computer Models for Merger Analysis in the Electricity Industry," (Joint with Severin Borenstein and James Bushnell), Federal Energy Regulatory Commission. Docket No. PL98-6-000, June 1998.

- "A Cournot-Nash Equilibrium Analysis of the New Jersey Electricity Market," December 1997. (Joint with Severin Borenstein and James Bushnell). Filed with the New Jersey Public Utility Commission as testimony on the potential for market power in a deregulated Pennsylvania-Jersey-Maryland Power Pool.

CONSULTING:

Customers First! Coalition, Energy Information Agency, Korean Electric Power Company, California Air Resource Board, City of West Sacramento

PH.D. COMMITTEES (FIRST JOB):

UC Davis:
Jonathan Hughes (chair, on-going)
Peter Huckfeldt (on-going)
Nick Sanders (on-going)
Adib Bagh (University of Kentucky, Math and Economics)
Seungjoon Lee (Korean Insurance Research Institute)
Jason Lepore (chair, Cal Poly)
Wei-Min Hu (Peking University)
Byeongil Ahn (Gyeongsang University)
Konstantinos Metaxoglou (chair, Bates and White LLC.)
Lan Li (University of Melbourne)
Neil Norman (Cornerstone Research)
Dae-Wook Kim (chair, Korean Institute for Industrial Economics and Trade)

Boston University:
Gustavo Genoni (2002, Finance, IAE, School of Business, Universidad Austral)
John Neumann (2003, Finance, St. John's University)

TEACHING:

- UC Davis
  - Graduate Empirical Industrial Organization (5 times)
    - Ratings: Mean 4.9 (out of 5)
  - Transportation Economics (3 times)
    - Ratings: Mean 4.6
  - Intermediate Microeconomics (1 time),
    - Ratings: Mean 4.8

- Undergraduate Industrial Organization (9 times)
  - Ratings: Mean 4.8
- Boston University
  - Modeling Business Decision Making,
    - Spring 2000, Spring 2001 and Spring 2002
    - Ratings: 4.53 (out of 5), 4.77, 4.70
  - Modeling Business Decision Making (honors),
    - Spring 2001 and Spring 2002
    - Ratings: 4.88, 4.70

UNIVERSITY SERVICE:

UC Davis:
2007-2008, Co-writer (with Jean Vandergehst) of a proposal for a Graduate Program in "Energy Science and Technology" and "Energy Policy and Management"
2006-Present, Member, Energy Institute Steering Committee
2008, Founding Faculty Member, UC Davis Energy Institute
2005-2006, Hiring Committee and Interviewing Committee
2004-2005, Hiring Committee and Interviewing Committee
2002-2003, Hiring Committee and Interviewing Committee
2002-2007, Graduate Advisor
Oral committees: Dae-Wook Kim, Konstantinos Metaxoglou, Neil Norman (chair), Seungjoon Lee, Wei-Min Hu, Lan Li, Sunhwa Lee, Byeongil Ahn, Michele Amaral, David Ong, Adib Bagh, Jason Lepore, Bei Li, Chenguang Li, Tina Saitone, Carlo Russo, Sandhya Patlolla, Peter Huckfeldt. Kyungwon Rho

Boston University:
2000-2001, Finance Hiring Committee and Interviewing Committee
1999-2000, Finance Hiring Committee

RECENT MEDIA CITATIONS:

Print: Alameda Times-Star, Arizona Daily Star, Argus, ATMmarketplace.com, Austin-American Statesman, Boston Globe, Buffalo News, California Aggie, Contra Costa Times, PE.com, bankrate.com, marketwatch.com, Crain's Business Report (New York), Credit Card Magazine, Kiosk Marketplace News, LA Observed, LA Times, International Herald Tribune, Northwestern Herald, Oakland Tribune, Oregonian, Philadelphia Inquirer, Providence Journal, New York Times, Sacramento Bee, St. Petersburg Times, Salon.com, San Diego Union Tribune, Salt Lake Tribune, San Diego Union Tribune, SF Chronicle, San Mateo County Times, Santa Rosa Press Democrat, Sarasota Herald-Tribune, Scripps News (DC), Tuscaloosa News Sun Herald, Quad City News (Iowa), Winston-Salem Journal, Worcester Telegram
Radio: KQED's "Forum", KXJZ, KFBK, KUOP, KCBS, KNX, WHYY with Marty Moss-Coane, WPR with Kathleen Dunn, Bloomberg Radio, Lambasted by Rush Limbaugh
Television: KCRA-3, CBS-13 Sacramento, NBC Nightly News, ABC World News, CBS Evening News, ABC Good Morning America

TIMOTHY E. LIPMAN, PHD
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Transportation Sustainability Research Center
Institute of Transportation Studies
2614 Dwight Way, 2nd Floor, MC 1728
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Phone: 510-642-4501 Email: telipman@tsrc.berkeley.edu
http://www.its.berkeley.edu/sustainabilitycenter/

PROFESSIONAL PREPARATION

Stanford University Anthropology B.A., 1990
University of California – Davis Transp. Technology and Policy M.S., 1998
University of California – Davis Ecology (Envt'l Policy Analysis AOE) Ph.D., 1999
University of California – Davis Inst. of Transportation Studies Postdoc, 2000
University of California – Berkeley Energy and Resources Group Postdoc, 2000-2003

APPOINTMENTS

- May 2008 – present: **Co-Director**, Transp. Sustainability Research Center, UC Berkeley
- July 2006 – April 2008: **Research Director**, Transp. Sustainability Research Center, UC Berkeley
- February 2004 – present: **Assistant Research Engineer**, Inst. of Transportation Studies, UC Berk.
- 2005 – present: **Member**, Transportation Research Board Committee on Transportation Energy
- ADC70
- November 2003 – June 2004: **Assistant Research Scientist**, Energy and Resources Group, UC Berk.
- June 2003 – October 2003: **Staff Research Associate**, Energy and Resources Group, UC Berkeley
- January 2003 – May 2003: **Post-Doctoral Researcher**, Inst. of Transportation Studies, UC Davis
- September 2000 – August 2002: **Post-Doctoral Researcher**, Energy and Resources Group, UC Berk.
- January 2000 – August 2000: **Post-Doctoral Researcher**, Inst. of Transportation Studies, UC Davis

SELECTED PEER-REVIEWED JOURNAL PUBLICATIONS

Lipman, Timothy E. and Mark A. Delucchi (2006), "An Analysis of the Retail and Lifecycle Costs of Hybrid Electric Vehicles," *Transportation Research – D* **11**(2): 115-132.

Lipman, Timothy E., Jennifer L. Edwards, and Daniel M. Kammen (2004), "Fuel Cell System Economics: Comparing the Costs of Generating Power with Stationary and Motor Vehicle PEM Fuel Cell Systems," *Energy Policy* **32**(1): 101-125.

Lipman, Timothy E. and Mark A. Delucchi (2002), "Emissions of Nitrous Oxide and Methane from Conventional and Alternative Motor Vehicles," *Climatic Change* **53**: 477-516.

Brodrick, Christine-Joy, Timothy E. Lipman, Mohammed Farschi, Nicholas Lutsey, Harry A. Dwyer, Daniel Sperling, S. William Gouse, D. Bruce Harris, and Foy G. King (2002), "Evaluation of Fuel Cell Auxiliary Power Units for Heavy-Duty Diesel Trucks," *Transportation Research – D* 7(4): 303-315.

Herzog, Antonia V., Timothy E. Lipman, Jennifer L. Edwards, and Daniel M. Kammen (2001), "Renewable Energy: A Viable Choice," *Environment* **43** (10): 8-20.

Delucchi, Mark A. and Timothy E. Lipman (2001), "An Analysis of the Retail and Lifecycle Cost of Battery-Powered Electric Vehicles," *Transportation Research – D* **6**: 371-404.

Lipman, Timothy E. and Daniel Sperling (1997), "Forecasting the Cost Path of an Electric Vehicle Drive System: A Monte Carlo Experience Curve Simulation," *Transportation Research Record* **1587**: 19-26.

ADDITIONAL SELECTED PUBLICATIONS

Lipman, Timothy E. (2004), "Integration of Motor Vehicle and Distributed Energy Systems," *Encyclopedia* of *Energy*, Academic Press/Elsevier Inc., ISBN 0-12-176480, March.

Lipman, Timothy E. and Daniel Sperling (2003), "Fuel Cell Commercialization Perspectives: Market concepts, competing technologies and cost challenges for automotive and stationary applications," *Handbook of Fuel Cells – Fundamentals, Technology, and Applications, Vol. 4: Fuel Cell Technology and Applications Part 2*, Edited by W. Vielstich, H. Gasteiger, and A. Lamm, John Wiley and Sons, Ltd., Chichester, pp. 1318-1329.

Shaheen, Susan, Timothy Lipman, and Elliot Martin (2006), "F-Cell" Fuel Cell Vehicle Fleet Driver Response Study," Prepared for DaimlerChrysler Research and Technology North America, December.

Weinert, Jonathan X. and Timothy E. Lipman (2006), *An Assessment of the Near-Term Costs of Hydrogen Refueling Stations and Station Components*, Inst. of Transportation Studies, Davis, UCD-ITSRR-06-03, January.

Delucchi, Mark A. and Timothy E. Lipman (2003), *A Lifecycle Emissions Model (LEM): Lifecycle Emissions from Transportation Fuels, Motor Vehicles, Transportation Modes, Electricity Use, Heating and Cooking Fuels, and Materials, APPENDIX A: Energy Use and Emissions from the Lifecycle of Diesel-Like Fuels Derived From Biomass*, Inst. of Transportation Studies, Davis, UCD-ITS-RR-03-17A, December 1.

Lipman, Timothy E. and Mark A. Delucchi (2003), *Retail and Lifecycle Cost Analysis of Hybrid Electric Vehicle Designs*, Inst. of Transportation Studies, Davis, UCD-ITS-RR-03-01, April.

Lipman, Timothy E., Jennifer L. Edwards, and Daniel M. Kammen (2002), "Economic Analysis of Hydrogen Energy Station Concepts: Are "H2E-Stations" a Key Link to a Hydrogen Fuel Cell Vehicle Infrastructure?" *Energy Development and Technology Working Paper Series*, EDT-003, University of California Energy Institute (UCEI), November.

SYNERGISTIC ACTIVITIES

- 2007-present: Co-Principle Investigator "California Clean Mobility Partnership" funded by AB 1811to test and investigate plug-in hybrid electric and fuel cell powered vehicles
- 2005-present: Co-Director of Pacific Region Combined Heat and Power Application Center
- 2005-present: Co-Principal Investigator for National Science Foundation MUSES Project: Automotive Material Flows and Greenhouse Gas Emissions Policies
- 2001-2006: Research Track Director for UC Davis Hydrogen Pathways Program
- 2001-present: Ongoing development and use of the MATLAB/Simulink Clean Energy Technologies Economics and Emissions Model (CETEEM)

Daniel M. Kammen

Research Focus: renewable energy science, technology and policy. Energy and climate change. Risk analysis.

a. **Professional Preparation**

Cornell University Physics (Cum Laude) B.A. 1984
Harvard University Physics M.A.1986
Harvard University Physics Ph.D. 1988

b. **Appointments**

Faculty Positions: Class of 1935 Distinguished Chair in Energy (2004 -); Professor, Goldman School of Public Policy, University of California, Berkeley (2001-present); Professor, Energy and Resources Group, University of California, Berkeley (2001-present); Professor, Department of Nuclear Engineering, University of California, Berkeley (2001-present); Associate Professor, Energy and Resources Group (1998-2001); Assistant Professor of Public and International Affairs, Woodrow Wilson School of Public and International Affairs, Princeton University (1993-98).

Administration and Research: Co-Director, Berkeley Institute of the Environment (2005-present); Founding Director, Renewable and Appropriate Energy Laboratory, University of California, Berkeley (1998-present); Director, Transportation Sustainability Research Center (2008-present); Postdoctoral Fellow, Department of Physics and Kennedy School of Government, Harvard University, (1991 – 1993); Weizmann Postdoctoral Fellow, Division of Engineering, and Division of Biology, California Institute of Technology (1998 – 1991). Permanent Fellow, African Academy of Sciences (2000 – present). Fellow, American Physical Society (1999 – present); Chair, Science, Technology and Environmental Policy Program, Princeton University (1994 – 1998).

National Advisory Board, Union of Concerned Scientists (2004 – present); Board of Directors, The Utility Reform Network (2002 – present), Associate Editor, *Annual Review of Environment and Resources* (2002-2006). Editor-in-Chief, *Environmental Research Letters* (2006 -)

c. **Publications** (182 journal articles; 5 books; 20+ research reports; 11 US House and Senate Committee Testimonies)

(i) Selected Publications:

Farrell A. E., Plevin, R. J. Turner, B. T., Jones, A. D. O'Hare, M. and Kammen, D. M. (2006) "Ethanol can contribute to energy and environmental goals", *Science*, **311**, 506 – 508.

Bailis, R., Ezzati, M. and Kammen, D. M. (2005) "Mortality and greenhouse gas impacts of biomass and petroleum energy futures in Africa", **308**, *Science*, 98 – 103.

Jacobson, A. and Kammen, D. M. (2005) " Science and engineering research that values the planet", *The Bridge: Journal of the National Academy of Engineering*, **Winter**, 11 – 17.

Herzog, A. V., Lipman, T., Edwards, J. and Kammen, D. M. (2001) "Renewable Energy: A Viable Choice", *Environment*, **43 (10)**, 8 – 20.

Ezzati, M. and Kammen, D. (2001) "Indoor air pollution from biomass combustion and acute respiratory infections in Kenya: An Exposure-response study", *The Lancet*, **358**, 619 – 624.

(ii) 5 other selected publications:

Kammen, D., M. and Pacca, S. (2004) "Assessing the costs of electricity", *Annual Review of Environment and Resources*, **29**, 1 – 44.

Bailis, R., Ezzati, M., and Kammen, D. M. (2003) "Greenhouse Gas Emissions from Cooking Technologies in Kenya", *Environmental Science & Technology*, **37 (10)**, 2051 - 2059.

Margolis, R. and Kammen, D. M. (1999) "Underinvestment: The energy technology and R&D policy challenge", *Science*, **285**, 690 - 692.

Duke, R. D., and Kammen, D. M. (1999) "The economics of energy market transformation initiatives", *The Energy Journal*, **20 (4)**, 15 – 64.

Kammen, D. M. and Hassenzahl, D. M. *Should We Risk It? Exploring Environmental, Health and Technological Problem Solving*, in press, Princeton University Press. ISBN 0-169-00426-9, 406 pages, 77 tables, 82 illustrations.. Book Club Selection: *Library of Science*. Reviewed in *Science*, *Risk Analysis*, *Scientific American*, *WholeEarth*.

d. **Synergistic Activities.**

(i) Research and Project Management

Member, Science and Technology Review Committee for the Global Environment Facility (GEF) for which he has reviewed, and participated in project and budget evaluation and oversight for over $1.4 billion in international energy and environmental projects, ranging in size from $5 - $400 million.

(ii) Curriculum and Program Development

Professor Kammen was the Chair of the Science, Technology and Environmental Policy Program at Princeton University, and played a significant role in developing the program. At Berkeley he is the founding director of the Renewable and Appropriate Energy Laboratory. Kammen has been a visiting lecturer in the Department of Physics, the University of Nairobi.

(iii) Public and Professional Lectures

Professor Kammen lectures internationally on a regular basis. Within the last six months he has been invited and spoke at the Erice Summer School in Physics, Sicily, Italy; Harvard, Princeton, Yale, Stanford, and Duke Universities. He has testified in front of both U. S. House and Senate committees on a range of energy, environment, and technology issues, as well in front of State of California energy and environmental committees. He has appeared on *'60 Minutes'*, *CNN*, , the ABC nightly news, NPR (and is a regular guest on *Science Friday)*, and local news on a regular basis.

(iv) Consultancies

Professor Kammen provides technical and policy input, reviews, and consultancies for, the U.S. Department of Energy, and the U.S. Environmental Protection Agency, the World Bank, the World Health Organization, the President's Council on Science and Technology, the Government of Sweden, and the United Nations Development Program.

(v) Service to the Scientific Community

Professor Kammen is a regular reviewer for *Science, Nature, Environmental Science & Technology, Energy Policy,* and *The Energy Journal.* He has served on US EPA and US DoE review committees, as well as on committees of the National Academy of Science. Kammen has been on the review committee for the Link Energy Fellowships, and a consultant for the e7 Energy Fellowships (for students from developing nations).

(vi) Student Mentoring

Professor Kammen currently supervises 13 doctoral and six masters students, teaches courses on career development in energy science and policy, teaches the gateway course at UC Berkeley on 'energy and society', and has mentored undergraduates at UC Berkeley, Princeton University, and Harvard University, as well as through minority science and engineering programs. His doctoral advisees are now on the faculty at: Harvard (School of Public Health), Yale (School of Forestry), U. of Wisconsin (Environmental Sciences), Georgetown (School of Foreign Service),

(vii) Research Support

US Dept. of Energy, The Energy Foundation, the California Energy Commission, ITRI (current annual total ~ $1,500,000/year).

e. **Collaborators & Other Affiliations**

(i) Collaborators: Dr. Evans Kituyi (University of Nairobi); Professor Majid Ezzati (School of Public Health, Harvard University); Professor John Holdren (Harvard University); Professor José Goldemberg (University of Sao Paulo, Brazil).

(ii) Graduate and Postdoctoral Advisors

Post-doctoral Advisor: Harvard: Professor Richard Wilson (Physics).

Post-doctoral Advisor: Caltech: Professor Christof Koch, Division of Biology and Computational Neural Systems Program

Ph.D. Advisor: Professor Robert Westervelt, Harvard University (Solid State Physics)

(iii) Graduate Students and Post-graduate Scholars Sponsored (past 5 years)

Post-doctoral advisees at the University of California, Berkeley (6): Dr. Tim Lipman, Dr. Magda Moner e Girona; Dr. Antonia Herzog; Dr. Lloyd Connelly, Dr. Frank Ling

Post-doctoral advisees at Princeton University (2): Dr. Daniel Klooster, Dr. Lisa Naughton

Doctoral advisees at the University of California, Berkeley (7 completed, 9 current)

Doctoral advisees at the Princeton University (5)

SUSAN A. SHAHEEN, PH.D.
CO-DIRECTOR & RESEARCH SCIENTIST

Transportation Sustainability Research Center (TSRC), University of California (UC), Berkeley;
1301 S. 46th Street; Richmond Field Station, Building 190; Richmond, CA 94804-4648
510-665-3483 (O) and 510-665-2183 (F)
& Institute of Transportation Studies-Davis, University of California, Davis (UC Davis)
sashaheen@tsrc.berkeley.edu and sashaheen@ucdavis.edu
www.imr.berkeley.edu and www.its.berkeley.edu/sustainabilitycenter/

Susan Shaheen holds a joint research appointment at the Transportation Sustainability Research Center (TSRC) and at the Institute of Transportation Studies-Davis. She is codirector of the transportation track of the Energy Efficiency Center at UC Davis and was honored as the first Honda Distinguished Scholar in Transportation in 2000. In October 2007, Susan became a Research Director at TSRC. She served as the Policy & Behavioral Research Program Leader at California Partners for Advanced Transit and Highways from 2003 to 2007, and as a special assistant to the Director's Office of the California Department of Transportation from 2001 to 2004. She has a Ph.D. in ecology, focusing on technology management and the environmental aspects of transportation, from the University of California, Davis (1999) and a MS in public policy analysis from the University of Rochester (1990). She completed her post-doctoral studies on advanced public transportation systems at UC Berkeley in July 2001. She has earned a variety of honors, including two national research awards for her contributions to a carsharing pilot program (2001) and a smart parking field test (2005). In May 2007, she received the Berkeley Staff Assembly's "Excellence in Management" award in recognition of her leadership and mentorship. She has co-edited one book and authored 31 journal articles and over 45 reports and proceedings articles. She is the chair of the Emerging and Innovative Public Transport and Technologies (AP020) Committee of the Transportation Research Board and served as the founding chair of the Carsharing/Station Car TRB Subcommittee from 1999 to 2004.

EDUCATION

Ph.D., University of California, Davis, Ecology with major emphasis on Technology Management and Environmental Aspects of Transportation (3.8 GPA), September 1999.
Dissertation: *Dynamics in Behavioral Adaptation to a Transportation Innovation: A Case Study of CarLink—A Smart Carsharing System.*
Thesis Committee: Daniel Sperling (chair), Ryuichi Kitamura, and Richard Walters.

MS, University of Rochester, Public Policy Analysis, 1990

BA, Nazareth College, Political Science and English, 1988 (Magna Cum Laude)

SELECTED BOOKS, PAPERS, AND REPORTS

Shaheen, Susan, Elliot Martin, and Timothy Lipman (2008). "Dynamics in Behavioral Response to A Fuel Cell Vehicle Fleet and Hydrogen Fueling Infrastructure," *Transportation Research Record*, Publication Forthcoming.

Shaheen, Susan and Timothy Lipman (2007). "Reducing Greenhouse Gas Emissions and Fuel Consumption: Sustainable Approaches for Surface Transportation," *Journal of International Association of Traffic and Safety Sciences (IATSS) Research.* Vol. 31, No. 1, pp. 6-20.

Lipman, Timothy and Susan Shaheen (2005). *Integrated Hydrogen and Intelligent Transportation Systems Evaluation for the California Department of Transportation.* UCB-ITS-PRR-2005-34. Berkeley, California. November, 63 pp.

Shaheen, Susan, Andrew Schwartz, and Kamill Wipyewski (2004). "Policy Considerations for Carsharing and Station Cars: Monitoring Growth, Trends, and Overall Impacts," *Transportation Research Record* No. 1887, pp. 128-136.

Shaheen, Susan and Rachel Finson (2004). "Intelligent Transportation Systems." *Energy Encyclopedia, Volume 3*, pp. 487-496.

Shaheen, Susan, Caroline Rodier, and Rachel Finson (2003). *Smart Mobility Model: A Case Study of the University of California & Davis Region.* UCB-ITS-PRR-2003-28. Berkeley, California. September, 184 pp.

Rodier, Caroline and Susan Shaheen (2003). "Carsharing and Carfree Housing: Predicted Travel, Emission, and Economic Benefits. A Case Study of the Sacramento, California Region," *Transportation Research Board 83rd Annual Meeting*, Washington, D.C.

Shaheen, Susan A. (2002). Introduction. *Cool Careers for Girls as Environmentalists*. By Ceel Pasternak. Manassas Park, VA: Impact Publications. 129 pp.

Shaheen, Susan (1999). *Dynamics in Behavioral Adaptation to a Transportation Innovation: A Case Study of CarLink—A Smart Carsharing System*. UCD-ITS-RR-99-16. Davis, California. October, 232 pp.

Sperling, Daniel and Susan A. Shaheen, editors. (1995). *Energy Strategies for a Sustainable Transportation System*. Washington, D.C.: American Council for an Energy Efficient Economy. 305 pp.

Shaheen, Susan A., Randall Guensler, and Francisca Mar. (1995). "Concurrent Air Quality Analysis Under the National Environmental Policy Act and Transportation/Air Quality Conformity," *Transportation Quarterly*, Fall, pp. 55-72.

CAROLINE J. RODIER, Ph.D.

CURRENT POSITION

Senior Researcher, Transportation Sustainability Research Center, Institute of Transportation Studies, University of California, Berkeley

EDUCATION

Ph.D., University of California, Davis, Ecology with major emphasis on Environmental Policy Analysis and Transportation Planning, 2000
Dissertation: Uncertainty in Travel and Emissions Models: A Case Study in the Sacramento Region. Dissertation Committee: Robert Johnston, Patricia Mokhtarian, James Cramer & David Layton

M.S., University of California, Davis, Community Development, 1994

B. A., Barnard College, Columbia University, U.S. History, 1989

EVALUATION RESEARCH

- *Apply research evaluation methods (observational, focus groups, and surveys) and conduct analyses to evaluate the travel, economic, and environmental effects of transportation and environmental policies (e.g., transit access technologies, social marketing, automated speed enforcement, and changeable message signs).*
- Conduct analysis of institutional barriers and steps to overcome those barriers (including literature reviews and expert and stakeholder interviews) related to implementation and enforcement of transportation and air quality regulations.
- Investigate the transportation needs and preferences of diverse population groups, such as elderly, immigrants, and Native Americans, and explore innovative transportation programs to address those needs.

URBAN MODELING RESEARCH

- Research support to the California Air Resources Board in their development of the scoping plan for Assembly Bill 32, the *Global Warming Solutions Act*, including an international review of the modeling evidence on the effectiveness of transit, land use, and auto pricing strategies.
- Modeled and evaluated the travel, economic, and air quality effects of intelligent transportation systems technologies, high occupancy vehicle lanes, transit improvements, and road pricing and land use control measures using the Sacramento land use, travel, and emissions models.
- Apply methods of uncertainty analysis to assess errors in land use, travel, and emissions models due to model structure, population projections, and induced travel in the Sacramento region.

SELECTED EXPERT SERVICE/PROFESSIONAL ACTIVITIES

- Research Associate, the Mineta Transportation Institute
- Transportation Research Board, Integrated Transportation and Land-Use Modeling Subcommittee, Member, 2001 to present
- Transportation Research Board, New Public Transportation Technologies Committee, Friend, 2004 to present

SELECTED PUBLICATIONS

Rodier, C. (2008). An International Review of the Modeling Evidence on the Effectiveness of Transit, Land Use, and Auto Pricing Strategies. Submitted to the Transportation Research Record. August 1.

Rodier, C., Benjamin-Chung, J. and S. Shaheen. (2008). Comprehension and Effectiveness of Safety Campaign Messages on Changeable Message Signs. Submitted to the Transportation Research Record. August 1.

Rodier, C., Benjamin-Chung, J. and Shaheen, S. (2008). Changeable Message Signs: Understanding Public Preferences for Message Types. Submitted to the Transportation Research Record. August 1.

Rodier, C. J. (2007). Verifying the Accuracy of Land Use Models Used in Transportation and Air Quality Planning: A Case Study in the Sacramento, California Region. WCTR Annual Meeting, June.

Shaheen, S.A. and C.J. Rodier. (2007) Video Transit Training for Older Travelers: A Case Study of the Rossmoor Senior Adult Community, California. *Transportation Research Record* No. 2034, pp. 11-1889-194.

Rodier, C. J., S. A., Shaheen, and A. Eaken. (2005). Transit-based smart parking in the San Francisco Bay Area: an assessment of user demand and behavioral effects. Transportation Research Record (in press).

Rodier, C. J. (2004). Verifying the Accuracy of Regional Models Used in Transportation and Air Quality Planning. Transportation Research Record, 1898, 45-51.

Rodier, C. J., R. A. Johnston, and D. R. Shabazian. (2003). Evaluation of advanced transit alternatives using consumer welfare. In Transportation and Information Systems. Cheltenham, England: Edward Elgar Publishing, 139-153.

Rodier, C. J. and R. A. Johnston. (2002). Uncertain socioeconomic projections used in travel and emissions models: could plausible errors result in air quality nonconformity? Transportation Research A, 36:613-631.

Hunt, J. D., R. A. Johnston, J. E. Abraham, C. J. Rodier, G. Garry, S. H. Putnam, and T. de la Barra. (2001). Comparisons from the Sacramento Model Testbed. Transportation Research Record, 1780, 53-63.

Walter McManus, PhD
Automotive Analysis Division
University of Michigan Transportation Research Institute
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Ann Arbor, MI 48109-2150
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Summary

Dr. Walter McManus is the Director of the Automotive Analysis division of the University of Michigan Transportation Research Institute. He earned a BA in economics from Louisiana State University in 1977 and a PhD in economics from UCLA (where he was a Stern Fellow) in 1983.

He is an economist with 20 years of automotive industry experience. His research applies tools of econometrics, competitive analysis, consumer demand theory, and forecasting to understand trends in the automotive industry. His research currently focuses on the interaction of the industry, society, and the environment.

His business career included nine years at General Motors (1989-1998) where he held various positions in market analysis and product development; and spent a year in a components factory as a production supervisor. He became executive director of forecasting and analytics for J.D. Power and Associates in 1999. In addition to leading the firm's global forecasting activities, he conducted research on the market diffusion of new technologies including powertrain (electric, hybrid, clean diesel, fuel cell, alternative fuels), safety, and telematics.

He recently received the National Association for Business Economics' Abramson Award for an article (the link between gasoline prices and vehicle sales: economic theory trumps conventional Detroit wisdom, Business Economics 1.42(2007): pp. 54-60) that criticized automotive industry economists for failing to recognize and warn the industry of the growing value of fuel economy to consumers since 2001. The result was that Detroit's false conventional wisdom was not overturned before billions of dollars of losses accumulated and thousands of American jobs were lost.

Areas of Expertise

- Applied economics
- Statistics and forecasting
- Applied demographic analysis
- Development of tools that enable better decision-making
- Visualizing information
- Leadership in multi-disciplinary project teams
- Knowledge of markets for light-duty vehicles
- Knowledge of technology diffusion in light-duty vehicles

Education

- PhD in Economics, UCLA, 1983
  - Sidney Stern Fellow
  - Fields: Labor, Industrial Organization, and Econometrics
  - Dissertation: "Effects of Language Characteristics on Earnings"
  - Dissertation Advisor: Finis Welch
  - U.S. DOL Dissertation Fellowship in Employment and Training
- BA in Economics, Louisiana State University, 1977

Selected Publications

The Link Between Gasoline Prices and Vehicle Sales, Business Economics, p. 53, January 2007.

Economic Analysis of Feebates to Reduce Greenhouse Gas Emissions from Light Vehicles for California, Automotive Analysis Division (AAD), University of Michigan Transportation Research Institute (UMTRI), May 2007.

Can Proactive Fuel Economy Strategies Help Automakers Mitigate Fuel-Price Risks? Automotive Analysis Division, (AAD), University of Michigan Transportation Research Institute (UMTRI), September 2006.

In The Tank – How Oil Prices Threaten Automakers' Profits and Jobs (with Alan Baum, Roland Hwang and Daniel D. Luria) Office for the Study of Automotive Transportation, July 2005.

The Effects of Higher Gasoline Prices on U.S. Light Vehicle Sales, Prices, and Variable Profit by Segment and Manufacturer Group, 2001 and 2004. Office for the Study of Automotive Transportation (OSAT), University of Michigan Transportation Research Institute (UMTRI), June 2005.

Future Potential of Hybrid and Diesel Powertrains in the US Light-Duty Vehicle Market, (with David L. Greene and K.G. Duleep), Report to Department of Energy, July 2004. *Consumer Acceptance of Alternative Powertrains*, OE Industry Review. Troy, MI: Original Equipment Suppliers Association, 2004.

Analysis of Tax Credits to Stimulate Consumer Demand for Advanced-Technology Fuel-Efficient Vehicles: Final Report to Energy Future Coalition Transportation Working Group. Westlake Village, CA: J.D. Power and Associates, 2003.

RESUME
NAME: **K.G. Duleep**

EDUCATION:

1989 M.B.A.
Wharton School
University of Pennsylvania
Philadelphia, Pennsylvania

1976 Doctoral Candidate (Aerospace Engineering)
University of Michigan
Ann Arbor, Michigan

1975 MS (Aerospace Engineering/Computer Information and Control Engineering)
University of Michigan
Ann Arbor, Michigan

1972 Bachelor of Technology (Aerospace Engineering)
Indian Institute of Technology
Madras, India

EXPERIENCE:

1988 - Present **Energy and Environmental Analysis, Inc.**
Managing Director

Responsible for directing all studies in the area of mobile source emission control, alternative fuels and fuel economy. Major projects under his direction include:

- Analysis of new technologies to improve vehicle fuel economy
- Development of techno-economic models to forecast vehicle attributes in the future
- Analysis of new polices and regulations to improve light vehicle fuel economy
- Support to auto manufacturers on compliance issues relating to fuel economy and emissions

1979 - 1988 **Energy and Environmental Analysis, Inc.**
Senior Professional

Lead engineering analyst on all mobile source emissions and fuel economy issues. Projects included:

- Development of emission factors for EPA's MOBILE3/4 Models.
- Estimates of 1990/95 fuel economy potential for domestic auto-manufacturers.

- Analysis of post-1990 heavy duty truck emission standards, and implications for Canada.
- Analysis of alternative fuel vehicle technology development.
- Review of inspection/maintenance data from several states to estimate program quality.

1976 - 1978 **Bendix**
Electronics and Engine Control Systems Group
Senior Engineer

Involved in a variety of design and development projects. Participated in the development of digital microprocessor control of engine parameters and contributed to control law analysis. Helped design a closed loop fuel control for 3-way catalyst systems, focusing on oxygen sensor operation.

Studied the design and development of a low-cost throttle body injection (TBI) system and marketed TBI systems to Chrysler, Ford and Fiat. Also helped design dynamometer testing and vehicle calibration to meet the statutory emission standards of 0.4 HC/3.4 CO/0.4 NO_x g/mile.

1973 - 1976 **University of Michigan**
Department of Aerospace Engineering
Research Assistant

Involved in gas dynamics/combustion/control projects: NO_x formation during methane combustion (AGA Project), control theory application to anticoagulant therapy, and light aircraft engine emissions baseline.

1972 - 1973 **Aeronautical Development Establishment**
Junior Scientific Officer

Scientific officer in the aerodynamics division responsible for aerodynamic design of target drones, wind-tunnel testing of MIG-21, and development of dynamic behavior model for transonic missile.

PUBLICATIONS:

Duleep, K.G., "Optimization Applications in Anti-Coagulant Therapy," AIAA Paper 76-204, presented at the AIAA/AAS Astrodynamic Conference, 1976.

Duleep, K.G., "Jet Flow Field During 'Screech,'" Applied Sciences (32), August 1976.

Duleep, K.G., "Survey and Analysis of Collection Methods for Automobile Particulate Emissions," APCA Paper 79-47, June 1979.

Difiglio, C., Dulla, R., and Duleep, K.G., "Cost-Effectiveness of 1985 Automobile Fuel Economy Standards," prepared for the Society of Automobile Engineers, October 1979.

Duleep, K.G., "Analysis of Automotive Particulate Sampling Techniques," SAE Paper No. 800184, February 1980.

Duleep, K.G., Kuhn, D.P., and Crawford, R.W., "1985 Light-Duty Truck Fuel Economy," SAE Paper No. 801387, October 1980.

Duleep, K.G. "Forecasting Fuel Economy - Review of Critical Issues," oral presentation at the SAE June 1982 meeting.

Lax, D.L., and Duleep, K.G., "Recent Trends in Factors Influencing Automotive Fuel Demand," SAE Paper No. 83054, 1983.

Duleep, K.G., "Future Automotive Emission Control Technology and Strategy," SAE Paper No. 841244, October 1984.

Duleep, K.G., Wang, D., and Crawford, R.W., "I/M Short Tests and Cutpoints for 1981 and Newer Emission Control Technology," SAE Paper No. 851185, May 1985.

Duleep, K.G., "Heavy-Duty Vehicle Fuel Economy Potential to 2001" presented at 71st Annual Meeting of the Transportation Research Board, January 1992.

Greene, David, and Duleep, K.G., "Costs and Benefits of Automotive Fuel Improvement: A Partial Analysis" presented at 71st Annual Meeting of the Transportation Research Board, January 1992.

Duleep, K.G., and Holmes, J.G., " Role of Oxygenates in Meeting U.S. Reformulated Gasoline Requirements" IX International Symposium on Alcohol Fuels, November 1991.

Duleep, K.G., "Post-2000 Fuel Economy Opportunities" SAE Government/Industry Meeting, May 1991.
Duleep, K.G., "Fuel Economy Technology Potential to 2010" OECD Conference on the Low Emissions/Low Consumption Automobile, Berlin, March 1991.

Duleep, K.G., "Technology Improvements to Increase Fuel Economy" OECD Conference on Low Emissions/Low Consumption Automobile, Rome, February 1990.

HONORS:

Directors List (First Rank), Wharton School

Merit Scholarship, University of Michigan.

First Prize Winner, University Science Fair, India.

PROFESSIONAL MEMBERSHIPS:

Tau Beta Pi (Engineering Honor Society).

Society of Automotive Engineers.

IV. Related research

Dr. David L. Greene

Dr. Greene has been conducting research on transportation energy and related policy issues for the U.S. Departments of Energy and Transportation and the Environmental Protection Agency for the past 30 years. Some of his recent research relevant to this proposal is listed below.

Systems Analysis of the Transition to Hydrogen Vehicles. Design and implementation of a market simulation model representing the transition to hydrogen-powered light-duty vehicle in the U.S. Model development and analysis sponsored by the U.S. Dept. of Energy over a period of 4 years. Total budget approximately $2.5 million. Ongoing.

Analysis of the Rebound Effect for Light-Duty Vehicles. A re-examination and re-estimation of the relationship between motor vehicle fuel economy and use. Sponsored by the U.S. Environmental Protection Agency, $100,000. Ongoing.

Analysis of the Potential for Voluntary Fuel Economy Standards in the U.S. and of Alternative Formulations of Standards Including Tradable Credits. Sponsored by the U.S. Department of Energy, approximately $100,000. Completed.

Assessment of the Market Potential for Hybrid and Diesel Vehicles in the United States. Sponsored by the U.S. Department of Energy, approximately $75,000. Completed.

Transitional Alternative Fuel Vehicles Model. An integrated market simulation model for analysis of potential transitions to alternative fuel vehicles in the U.S. Sponsored by the U.S. Department of Energy, approximately $600,000. Completed.

Analysis of Feebates, Rebates and Gas-Guzzler Taxes. Sponsored by the U.S. Department of Energy, approximately $60,000. Completed.

An Integrated Multi-pathway Biofuel System Design under Uncertainties, supported by Chevron Technology Ventures, LLC, $299,082, 2007-2009, (PI: Yueyue Fan; Co-PI: Joan Ogden): In this research, we are developing optimization for strategic bioenergy infrastructure system planning incorporating spatial and temporal dynamics and biomass feedstock supply uncertainties.

Optimal Design for A Self-sustainable HOT Network, supported by Sustainable Transportation Center at UC Davis, $ 59,912.33, 2007-2008 (PI: Yueyue Fan): In this research, we developed a mathematical programming model that determines, for multiple performance measures, the best toll pricing strategies with simultaneously considering carpooling behaviors of drivers from various income groups reacting to different tolls. The model developed in this project is simpler than the proposed project in terms of scale and complexity, but shares a similar structure as the one proposed for manufacturer's decision model, i.e., a nonlinear optimization model subject to logit user behavior constraints.

Several previous studies of the manufacturing and lifecycle costs of advanced technology vehicles, various sponsors, 1996-2008 (Lipman)

Assessment of Material Flows in the US Auto Industry in Response to Greenhouse Gas Emission Policies, National Science Foundation MUSES,2006-2011 (Lipman, McManus, and others)

Feebate Policy Assessment Studies, Energy Foundation and Union of Concerned Scientists, 2005-2008 (McManus)

Stakeholder Assessment of Potential AB 32 Policies, Air Resources Board, 2007-2008 (Shaheen and Rodier).

Plug-in hybrid vehicle commercialization assessments, 2006-2008, Energy Foundation and NREL (Kammen)

V. Publications list

1. Bunch, D.S., "Behavioral Frontiers in Choice Modeling," (with W. Adamowicz, T. A. Cameron, B. G. B. C. Dellaert, M. Hanneman, M. Keane, J. Louviere, R. Meyer, T. Steenburgh and J. Swait), Marketing Letters, In Press (2008).
2. Bunch, D.S., California Air Resources Board –Institute of Transportation Studies (CARBITS) Vehicle Market Microsimulation Model for California, June 8, 2004. Prepared for California Air Resources Board under contract 02-310.
3. Bunch, D.S., "Automobile Demand and Type Choice," (with B. Chen), Handbook of Transport Modeling, Second Edition, David A. Hensher and Kenneth J. Button, editors, Pergamon (2008), pp. 541-556.
4. Bunch, D.S., "Hybrid Choice Models: Progress and Challenges," (with Moshe Ben-Akiva, Daniel McFadden, Kenneth Train, Joan Walker, Chandra Bhat, Michel Bierlaire, Denis Bolduc, Axel Borsch-Supan, David Brownstone, Andrew Daly, Andre de Palma, Dinesh Gopinath, Anders Karlstrom, Marcela A. Munizaga), Marketing Letters, 13(3): pp. 163-175 (August 2002).
5. Bunch, D.S., "Joint Mixed Logit Models of Stated and Revealed Preferences for Alternative-fuel Vehicles" (with David Brownstone and Kenneth Train). Transportation Research B, Volume 34, Issue 5 (June 2000), pp. 315-449.
6. Bunch, D.S., "Combining Sources of Preference Data for Modeling Complex Decision Processes" (with Jordan J. Louviere, Robert J. Meyer, Richard Carson, Benedict Delleart, W. Michael Hanemann, David Hensher, and Julie Irwin). Marketing Letters, Volume 10, Issue 3 (August 1999), pp. 205-217.
7. Bunch, D.S., "Determinants of Alternative Fuel Vehicle Choice in the Continental United States" (with Melanie Tompkins, Danilo Santini, Mark Bradley, Anant Vyas, and David Poyer), Transportation Research Record, Number 1641, Energy and Environment: Energy Air Quality, and Fuels 1998, Transportation Research Board, National Research Council.
8. Bunch, D.S., "Commercial Fleet Demand for Alternative-fuel Vehicles," (with Thomas F. Golob, Jane Torous, David Brownstone, Soheila Crane, and Mark Bradley), Transportation Research A Vol. 31A (1997): 219-233.
9. Bunch, D.S., "A Vehicle Usage Forecasting Model Based on Revealed and Stated Vehicle Type Choice and Utilization Data," (with Thomas F. Golob and David Brownstone), Journal of Transport Economics and Policy Vol. 31 (1997): 69-92.
10. Bunch, D.S., "A Dynamic Forecasting System for Vehicle Markets with Clean-Fuel Vehicles," (with David Brownstone and Thomas F. Golob). In D. A. Hensher, J. King, and T. H Oum eds., World Transport Research, Volume 1 (1996): 189-203.
11. Bunch, D.S., "A Vehicle Transactions Choice Model for Use in Forecasting Demand for Alternative-Fuel Vehicles," (with David Brownstone, Thomas F. Golob, and Weiping Ren), Research in Transportation Economics, Vol. 4 (1996): 87-129.
12. Bunch, D.S., "Demand for Clean-Fuel Vehicles in California: A Discrete-Choice Stated Preference Survey" (with Mark Bradley, Thomas F. Golob, Ryuichi Kitamura, Gareth P. Occhiuzzo). Transportation Research A, Vol. 27A, No. 3, pp. 237-253, 1993.

13. Bunch, D.S., "Predicting the Market Penetration of Electric and Clean-fuel Vehicles" (with Thomas F. Golob, Ryuichi Kitamura, and Mark Bradley), The Science of the Total Environment, 134 (1993) pp. 371-381.
14. Bunch, D.S., "Estimability in the Multinomial Probit Model," Transportation Research B, 1991, Vol 25B(1), pp. 1-12.
15. Bunch, D.S., "Heterogeneity and State Dependence in Household Car Ownership: A Panel Analysis Using Ordered-Response Probit Models with Error Components," 11th International Symposium on Transportation and Traffic Theory, Elsevier, July 1990 (with Ryuichi Kitamura).
28. Davis, W.B., M.D. Levine, K. Train and K.G. Duleep, 1995. "Effects of Feebates on Vehicle Fuel Economy, Carbon Dioxide Emissions, and Consumer Surplus", DOE/PO-0031, Office of Policy, U.S. Department of Energy, Washington, D.C.
29. Delucchi, Mark A. and Timothy E. Lipman (2001), "An Analysis of the Retail and Lifecycle Cost of Battery-Powered Electric Vehicles," Transportation Research – D 6: 371-404.
30. Dumas, A., D.L. Greene and A. Bourbeau, 2007. "North America Feebate Analysis Model", chapter 7 in D. Sperling and J.S. Cannon, eds., *Driving Climate Change*, Academic Press, New York.
31. Energy and Environmental Analysis, Inc., 2006. "Technologies to Reduce Greenhouse Gas Emissions from Light-Duty Vehicles", Draft Final Report, prepared for Transport Canada, Ottawa, Ontario, Canada, June, 2006.
32. Energy and Environmental Analysis, Inc., 2005. "Automotive Technology Cost and Benefit Estimates", prepared for Transport Canada, Ottawa, Canada by EEA, Inc., Arlington, Virginia, March.
33. Greene, D.L., 2008. "Feebates, Footprints and Highway Safety", *Transportation Research D*, forthcoming.
34. Greene, D.L., J. German and M.A. Delucchi, 2008. "Fuel Economy: The Case for Market Failure", in D. Sperling and J. Cannon, eds., *Reducing Climate Impacts in the Transportation Sector*, Springer, Dordrecht, The Netherlands.
35. Greene, D.L., P.D. Patterson, M. Singh, and J. Li, 2005. "Feebates, rebates and gas-guzzler taxes: a study of incentives for increased fuel economy", *Energy Policy*, vol. 33, pp. 757-775.
36. Greene, D.L, K.G. Duleep, and W. McManus, 2004. *Future Potential of Hybrid and Diesel Powertrains in the U.S. Light-Duty Vehicle Market*, ORNL/TM-2004/181, Oak Ridge National Laboratory, Oak Ridge, Tennessee, August.
37. Greene, D.L. and J.L. Hopson, 2003. "Analysis of Alternative Forms of Automotive Fuel Economy Standards for the United States", *Transportation Research Record 1842*, pp. 20-28, Transportation Research Board, National Research Council, Washington, D.C.
38. Greene, D.L. and J. DeCicco, 2000. "Engineering-Economic Analysis of Automotive Fuel Economy Potential in the United States", pp. 477-536 in, *Annual Review of Energy and the Environment*, vol. 25, Annual Reviews, Palo Alto, California.
39. Greene, D.L., 1991. "The Cost of Short-run Pricing Strategies to Increase Corporate Average Fuel Economy," *Economic Inquiry*, vol. XXIX, no. 1, pp. 101-114.
40. Kammen, D. M., Arons, S., Lemoine, D., and Hummel, H. (2008) "Evaluating the cost-effectiveness of greenhouse gas emission reductions from deploying plug-in hybrid electric vehicles," Brooking Institute (Washington, DC).
41. Leiby, P.N., D.L. Greene, D. Bowman and E. Tworek, "Systems Analysis of Hydrogen Transition with HyTrans," *Transportation Research Record*, No. 1983, pp. 129-139, 2007.
42. Lemoine, D., Kammen, D.M., and Farrell, A.E. (2008) "An innovation and policy agenda for commercially competitive plug-in hybrid electric vehicles", Environmental Research Letters, 3, 1 – 8.
43. Lipman, Timothy E. and Mark A. Delucchi (2006), "An Analysis of the Retail and Lifecycle Costs of Hybrid Electric Vehicles," Transportation Research – D 11(2): 115-132.

44. McManus, W.S. *Economic Analysis of Feebates to Reduce Greenhouse Gas Emissions from Light Vehicles for California*. Publication UMTRI-2007-9-12. University of Michigan Transportation Research Institute, Ann Arbor, Michigan. 2007.
45. McManus, W., 2007. "Economic analysis of feebates to reduce greenhouse gas emissions from light vehicles for California", University of Michigan Transportation Research Institute, Ann Arbor, Michigan, May; on line at http://mpra.ub.uni-muenchen.de/3461/ .
46. National Research Council (NRC), 2002. *Effectiveness and Impacts of Corporate Average Fuel Economy (CAFE) Standards*, National Academies Press, Washington, D.C. (D.L. Greene, committee member)

EXHIBIT B

BUDGET DETAIL AND PAYMENT PROVISIONS

1. Invoicing

A. For services satisf actorily rendered in accordance with this agreement and upon receipt and approval of the invoices which properly detail all charges the Air Resources Board agrees to compensate the Regents of the University of California, Davis for actual expenditures incurred in accordance with the rates specified herein or attached hereto.

B. Invoices shall inclu de the Agreement Number and shall be submitted in triplicate not more frequently than quarterly in arrears to Ms. Emma Plasencia at the address stated in Exhibit A, Article 2.

C. Budget Flexibility: Subject to the prior review and approval of the contract manager, line items shifts of up to $25,000 or ten percent of the annual contract total, whichever is less, may be made up to a cumulative maximum of $25,000 or 10%, whichever is less, for all line item shifts over the life of the contract. There must be a substantial business justification for any shifts made. Fund shifts which increase Indirect, Overhead or General Expense line items are prohibited. Line item shifts may be proposed/requested by either the State or the University in writing and must not increase or decrease the total contract amount allocated. Any line item shifts must be approved in writing by the Division Chief of the Research Division), or his or her designee, and must be sent to Contracts Section within 10 days of approval for inclusion in contract folder. If the contract is formally amended, any line item shifts agreed to by the parties must be included in the amendment

2. Budget Contingency Clause

A. It is m utually agreed that if the Budget Act of the current year and/or any subsequent years covered under this Agreement does not appropriate sufficient funds for the program, this Agreement shall be of no further force and effect. In this event, the State shall have no liability to pay any funds whatsoever to Contractor or to furnish any other considerations under this Agreement and Contractor shall not be obligated to perform any provisions of this Agreement.

B. If funding for any fiscal year is reduced or deleted by the Budget Act for purposes of this program, the State shall have the option to either cancel this Agreement with no liability occurring to the State, or offer an agreement amendment to Contractor to reflect the reduced amount.

3. Payment

A. Costs for this Agreement shall be computed in accordance with State Administrative Manual Sections 8752 and 8752.1.

B. Nothing herei n contained shall preclude advance payments pursuant to Article 1, Chapter 3, Part 1, Division 3, Title 2 of the Government Code of the State of California.

C. ARB shall withhold payment equal to ten percent of the total Agreement cost until completion of all work and submission to ARB by University of a final report (including computer diskette copy) approved in accordance with Exhibit F, by ARB. It is University's responsibility to submit an invoice in triplicate with the revised final report for ten percent withheld.

D. University will be paid for the payment period completed upon receipt, by ARB, of an invoice and progress report satisfying the requirements of this Agreement. The invoice and progress report must be deemed by ARB to reflect reasonable work performed in accordance with the Agreement.

E. Th e amount to be paid to University under this Agreement includes all sales and use taxes incurred pursuant to this Agreement. University shall not receive additional compensation for reimbursement of such taxes and shall not decrease work to compensate therefore.

Budget Submittal Form

This form is supplied for presenting budget detail to the Air Resources Board.

PLEASE TYPE OR PRINT:

Title of Proposal: Potential Design, Implementation, and Benefits of a Feebate Program for New Passenger Vehicles in California

Total Budget Requested: $796,641

Period Covered (months): 16 months

University: University of California, Davis

Address: 1850 Research Park Drive, Suite 300 Davis, CA 95618

Name of person authorized to bind this bid: Paula Noble

Title: Contracts & Grants Analyst

Phone: (530) 754-8115

Signature of person authorized to bind this bid: _____

Budget Summary

Budget details must be supplied on pages 3-11 and on additional pages if necessary.
Instructions and definitions of terms are provided in Attachment 1 of the Guidelines for Proposals.

Direct Costs		
1.	Labor & Employee Fringe Benefits	$218,478
2.	Subcontractor(s)/Consultant(s)	$516,075
3.	Equipment	$0
4.	Travel & Subsistence	$0
5.	Electronic Data Processing	$10,000
6.	Photocopying & Printing	$0
7.	Mail, Telephone, and Fax	$0
8.	Materials & Supplies	$5,000
9.	Analyses	$0
10.	Miscellaneous	$21,240
	Total Direct Cost	**$770,793**

Indirect Costs		
11.	Overhead	$25,848
	Total Indirect Cost	**$25,848**

Total Direct and Indirect Cost:	**$796,641**

Budget Detail
I. Direct Costs

1a. Labor Charges for Universities and Other State Agencies

	Individual's Name	Work Title	Mo. Salary	Est. Months	% of Effort or % of Salary	Total Salary Requested
A.	David Greene	Visiting Researcher	$11,111.00	3.00	100.00%	$33,333
B.	David Bunch	Professor	$17,000.00	2.00	100.00%	$34,000
C.	Yueyue Fan	Professor	$10,000.00	1.50	100.00%	$15,000
D.	Chris Knittel	Professor	$11,003.00	2.00	100.00%	$22,006
E.	TBD	Graduate Student Researcher	$3,229.00	6.00	100.00%	$19,374
F.	TBD	Graduate Student Researcher	$3,229.00	6.00	100.00%	$19,374
G.	TBD	Graduate Student Researcher	$3,229.00	6.00	100.00%	$19,374
H.	TBD	Graduate Student Researcher	$3,229.00	6.00	100.00%	$19,374
I.	Christina Adamson	Financial Coordinator	$3,936.00	9.00	25.00%	$8,856
J.	Roberta Devine	Financial Assistant	$3,508.00	9.00	25.00%	$7,893

Subtotal: $198,584

Cost justifications. Describe exactly why each individual listed in the Budget Detail is needed in this project (i.e., their role in the project), why this particular person was chosen for this role, and why their proposed level of effort is necessary. Describe, for each position listed, why the specified rate is reasonable or competitive. (Use additional page if necessary).

Dr. David Greene and Dr. David Bunch will be acting as Co-PI's on this project. Professor Yueyue Fan will direct the implementation and programming of the manufacturer decision model and Chris Knittel will direct the economic analysis of feebate policy impacts. Monthly rates used for each individual are the current rates for each individual.

All four Graduate Student Researchers (GSR III) are budgeted at the current GSR III rate of $3,229/month determined by the campus' Graduate Studies office. These four students will be assisting Dr. Greene, Professor Bunch, Professor Fan and Professor Knittel with the tasks each will be directing.

Christina Adamson and Roberta Devine are the staff responsible for contract, financial and personnel administration of this project.

1b. Fringe Benefits

	Individual's Name	BASE ($)	RATE (%)	COST
A.	David Greene	$33,333.00	12.70%	$4,233
B.	David Bunch	$34,000.00	12.70%	$4,318
C.	Yueyue Fan	$15,000.00	12.70%	$1,905
D.	Chris Knittel	$22,006.00	12.70%	$2,795
E.	TBD	$19,374.00	2.15%	$417
F.	TBD	$19,374.00	2.15%	$417
G.	TBD	$19,374.00	2.15%	$417
H.	TBD	$19,374.00	2.15%	$417
I.	Christina Adamson	$8,856.00	25.00%	$2,214
J.	Roberta Devine	$7,893.00	35.00%	$2,763

Subtotal: $19,894

Cost justifications. Provide the Basis for the Fringe Benefit Rates. (Use additional page if necessary).

Benefit rates provided above are actual rates for those known employees. A campus composite rate of 1.3% during the academic year and 3% during the summer is used for the GSR's.

2. Subcontractors & Consultants

List all subcontractors and consultants. **Also submit separate Budget Submittal Form for each subcontractor and consultant.**

	Subcontractor or consultant	Cost
A.	UC Berkeley	$425,000
B.	UC Irvine	$21,075
C.	EEA, ICF, Inc.	$70,000
D.	N/A	$0

(use additional page if necessary)

Subtotal: $516,075

Cost justifications. Describe exactly why each subcontractor is needed in this project (i.e., their role in the project). Describe, for each subcontractor, why the specified rate is reasonable or competitive. (Use additional page if necessary).

UC Berkeley will be playing a major role in the research on this project. Dr. Lipman and other UCB researchers will be taking a lead on several of the tasks outlined in the technical proposal, including focus group surveys. Dr. Brownstone from UC Irvine will be assisting Dr. Bunch with modeling.
EEA, ICFI will supply a detailed database of vehicles offered for sale in the U.S. in the base year, their prices and technical attributes, their expected date of major redesign, and their base-year use of GHG mitigation technologies.All groups include individuals with extensive knowledge and experience to carry-out the necessary research.

3. Equipment (Itemize)

	Item	Cost
A.	N/A	$0
B.	N/A	$0
C.	N/A	$0
D.	N/A	$0

Subtotal: $0

Cost justifications. Describe exactly why each listed equipment item is needed in this project, and why the cost is reasonable. (Use additional page if necessary).
(Refer to Exhibit E, page 19)

N/A

4. Travel and Subsistence (Itemize). Use State Rates (Appendix IV).
NO FOREIGN TRAVEL ALLOWED.

	Description	Cost
A.	Air transportation	$0
B.	Ground transportation	$0
C.	Per diem or subsistence	$0
D.	Other (Lodging & Parking)	$0

Subtotal: $0

Cost justifications. Describe the purpose and duration of each trip and explain why the travel is necessary. (Use additional page if necessary).

N/A

5. Electronic Data Processing (Itemize)

	Description	Cost
A.	R.L. Polk & Company (data)	$10,000
B.	N/A	$0
C.	N/A	$0
D.	N/A	$0

Subtotal: $10,000

Cost justifications. Explain the need for the expenditure and the basis for the costs. (Use additional page if necessary).

The purchase of sales data for the Northeast (as well as remaining states minus California) will be used for aggregate level sales data for estimation and calibration purposes.

6. Photocopying & Printing (Itemize)

	Description of product	Cost
A.	N/A	$0
B.	N/A	$0

Subtotal: $0

Cost justifications.. Explain the need for the expenditure and the basis for the costs. (Use additional page if necessary).

N/A

7. Mail, Telephone & Fax (Itemize)

	Item	Cost
A.	N/A	$0
B.	N/A	$0
C.	N/A	$0

Subtotal: $0

Cost justifications. Explain the need for the expenditure and the basis for the costs. (Use additional page if necessary).

N/A

8. Materials & Supplies (Itemize)

	Item	Cost
A.	Computer Software	$5,000
B.	N/A	$0
C.	N/A	$0
D.	N/A	$0
E.	N/A	$0
F.	N/A	$0
G.	N/A	$0
H.	N/A	$0
I.	N/A	$0

Subtotal: $5,000

Cost justifications. Describe exactly why each item listed above is needed in this project. Explain why the proposed cost is reasonable. (Use additional page if necessary).

Computer software will need to be purchased to create the computer model, which is listed as a deliverable in the technical proposal.

9. Analyses (Itemize)

	Description	Cost
A.	N/A	$0
B.	N/A	$0
C.	N/A	$0
D.	N/A	$0
E.	N/A	$0
F.	N/A	$0
G.	N/A	$0
H.	N/A	$0
I.	N/A	$0

Subtotal: $0

Cost justifications. Describe the purpose of each different analysis and explain why it is needed in this project. Explain why the proposed rate is reasonable. (Use additional page if necessary).

N/A

10. Miscellaneous (Itemize)

	Item	Cost
A.	2 quarters Tuition @ $2,655/qtr (per GSR)	$21,240
B.	N/A	$0
C.	N/A	$0
D.	N/A	$0

Subtotal: $21,240

Cost justifications. Justify all costs not included in the categories above. Explain the need for the expenditure and the basis for the costs. (Use additional page if necessary).

The current in-state tuition rate for graduate students is $3,540/quarter. For extramurally funded students, the campus reimburses the department 25% of the tuition, reducing the cost to $2,655/quarter. The cost above are for four students for two quarters (Winter '09 and Spring '09).

Total Direct Costs (add subtotals for categories 1-10): $770,793

II. Indirect Costs

11. Overhead and Other Indirect Costs

	Base (Salaries, total direct costs, etc.) ($)	Rate (%)	Cost
A.	$258,477.77	10.00%	$25,848
B.	*Amount above excludes tuition (under Miscellaneous section)*		$0
C.			$0

Subtotal: $25,848

Total Indirect Cost: $25,848

Total Project Cost: $796,641

Budget Submittal Form

This form is supplied for presenting budget detail to the Air Resources Board.

PLEASE TYPE OR PRINT:

Title of Proposal:	Potential Design, Implementation, and Benefits of a Feebate Program for New Passenger Vehicles in California - (subcontract under UCD)
Total Budget Requested:	$425,000
Period Covered (months):	16 months
University:	University of California, Berkeley
Address:	
Name of person authorized to bind this bid:	
Title:	
Phone:	
Signature of person authorized to bind this bid:	_____

Budget Summary

Budget details must be supplied on pages 3-11 and on additional pages if necessary.
Instructions and definitions of terms are provided in Attachment 1 of the Guidelines for Proposals.

Direct Costs		
1.	Labor & Employee Fringe Benefits	$226,582
2.	Subcontractor(s)/Consultant(s)	$127,743
3.	Equipment	$0
4.	Travel & Subsistence	$13,500
5.	Electronic Data Processing	$0
6.	Photocopying & Printing	$0
7.	Mail, Telephone, and Fax	$448
8.	Materials & Supplies	$22,788
9.	Analyses	$0
10.	Miscellaneous	$5,107
	Total Direct Cost	**$396,168**

Indirect Costs		
11.	Overhead	$28,832
	Total Indirect Cost	**$28,832**

Total Direct and Indirect Cost:	**$425,000**

Budget Detail
I. Direct Costs

1a. Labor Charges for Universities and Other State Agencies

	Individual's Name	Work Title	Mo. Salary	Est. Months	% of Effort or % of Salary	Total Salary Requested
A.	Tim Lipman	Asst. Research Engineer	$7,709	9.00	36.02%	$24,992
B.	Dan Kammen	Professor	$13,200	1.00	50.00%	$6,600
C.	Susan Shaheen	Sr. Development Engineer	$9,882	9.00	26.59%	$23,647
D.	Caroline Rodier	Sr. Development Engineer	$7,367	6.00	41.50%	$18,343
E.	TBD	Research Engineer	$14,483	4.00	50.00%	$28,966
F.	TBD	Post Doctoral Researcher (PGR XIV)	$5,081	9.00	32.94%	$15,063
G.	TBD	Graduate Student Researcher III	$3,294	9.00	76.95%	$22,813
H.	Rachel Finson	Principal Public Administration Analyst	$6,663	9.00	26.93%	$16,151
I.	Denise Allen	Public Administration Analyst	$4,056	9.00	43.13%	$15,744
J.	Kim Strasburg	Senior Public Administration Analyst	$6,037	9.00	21.55%	$11,708

Subtotal: $184,026

Cost justifications:

Dr. Tim Lipman will be serving as the Principal Investigator for UC Berkeley. Dr. Lipman and his research team will be taking a lead role on several of the tasks outlined in the technical proposal, including focus group surveys.

1b. Fringe Benefits

	Individual's Name	BASE ($)	RATE (%)	COST
A.	Tim Lipman	$24,992	28.96%	$7,238
B.	Dan Kammen	$6,600	12.70%	$838
C.	Susan Shaheen	$23,647	11.11%	$2,628
D.	Caroline Rodier	$18,343	35.79%	$6,565
E.	TBD	$28,966	25.00%	$7,242
F.	TBD	$15,063	17.00%	$2,561
G.	TBD	$22,813	2.40%	$547
H.	Rachel Finson	$16,151	26.74%	$4,319
I.	Denise Allen	$15,744	42.25%	$6,652
J.	Kim Strasburg	$11,708	33.89%	$3,968
			Subtotal:	**$42,556**

Cost justifications:

Rates listed above are actual rates for those listed or composite rates for those TBD individuals.

2. Subcontractors & Consultants

List all subcontractors and consultants. **Also submit separate Budget Submittal Form for each subcontractor and consultant.**

	Subcontractor or consultant	Cost
A.	Ewald & Wasserman Research Consultants, LLC.	$127,743
B.	N/A	$0
C.	N/A	$0
D.	N/A	$0
(use additional page if necessary)		

Subtotal: $127,743

Cost justifications:

Administration of the statewide survey and focus group recruitment. Detailed budget attached.

3. Equipment (Itemize)

	Item	Cost
A.	N/A	$0
B.	N/A	$0
C.	N/A	$0
D.	N/A	$0

Subtotal: $0

Cost justifications:

N/A

4. Travel and Subsistence (Itemize). Use State Rates (Appendix IV). NO FOREIGN TRAVEL ALLOWED.

	Description	Cost
A.	Air transportation	$3,900
B.	Ground transportation	$4,000
C.	Per diem or subsistence	$2,500
D.	Other (Lodging & Parking)	$3,100

Subtotal: $13,500

Cost justifications:

Travel will consist of attendance at conference and out of state meetings to present findings. In addition, in-state trips will be taken for focus groups and interviews.

5. Electronic Data Processing (Itemize)

	Description	Cost
A.	N/A	$0
B.	N/A	$0
C.	N/A	$0
D.	N/A	$0

Subtotal: $0

Cost justifications:

N/A

6. Photocopying & Printing (Itemize)

	Description of product	Cost
A.	N/A	$0
B.	N/A	$0

Subtotal: $0

Cost justifications:

N/A

7. Mail, Telephone & Fax (Itemize)

	Item	Cost
A.	Telecommunications	$448
B.		
C.		

Subtotal: $448

Cost justifications:

Telecommunications expenses for focus groups, status meetings with UC Davis campus and other project participants.

8. Materials & Supplies (Itemize)

	Item	Cost
A.	Software, publications and misc. supplies	$3,500
B.	GAEL Insurance	$1,288
C.	Supplies and incentives for focus groups	$18,000
D.		
E.		
F.		
G.		
H.		
I.		

Subtotal: $22,788

Cost justifications:

9. Analyses (Itemize)

	Description	Cost
A.	N/A	$0
B.	N/A	$0
C.	N/A	$0
D.	N/A	$0
E.	N/A	$0
F.	N/A	$0
G.	N/A	$0
H.	N/A	$0
I.	N/A	$0

Subtotal: $0

Cost justifications:

N/A

10. Miscellaneous (Itemize)

	Item	Cost.
A.	One Quarter Resident Tuition	$5,107
B.		
C.		
D.		

Subtotal: $5,107

Cost justifications:

Total Direct Costs (add subtotals for categories 1-10): $396,168

II. Indirect Costs

11. Overhead and Other Indirect Costs

	Base (Salaries, total direct costs, etc.) ($)	Rate (%)	Cost
A.	$288,318	10.00%	$28,832
B.	*(calculation excludes tuition and sub-contract amount exceeding $25k)*		$0
C.			$0

Subtotal: $28,832

Total Indirect Cost: $28,832

Total Project Cost: $425,000

Budget Submittal Form

This form is supplied for presenting budget detail to the Air Resources Board.

PLEASE TYPE OR PRINT:

Title of Proposal: Potential Design, Implementation, and Benefits of a Feebate Program for New Passenger Vehicles in California (subcontractor to UC Berkeley)

Total Budget Requested: $127,743

Period Covered (months): 16 months

University: Ewald & Wasserman Research Consultants

Address: 27 Maiden Lane, Suite 500, San Francisco, CA 94108

Name of person authorized to bind this bid:

Title:

Phone: 415-230-7740

Signature of person authorized to bind this bid: _____

Budget Summary

Budget details must be supplied on pages 3-11 and on additional pages if necessary.
Instructions and definitions of terms are provided in Attachment 1 of the Guidelines for Proposals.

NOTE: Totals in categories in this summary are automatically updated from pages 3-11 when using Excel file.

Direct Costs

1.	Labor & Employee Fringe Benefits	$114,498
2.	Subcontractor(s)/Consultant(s)	$0
3.	Equipment	$0
4.	Travel & Subsistence	$0
5.	Electronic Data Processing	$0
6.	Photocopying & Printing	$0
7.	Mail, Telephone, and Fax	$3,030
8.	Materials & Supplies	$7,995
9.	Analyses	$0
10.	Miscellaneous	$2,220
	Total Direct Cost	**$127,743**

Indirect Costs

11.	Overhead	$0
	Total Indirect Cost	**$0**

Total Direct and Indirect Cost: $127,743

Budget Detail
I. Direct Costs

1a. Labor Charges for Universities and Other State Agencies

Note: Total Salary Requested cells automatically calculate when using Excel file.

	Individual's Name	Work Title	Mo. Salary	Est. Months	% of Effort or % of Salary	Total Salary Requested
A.	Katrin Ewald	Project Director	$12,500.00	4.00	9.70%	$ 1,212
B.	Lisa Wasserman	Project Manager	$8,000.00	4.00	51.08%	$ 4,086
C.	tbd (multiple)	CATI Supervisors	$3,750.00	4.00	110.72%	$ 4,152
D.	tbd (multiple)	CATI Interviewers	$3,166.67	4.00	2655.38%	$ 84,087
E.						$0
F.						$0
G.						$0
H.						$0
I.						$0

(use additional page if necessary)

Subtotal: $93,537

Cost justifications. Describe exactly why each individual listed in the Budget Detail is needed in this project (i.e., their role in the project), why this particular person was chosen for this role, and why their proposed level of effort is necessary. Describe, for each position listed, why the specified rate is reasonable or competitive. (Use additional page if necessary).

Katrin Ewald willl serve as the project director of Ewald & Wasserman (E&W) and will have the oversight of the project, including the focus gorup recuitment, organization of facilites, consultation on the telephone survey instrument , CATI programming, the finalization of the sampling plan as well as the final data prepration and data delivery.

Lisa Wasserman will serve as the project manager and client liason of E&W and will coordinate the focus group recruit and assist in the procurement of facilities. She will also coordinate the Spanish translations of all documents and the telephone interviewer training, as well as the staff coordination in the CATI laboratory.

CATI supervisors will be responsible for the station monitoring of CATI interviewers at a ratio of approximately 1:21 as well as staff supervision and management.

CATI interviewers will be responsible for conducting the telephone surveys and for screening respondents for focus group participation.

1b. Fringe Benefits

Note: COST cells automatically calculate when using Excel file.

	Individual's Name	BASE ($)		RATE (%)	COST
A.	Katrin Ewald	$1,500.00		19.25%	$289
B.	Lisa Wasserman	$5,060	$5,060	19.25%	$974
C.	CATI Supervisors	$5,079	$5,079	18.25%	$927
D.	CATI Interviewers	$102,858	$102,858	18.25%	$18,772
E.					$0
F.					$0
G.					$0
H.					$0
I.					$0
(use additional page if necessary)					

Subtotal: $20,961

Cost justifications. Provide the Basis for the Fringe Benefit Rates. (Use additional page if necessary).

PERSONNEL COST WORKSHEET ANNUAL/ SIMPLIFIED ALLOCATION METHOD

POSITION	Annual Salary (A) a	FICA (B)	(FUTA) CA and Fed unemployment (C)	Workers Comp (D)	SF City Employer Tax 1.60%	SF City Health Tax (J) 4%	Total Benefits b	Total Personnel Cost (a+b)	Indirect Cost Rate Percentage
Katrin Ewald	$ 156,000	$11,934	$ 6,240	$ 1,560	$ 2,496	$ 6,240	$ 28,470	$ 184,470	18.25%
Lisa Wasserman	$ 95,000	$ 7,268	$ 3,800	$ 950	$ 1,520	$ 3,800	$ 17,338	$ 112,338	18.25%
CATI Supervisor	$ 45,000	$ 3,443	$ 1,800	$ 450	$ 720	$ 1,800	$ 8,213	$ 53,213	18.25%
CATI Interviewer	$ 38,000	$ 2,907	$ 1,520	$ 380	$ 608	$ 1,520	$ 6,935	$ 44,935	18.25%

2. Subcontractors & Consultants

List all subcontractors and consultants. **Also submit separate Budget Submittal Form for each subcontractor and consultant.**

Subcontractor or consultant	Cost
A.	
B.	
C.	
D.	
(use additional page if necessary)	

Subtotal: $0

Cost justifications. Describe exactly why each subcontractor is needed in this project (i.e., their role in the project). Describe, for each subcontractor, why the specified rate is reasonable or competitive. (Use additional page if necessary).

see attached.

3. Equipment (Itemize)

Item	Cost
A.	
B.	
C.	
D.	

Subtotal: $0

Cost justifications. Describe exactly why each listed equipment item is needed in this project, and why the cost is reasonable. (Use additional page if necessary).
(Refer to Exhibit E, page 19)

4. Travel and Subsistence (Itemize). Use State Rates (Appendix IV). NO FOREIGN TRAVEL ALLOWED.

	Description	Cost
A.	Air transportation	
B.	Ground transportation	
C.	Per diem or subsistence	
D.	Other (Lodging & Parking)	

Subtotal: $0

Cost justifications. Describe the purpose and duration of each trip and explain why the travel is necessary. (Use additional page if necessary).

5. Electronic Data Processing (Itemize)

	Description	Cost
A.		
B.		
C.		
D.		

Subtotal: $0

Cost justifications. Explain the need for the expenditure and the basis for the costs. (Use additional page if necessary).

6. Photocopying & Printing (Itemize)

	Description of product	Cost
A.		
B.		

Subtotal: $0

Cost justifications. Explain the need for the expenditure and the basis for the costs. (Use additional page if necessary).

7. Mail, Telephone & Fax (Itemize)

	Item	Cost
A.	Telephone cost for telephone survey	$3,030
B.		
C.		

Subtotal: $3,030

Cost justifications. Explain the need for the expenditure and the basis for the costs. (Use additional page if necessary).

Telephone cost for conducting 3,000 statewide telephone surveys.

8. Materials & Supplies (Itemize)

	Item	Cost
A.	RDD sample cost for telephone survey	$7,995
B.		
C.		
D.		
E.		
F.		
G.		
H.		
I.		

Subtotal: $7,995

Cost justifications. Describe exactly why each item listed above is needed in this project. Explain why the proposed cost is reasonable. (Use additional page if necessary).

This is the cost for the RDD sample purchased from a professional sample vendor to be dialed for the Statewide telephone survey.

9. Analyses (Itemize)

	Description	Cost
A.		
B.		
C.		
D.		
E.		
F.		
G.		
H.		
I.		

Subtotal: $0

Cost justifications. Describe the purpose of each different analysis and explain why it is needed in this project. Explain why the proposed rate is reasonable. (Use additional page if necessary).

10. Miscellaneous (Itemize)

	Item	Cost
A.	Programming cost for CATI system.	$850
B.	Cost for Ads/telephone/mail and phone reminders for 12 focus g	$1,370
C.		
D.		

Subtotal: $2,220

Cost justifications. Justify all costs not included in the categories above. Explain the need for the expenditure and the basis for the costs. (Use additional page if necessary).

Cost for Spanish translation and programming survey into eletronic format to be used in CATI survey.

Total Direct Costs (add subtotals for categories 1-10): $127,743

II. Indirect Costs

11. Overhead and Other Indirect Costs

	Base (Salaries, total direct costs, etc.) ($)	Rate (%)	Cost
A.			$0
B.			$0
C.			$0

Subtotal: $0

Total Indirect Cost: $0

Total Project Cost: $127,743

Budget Submittal Form

This form is supplied for presenting budget detail to the Air Resources Board.

PLEASE TYPE OR PRINT:

Title of Proposal:	Potential Design, Implementation, and Benefits of a Feebate Program for New Passenger Vehicles in California - (subcontract to UC Davis)
Total Budget Requested:	$21,075
Period Covered (months):	16 months
University:	University of California, Irvine
Address:	
Name of person authorized to bind this bid:	
Title:	
Phone:	
Signature of person authorized to bind this bid:	_____

Budget Summary

Budget details must be supplied on pages 3-11 and on additional pages if necessary.
Instructions and definitions of terms are provided in Attachment 1 of the Guidelines for Proposals.

Direct Costs		
1.	Labor & Employee Fringe Benefits	$19,159
2.	Subcontractor(s)/Consultant(s)	$0
3.	Equipment	$0
4.	Travel & Subsistence	$0
5.	Electronic Data Processing	$0
6.	Photocopying & Printing	$0
7.	Mail, Telephone, and Fax	$0
8.	Materials & Supplies	$0
9.	Analyses	$0
10.	Miscellaneous	$0
	Total Direct Cost	**$19,159**

Indirect Costs		
11.	Overhead	$1,916
	Total Indirect Cost	**$1,916**

Total Direct and Indirect Cost:	**$21,075**

Budget Detail
I. Direct Costs

1a. Labor Charges for Universities and Other State Agencies

	Individual's Name	Work Title	Mo. Salary	Est. Months	% of Effort or % of Salary	Total Salary Requested
A.	David Brownstone	Professor	$17,000.00	1.00	100.00%	$17,000
B.						$0
C.						$0
D.						$0
E.						$0
F.						$0
G.						$0
H.						$0
I.						$0

Subtotal: $17,000

Cost justifications. Describe exactly why each individual listed in the Budget Detail is needed in this project (i.e., their role in the project), why this particular person was chosen for this role, and why their proposed level of effort is necessary. Describe, for each position listed, why the specified rate is reasonable or competitive. (Use additional page if necessary).

Dr. Brownstone will be assisting Dr. David Bunch, from UC Davis, with modeling.

1b. Fringe Benefits

	Individual's Name	BASE ($)	RATE (%)	COST
A.	David Brownstone	$17,000.00	12.70%	$2,159
B.				$0
C.				$0
D.				$0
E.				$0
F.				$0
G.				$0
H.				$0
I.				$0
(use additional page if necessary)				

Subtotal: $2,159

Cost justifications. Provide the Basis for the Fringe Benefit Rates. (Use additional page if necessary).

Actual benefit rate used for Professor Brownstone.

2. Subcontractors & Consultants

List all subcontractors and consultants. **Also submit separate Budget Submittal Form for each subcontractor and consultant.**

Subcontractor or consultant	Cost
A.	
B.	
C.	
D.	
(use additional page if necessary)	

Subtotal: $0

Cost justifications. Describe exactly why each subcontractor is needed in this project (i.e., their role in the project). Describe, for each subcontractor, why the specified rate is reasonable or competitive. (Use additional page if necessary).

3. Equipment (Itemize)

Item	Cost
A.	
B.	
C.	
D.	

Subtotal: $0

Cost justifications. Describe exactly why each listed equipment item is needed in this project, and why the cost is reasonable. (Use additional page if necessary).
(Refer to Exhibit E, page 19)

4. Travel and Subsistence (Itemize). Use State Rates (Appendix IV).
NO FOREIGN TRAVEL ALLOWED.

	Description	Cost
A.	Air transportation	
B.	Ground transportation	
C.	Per diem or subsistence	
D.	Other (Lodging & Parking)	

Subtotal: $0

Cost justifications. Describe the purpose and duration of each trip and explain why the travel is necessary. (Use additional page if necessary).

5. Electronic Data Processing (Itemize)

	Description	Cost
A.		
B.		
C.		
D.		

Subtotal: $0

Cost justifications. Explain the need for the expenditure and the basis for the costs. (Use additional page if necessary).

6. Photocopying & Printing (Itemize)

	Description of product	Cost
A.		
B.		

Subtotal: $0

Cost justifications. Explain the need for the expenditure and the basis for the costs. (Use additional page if necessary).

7. Mail, Telephone & Fax (Itemize)

	Item	Cost
A.		
B.		
C.		

Subtotal: $0

Cost justifications. Explain the need for the expenditure and the basis for the costs. (Use additional page if necessary).

8. Materials & Supplies (Itemize)

	Item	Cost
A.		
B.		
C.		
D.		
E.		
F.		
G.		
H.		
I.		

Subtotal: $0

Cost justifications. Describe exactly why each item listed above is needed in this project. Explain why the proposed cost is reasonable. (Use additional page if necessary).

9. Analyses (Itemize)

	Description	Cost
A.		
B.		
C.		
D.		
E.		
F.		
G.		
H.		
I.		

Subtotal:	**$0**

Cost justifications. Describe the purpose of each different analysis and explain why it is needed in this project. Explain why the proposed rate is reasonable. (Use additional page if necessary).

10. Miscellaneous (Itemize)

Item	Cost
A.	
B.	
C.	
D.	

Subtotal: $0

Cost justifications. Justify all costs not included in the categories above. Explain the need for the expenditure and the basis for the costs. (Use additional page if necessary).

Total Direct Costs (add subtotals for categories 1-10): $19,159

II. Indirect Costs

11. Overhead and Other Indirect Costs

	Base (Salaries, total direct costs, etc.) ($)	Rate (%)	Cost
A.	$19,159.00	10.00%	$1,916
B.			$0
C.			$0

Subtotal: $1,916

Total Indirect Cost: $1,916

Total Project Cost: $21,075

Budget Submittal Form

This form is supplied for presenting budget detail to the Air Resources Board.

PLEASE TYPE OR PRINT:

Title of Proposal: Potential Design, Implementation, and Benefits of a Feebate Program for New Passenger Vehicles in California

Total Budget Requested: $70,000

Period Covered (months): 16 Months

Subcontractor: ICF International

Address: 9300 Lee Highway Fairfax, VA 22031-1207

Name of person authorized to bind this bid: Laurence M. Rose

Title: Vice President, Director of Contracts

Phone: 703-934-3557 (e-mail: Lrose@icifi.com)

Signature of person authorized to bind this bid: _____

Budget Summary

Budget details must be supplied on pages 3-11 and on additional pages if necessary.
Instructions and definitions of terms are provided in Attachment 1 of the Guidelines for Proposals.

Direct Costs		
1.	Labor & Employee Fringe Benefits	$64,203
2.	Subcontractor(s)/Consultant(s)	$0
3.	Equipment	$0
4.	Travel & Subsistence	$5,797
5.	Electronic Data Processing	$0
6.	Photocopying & Printing	$0
7.	Mail, Telephone, and Fax	$0
8.	Materials & Supplies	$0
9.	Analyses	$0
10.	Miscellaneous	$0
	Total Direct Cost	**$70,000**

Indirect Costs		
11.	Overhead	$0
	Total Indirect Cost	**$0**

Total Direct and Indirect Cost:	**$70,000**

Budget Detail
I. Direct Costs

1a. Labor Charges for Universities and Other State Agencies

	Individual's Name	Work Title	Hourly Salary	Est. Hours	% of Effort or % of Salary	Total Salary Requested
A.	K Gopalakrishnan Duleep	Executive	$338.83	120.00	100.00%	$40,660
B.	Douglas Elliot	Project Manager	$201.70	48.00	100.00%	$9,682
C.	Lawrence A Muljo	Analyst	$83.10	64.00	100.00%	$5,318
D.	Russell M. Meyer	Senior Associate	$79.11	108.00	100.00%	$8,544
E.						$0
F.						$0
G.						$0
H.						$0
I.						$0
I.						$0

Subtotal: $64,203

Cost justifications. Describe exactly why each individual listed in the Budget Detail is needed in this project (i.e., their role in the project), why this particular person was chosen for this role, and why their proposed level of effort is necessary. Describe, for each position listed, why the specified rate is reasonable or competitive. (Use additional page if necessary).

1b. Fringe Benefits

Note: COST cells automatically calculate when using Excel file.

Individual's Name	BASE ($)	RATE (%)	COST
A.			$0
B.			$0
C.			$0
D.			$0
E.			$0
F.			$0
G.			$0
H.			$0
I.			$0
(use additional page if necessary)			

Subtotal:	**$0**

Cost justifications. Provide the Basis for the Fringe Benefit Rates. (Use additional page if necessary).

2. Subcontractors & Consultants

List all subcontractors and consultants. **Also submit separate Budget Submittal Form for each subcontractor and consultant.**

	Subcontractor or consultant	Cost
A.		
B.		
C.		
D.		
(use additional page if necessary)		

Subtotal: $0

Cost justifications. Describe exactly why each subcontractor is needed in this project (i.e., their role in the project). Describe, for each subcontractor, why the specified rate is reasonable or competitive. (Use additional page if necessary).

3. Equipment (Itemize)

	Item	Cost
A.		
B.		
C.		
D.		

Subtotal: $0

Cost justifications. Describe exactly why each listed equipment item is needed in this project, and why the cost is reasonable. (Use additional page if necessary).
(Refer to Exhibit E, page 19)

4. Travel and Subsistence (Itemize). Use State Rates (Appendix IV). NO FOREIGN TRAVEL ALLOWED.

	Description	Cost
A.	Air, Ground transportation, Lodging and Subsistence	$5,797
B.		
C.		
D.		

Subtotal: $5,797

Cost justifications. Describe the purpose and duration of each trip and explain why the travel is necessary. (Use additional page if necessary).

Travel is required for 3 trips for all four employees. Average cost per trip is $483/person. This includes air and ground transportation, lodging and subsistence.

5. Electronic Data Processing (Itemize)

	Description	Cost
A.		
B.		
C.		
D.		

Subtotal: $0

Cost justifications. Explain the need for the expenditure and the basis for the costs. (Use additional page if necessary).

6. Photocopying & Printing (Itemize)

	Description of product	Cost
A.		
B.		

Subtotal: $0

Cost justifications. Explain the need for the expenditure and the basis for the costs. (Use additional page if necessary).

7. Mail, Telephone & Fax (Itemize)

	Item	Cost
A.		
B.		
C.		

Subtotal: $0

Cost justifications. Explain the need for the expenditure and the basis for the costs. (Use additional page if necessary).

8. Materials & Supplies (Itemize)

	Item	Cost
A.		
B.		
C.		
D.		
E.		
F.		
G.		
H.		
I.		

Subtotal:	$0

Cost justifications. Describe exactly why each item listed above is needed in this project. Explain why the proposed cost is reasonable. (Use additional page if necessary).

9. Analyses (Itemize)

	Description	Cost
A.		
B.		
C.		
D.		
E.		
F.		
G.		
H.		
I.		

Subtotal:	**$0**

Cost justifications. Describe the purpose of each different analysis and explain why it is needed in this project. Explain why the proposed rate is reasonable. (Use additional page if necessary).

10. Miscellaneous (Itemize)

	Item	Cost
A.		
B.		
C.		
D.		

Subtotal:	**$0**

Cost justifications. Justify all costs not included in the categories above. Explain the need for the expenditure and the basis for the costs. (Use additional page if necessary).

Total Direct Costs (add subtotals for categories 1-10):	$70,000

II. Indirect Costs

11. Overhead and Other Indirect Costs

	Base (Salaries, total direct costs, etc.) ($)	Rate (%)	Cost
A.			$0
B.			$0
C.			$0

Subtotal: $0

Total Indirect Cost: $0

Total Project Cost: $70,000

EXHIBIT D

SPECIAL TERMS AND CONDITIONS

1. Termination

A. This Agreement may be canceled at any time by either party, upon thirty (30) days written notice to the other party.

B. In the case of early termination, the performing agency will submit an invoice in triplicate and a report in triplicate covering services to termination date, following the invoice and progress report requirements of this Agreement. A copy and description of any data collected up to termination date will also be provided to ARB.

C. Upon receipt of the invoice, progress report, and data, a final payment will be made to the performing agency. This payment shall be for all ARB-approved, actually incurred costs in accordance with Exhibits A and B, and shall include labor, and materials purchased or utilized (including all noncancellable commitments) to termination date, and pro rata indirect costs as specified in the proposal budget.

2. Disputes

A. ARB reserves the right to issue an order to stop work in the event that a dispute should arise, or in the event that the ARB gives the performing agency a notice that this Agreement will be terminated. The stop-work order will be in effect until the dispute has been resolved or this Agreement has been terminated.

B. Any dispute concerning a question of fact arising under the terms of this Agreement which is not disposed of within a reasonable period of time by agency employees normally responsible for the administration of this agreement, shall be brought to the attention of the Executive Officer or designated representative of each agency for joint resolution.

3. Amendments

ARB reserves the right to amend this agreement for additional time and/or additional funding.

EXHIBIT E

ADDITIONAL PROVISIONS

1. Equipment Provisions

A. Equipment is defined as movable articles of nonexpendable property that meet the following requirements:

1. Have a normal useful life (including extended life due to repairs) of at least one year;
2. Have a unit acquisition cost of at least $5,000 for other than land and structures (for example, identical assets costing $3,000 each for a $12,000 total would not meet the requirements); and,
3. Be used to conduct work under this contract, and/or,
4. All EDP equipment used to conduct work under this contract.

B. The cost of equipment includes the purchase price plus all costs to acquire, install, and prepare equipment for its intended use.

C. The ARB reserves the right to purchase total equipment whose cost is greater than $25,000 and any and all EDP equipment for this contract, through the State procurement process. Contractor's proposed cost of this equipment will be deducted from the total amount payable to the Contractor. The equipment provided by ARB will be equivalent to Contractor's specifications, as described in Contractor's proposal.

D. In the event Contractor purchases with ARB funds, procures, uses, or otherwise takes possession of equipment owned by ARB to perform work under this contract, title to such equipment shall remain with ARB and such equipment shall become ARB's equipment upon delivery thereof into the Contractor's control or possession.

E. Contractor shall obtain written approval from ARB prior to the purchase of equipment that is not specifically identified and listed in the approved budget and which is valued at more than $5,000. The contract funding shall be adjusted for any equipment or supplies furnished by ARB.

F. ARB reserves the right to full and adequate access to ARB equipment.

G. Contractor shall maintain and administer a program for the utilization, maintenance, repair, protection, and preservation of ARB equipment, whether acquired from the ARB or purchased with ARB funds from a third party, so as to assure its full availability and usefulness for performance of this contract or as long as this equipment remains in the control or possession of the Contractor.

The Contractor will install upon each item of equipment a tag identifying the equipment as belonging to the ARB and will maintain location records of all equipment. The Contractor shall take steps to comply with all appropriate directions or instructions that the ARB may prescribe for the protection of ARB equipment.

H. Contractor shall provide to ARB, with the final invoice, a final equipment inventory. The final invoice shall contain an itemization of equipment purchased with ARB funds or procured through the State procurement process, including the type of equipment, manufacturer, serial number, and cost. All ARB equipment shall be returned to the ARB at ARB's expense in full operating condition upon termination of this contract, unless ARB approves a different disposition in writing. Disposition of the equipment shall be in accordance with the instructions from ARB, to be issued after receipt of the final inventory.

2. <u>Reports and Data Compilations</u>

A. ***With respect to each invoice period, University shall forward to the ARB Contract Administrator, one (1) electronic copy of the progress report and mail one (1) copy of the progress report along with each invoice. (Do not use Express Mail). When emailing the progress report, the "subject line" should state the contract number and the billing period. Each progress report will begin with the following disclaimer:***

> *The statements and conclusions in this report are those of the University and not necessarily those of the California Air Resources Board. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.*

B. Each progress report will also include:

1. A brief narrative account of project tasks completed or partially completed since the last progress report;

2. A brief discussion of problems encountered during the reporting period and how they were or are proposed to be resolved;

3. A brief discussion of work planned, by project task, before the next progress report; and

4. A graph or table showing allocation of the budget and amount used to date.

5. A graph or table showing percent of work completion for each task.

C. If the project is behind schedule, the progress report must contain an explanation of reasons and how the University plans to resume the schedule.

D. Six months prior to Agreement termination date, University will deliver to ARB twenty (20) bound copies of a draft final report. The reports may be stapled or spiral bound, depending on size. The draft final report will conform to Exhibit F.

E. Within forty-five (45) days of receipt of ARB's comments on the draft Final Report (Exhibit F), University will deliver to ARB's Contract Manager two (2) copies of the Final Report incorporating all reasonable alterations and additions requested by ARB. Upon approval of the amended final report approved by ARB in accordance to Exhibit F, University will within two (2) weeks, deliver to ARB two (2) camera ready UNBOUND originals of a Final Report incorporating all final alterations and additions. The final report will conform to the Contract Final Report Format, Exhibit F.

F. Together with the final report, University will deliver a copy of the report on diskette/CD, using any common word processing software (please specify the software used) and a set of all data compilations as specified by the ARB Contract Manager.

G. University's obligation under this Agreement shall be deemed discharged only upon submittal to ARB of an acceptable final report in accordance to Exhibit F, report diskette/CD, all required data compilations, and any other project deliverables.

H. Prior to completion of this Agreement, University shall be entitled to release or make available reports, information, or other data prepared or assembled by it pursuant to this Agreement, in scientific journals and other publications and at scientific meetings, provided however, that a copy of the publication be submitted to ARB for review and comment 45 days prior to such publication. Further, University shall place the disclaimer statement in a conspicuous place on all such reports or publications. Health related reports should include an acknowledgment to the late Dr. Friedman. Nothing in this provision shall be construed to limit the right of State to release information obtained from the University or to publish reports, information, or data in State publications.

3. **Copyrightable Materials**

In recognition of the policy of ARB and University to promote and safeguard free and open inquiry by faculty, students and the members of the public and in furtherance of such policy, both parties agree to the following with respect to rights in data and copyrights under this Agreement:

A. The term "Subject Data" shall mean all original and raw research data, notes, computer programs, writings, sound recordings, pictorial reproductions, drawings or other graphical representations, and works of any similar nature, produced by University in performance of this Agreement, but specifically excluding "Reports," as defined in this Agreement. Subject Data also excludes financial reports, cost analyses, and similar information incidental to contract administration.

B. The term "Reports" shall have the meaning assigned to it in this Exhibit F of this Agreement.

C. Ownership of all Subject Data and copyrights arising from Subject Data shall be vested in University while ownership of all Reports and copyrights arising from the Reports delivered under this Agreement shall be vested in ARB. University agrees to make available to the public for public benefit, to the extent the University shall have the legal right to do so, without license or fee, any scholarly articles which are published from the Subject Data.

D. Nothing in this exhibit or Agreement shall be construed to limit the right of University faculty, students or staff to publish the Subject Data in the form of scholarly articles in academic journals nor to affect, abrogate or limit the right of University faculty, staff or students to make use of the Subject Data.

4. Travel & Per Diem

A. Any reimbursement for necessary travel and per diem shall be at the University's approved travel rates.

B. No foreign travel shall be reimbursed unless prior written authorization is obtained from ARB.

5. Meetings

A. Initial meeting. Before work on the contract begins, the Principal Investigator and key personnel will meet with the ARB Contract Manager and other staff to discuss the overall plan, details of performing the tasks, the project schedule, items related to personnel or changes in personnel, and any issues that may need to be resolved before work can begin.

B. Progress review meetings. The Principal Investigator and appropriate members of his or her staff will meet with ARB's Contract Manager at quarterly intervals to discuss the progress of the project. This meeting may be conducted by phone.

C. Technical Seminar. The Contractor will present the results of the project to ARB staff and a possible webcast at a seminar at ARB facilities in Sacramento or El Monte.

6. Confidentiality

A. It is understood that in the course of carrying out this Agreement, State may wish to provide University with proprietary or confidential information of State (Proprietary Information). University agrees to use its best efforts to hold proprietary information in confidence and shall return it to State upon the completion of the project.

B. This obligation shall apply only to proprietary information that is designated or identified as such in writing by State prior to the disclosure thereof. All proprietary information shall be sent only to the Principal Investigator. Moreover, this obligation shall not apply to any proprietary information which: a) is or becomes publicly known through no wrongful or negligent act on the part of University; b) is already known to University at the time of disclosure; c) independently developed by University without breach of this agreement; or d) is generally disclosed to third parties by State without similar restrictions on such third parties.

7. Studies Involving Human or Animal Subjects

A copy of the Institutional Review Board (IRB) approval must be submitted to ARB upon receipt by the investigator.

8. Patent Provisions

These provisions apply only to non-state entity subcontractors that may be a part of this Agreement.

A. Definitions

1. "Invention" means any discovery or product of creative imagination, thought, mental synthesis, or purposeful experimentation conceived or first reduce to practice in the course of or under this Agreement. The term "invention" includes, but is not limited to, any art, method, process, device, machine, manufacture, design, or composition of matter, or any new and useful improvement or application thereof, or any variety of plant, that is or may be patentable under the patent laws of the United States of America.

2. "Agreement" means any legally enforceable agreement, covenant, compact grant, or other arrangement or subcontract setting forth terms and conditions to do or not to do something and entered into by or for the benefit of the State where a purpose of the agreement is the conduct of experimental, developmental, or research work.

3. "Subcontract" means an agreement under or subordinate to a previous or prime agreement, including this Agreement.

4. "Subcontractor" means an individual or firms that contracts with Contractor to perform part or all of the prime Contractor's work under this Agreement.

5. "To bring to the point of practical application" means to manufacture in the case of a composition or product, to practice in the case of a process, or to operate in the case of a machine, device, or system and, in each case, under such conditions as to establish that the invention is being worked, operated, or utilized, and that its benefits are reasonable accessible to the public.

B. **Rights Granted to the State**

Subcontractor agrees to grant to State all right, title, and interest in and to each invention discovered, conceived, or first reduced to practical application during performance of the Subcontract, subject to the reservation of a non-exclusive paid-up worldwide license to Subcontractor.

C. **Invention Disclosures and Reports**

With respect to each invention, Subcontractor shall furnish to ARB:

1. A written disclosure of each invention within six (6) months after conception or first actual reduction to practice, whichever occurs first under the Subcontract, sufficiently complete in technical detail to convey to one skilled in the art to which the invention pertains a clear understanding to the nature, purpose, and operation, and the physical, chemical, and electrical characteristics of the invention;

2. A final report listing all inventions, including all those previously disclosed, or certifying that there are no inventions prior to final payment under this Subcontract.

3. Information in writing, as soon as is practicable, of the date and identity of any public use, sale, or publication of any such invention made by or known to Subcontractor, or of any contemplated publication by Subcontractor;

4. Upon request, such duly executed instruments and other papers as deemed by ARB necessary to vest in State the rights granted it under this patent provision and to enable State to apply for and prosecute any patent application in any country covering such invention where State has the right under this patent provision to file such application; and

5. Upon request, an irrevocable power of attorney to inspect and make copies of any United States patent application filed by or on behalf of Subcontractor. This demand may also be made under subdivision 8.

D. **License Granted by Subcontractor to Others Subject to State's Rights**

Subcontractor recognizes that State may contract for property or services with respect to which the vendor may be liable to Subcontractor for royalties for the use of an invention on account of such a contract. Subcontractor further recognizes that it is the policy of State not to pay, in connection with its agreements, charges for use of patents in which the State holds title. In recognition of this policy, Subcontractor agrees to participate in and make appropriate arrangements for the exclusion of such charges from such agreements or for the refund of amounts received by Subcontractor with respect to any such charges not so excluded.

E. **Subcontracts**

1. Contractor shall, unless otherwise authorized or directed by State, include a patent rights clause containing all the terms of this patent provision in any Subcontract hereunder where the purpose of the subcontract is the conduct of experimental, developmental, or research work. In the event of refusal by a Subcontractor to accept this patent provision, Contractor:

   (1) shall promptly submit a written report to the State setting forth the Subcontractor's reasons for such refusal or the reasons Contractor is of the opinion that the inclusion of this clause would be unacceptable, and other pertinent information that may expedite disposition of this matter; and

   (2) shall not proceed with the Subcontract without the written authorization of State.

2. Contractor shall not, in any Subcontract or by using such a Subcontract as consideration thereof, acquire any rights to inventions for its own use (as distinguished from such rights as may be required solely to fulfill its agreement obligations to State in the performance of this Agreement).

3. Contractor, at the earliest practicable date, shall also notify State in writing of any Subcontract containing a patent rights clause, furnish to State a copy of such Subcontract, and notify State when such Subcontract is completed. It is understood that State is a third party beneficiary of any Subcontract clause granting rights to State in inventions, and Contractor hereby assigns to State all the rights that Contractor would have to enforce the Subcontractor's obligations for the benefit of State with respect to inventions. Contractor shall not be obligated to enforce the agreements of any Subcontractor to State with regard to inventions.

F. **Right to Disclose Inventions**

State may duplicate and disclose reports and disclosures of inventions required to be furnished by Subcontractor pursuant to this patent provision.

G. **Forfeiture of Rights in Unreported Inventions**

Subcontractor shall forfeit to State all rights in any invention which Subcontractor fails to report to State, at or prior to the time Subcontractor (1) files or causes to be filed a United States or foreign application thereon, or (2) submits the final report required by 3., B of this patent provision, whichever is later, provided that Subcontractor shall not forfeit rights in an invention if (a) contending that the invention is not an invention, it nevertheless reports the invention and all the facts pertinent to Subcontractor's contention to State, the time specified in 3. A above, or (b) Subcontractor establishes that the failure to report was due entirely to causes beyond Subcontractor's control and without Subcontractor's fault or negligence. Subcontractor shall be deemed to hold any such forfeited invention and the patent applications and patent pertaining thereto, in trust for State pending written assignment of the invention. The right accruing to State under this paragraph shall be in addition to and shall not supersede any other rights State may have in relation to unreported inventions.

H. **Examination of Records Relating to Inventions**

State shall, until the expiration of three years after final payment under this agreement, have the right to examine any books, records, documents, and other supporting data of Subcontractor that State shall reasonably deem directly pertinent to the discovery or identification of inventions or to compliance by Subcontractor with the requirements of this patent provision.

EXHIBIT F

RESEARCH FINAL REPORT FORMAT

The research contract Final Report (Report) is as important to the contract as the research itself. The Report is a record of the project and its results, and is used in several ways. Therefore, the Report must be well organized and contain certain specific information. The ARB's Research Screening Committee (RSC) reviews all draft Final Reports, paying special attention to the Abstract and Executive Summary. If the RSC finds that the Report does not fulfill the requirements stated in this Appendix, the document will not be approved for release, and final payment for the work completed may be withheld. This Appendix outlines the requirements that must be met when producing the Report.

Note: In partial fulfillment of the Final Report requirements, the Contractor shall submit a copy of the Report on a CD in PDF format and in a word-processing format, preferably in Word - Version 6.0 or later. This is in addition to the submission of any paper copies required. The diskette shall be clearly labeled with the contract title, ARB contract number, the words "Final Report", and the date the report was submitted.

Legibility. Each page of the approved Final Report must be legible and camera-ready.

Binding. The draft Report, including its appendices, must be either spiral bound or stapled, depending on size. The revised Report and its appendices should be spiral bound, except for two unbound, camera-ready originals.

Cover. Do not supply a cover for the Report. The ARB will provide its standard cover.

One-sided vs. two-sided. To conserve paper, both the draft Report and the revised Report, except for the unbound camera-ready copies, should be printed on both sides of the page. The unbound camera-ready copies must be printed on only one side of the page.

Title. The title of the Report should exactly duplicate the title of the contract unless a change is approved in writing by the contract manager.

Spacing. In order to conserve paper, copying costs, and postage, please use single or one-line (1) spacing.

Page size. All pages should be of standard size (8 ½" x 11") to allow for photo-reproduction.

Large tables or figures. Foldout or photo-reduced tables or figures are not acceptable because they cannot be readily reproduced. Large tables and figures should be presented on consecutive
8 ½" x 11" pages, each page containing one portion of the larger chart.

Color. Color presentations are not acceptable; printing shall be black on white only.

Corporate identification. Do not include corporate identification on any page of the Final Report, except the title page.

Unit notation. Measurements in the Reports should be expressed in metric units. However, for the convenience of engineers and other scientists accustomed to using the British system, values may be given in British units as well in parentheses after the value in metric units. The expression of measurements in both systems is especially encouraged for engineering reports.

Section order. The Report should contain the following sections, in the order listed below:

Title page
Disclaimer
Acknowledgment (1)
Acknowledgment (2)
Table of Contents
List of Figures
List of Tables
Abstract
Executive Summary
Body of Report
References
List of inventions reported and copyrighted materials produced
Glossary of Terms, Abbreviations, and Symbols
Appendices

Page numbering. Beginning with the body of the Report, pages shall be numbered consecutively beginning with "1", including all appendices and attachments. Pages preceding the body of the Report shall be numbered consecutively, in ascending order, with small Roman numerals.

Title page. The title page should include, at a minimum, the contract number, contract title, name of the principal investigator, contractor organization, date, and this statement: "Prepared for the California Air Resources Board and the California Environmental Protection Agency"

Disclaimer. A page dedicated to this statement must follow the Title Page:

The statements and conclusions in this Report are those of the contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

Acknowledgment (1). Only this section should contain acknowledgments of key personnel and organizations who were associated with the project. The last paragraph of the acknowledgments must read as follows:

This Report was submitted in fulfillment of [ARB contract number and project title] by [contractor organization] under the [partial] sponsorship of the California Air Resources Board. Work was completed as of [date].

Acknowledgment (2). Health reports should include an acknowledgment to the late Dr. Friedman. Reports should include the following paragraph:

This project is funded under the ARB's Dr. William F. Friedman Health Research Program. During Dr. Friedman's tenure on the Board, he played a major role in guiding ARB's health research program. His commitment to the citizens of California was evident through his personal and professional interest in the Board's health research, especially in studies related to children's health. The Board is sincerely grateful for all of Dr. Friedman's personal and professional contributions to the State of California.

Table of Contents. This should list all the sections, chapters, and appendices, together with their page numbers. Check for completeness and correct reference to pages in the Report.

List of Figures. This list is optional if there are fewer than five illustrations.

List of Tables. This list is optional if there are fewer than five tables.

Abstract. The abstract should tell the reader, in nontechnical terms, the purpose and scope of the work undertaken, describe the work performed, and present the results obtained and conclusions. The purpose of the abstract is to provide the reader with useful information and a means of determining whether the complete document should be obtained for study. The length of the abstract should be no more than about 200 words. Only those concepts that are addressed in the executive summary should be included in the abstract.

Example of an abstract:

A recently developed ground-based instrument, employing light detecting and ranging (lidar) technology, was evaluated and found to accurately measure ozone concentrations at altitudes of up to 3,000 meters. The novel approach used in this study provides true vertical distributions of ozone concentrations aloft and better temporal coverage of these distributions than other, more common methods, such as those using aircraft and ozonesonde (balloon) techniques. The ozone and aerosol measurements from this study, in conjunction with temperature and wind measurements, will provide a better characterization of atmospheric conditions aloft and the processes involved in the formation of unhealthful ozone concentrations than can be achieved with traditional ground-based monitors.

Executive Summary. The function of the executive summary is to inform the reader about the important aspects of the work that was done, permitting the reader to understand the research without reading the entire Report. It should state the objectives of the research and briefly describe the experimental methodology[ies] used, results, conclusions, and recommendations for further study. All of the concepts brought out in the abstract should be expanded upon in the Executive Summary. Conversely, the Executive Summary should not contain concepts that are not expanded upon in the body of the Report.

The Executive Summary will be used in several applications as written; therefore, please observe the style considerations discussed below.

Limit the Executive Summary to two pages, single spaced.

Use narrative form. Use a style and vocabulary level comparable to that in Scientific American or the New York Times.

Do not list contract tasks in lieu of discussing the methodology.

Discuss the results rather than listing them.

Avoid jargon.

Define technical terms.

Use passive voice if active voice is awkward.

Avoid the temptation to lump separate topics together in one sentence to cut down on length.

The Executive Summary should contain four sections: Background, Methods, Results, and Conclusions, described below.

THE BACKGROUND SECTION. For the Background, provide a one-paragraph discussion of the reasons the research was needed. Relate the research to the Board's regulatory functions, such as establishing ambient air quality standards for the protection of human health, crops, and ecosystems; the improvement and updating of emissions inventories; and the development of air pollution control strategies.

THE METHODS SECTION. At the beginning of the Methods section, state what was done in general, in one or two sentences.

The methodology should be described in general, nontechnical terms, unless the purpose of the research was to develop a new methodology or demonstrate a new apparatus or technique. Even in those cases, technical aspects of the methodology should be kept to the minimum necessary for understanding the project. Use terminology with which the reader is likely to be familiar. If it is necessary to use

technical terms, define them. Details, such as names of manufacturers and statistical analysis techniques, should be omitted.

Specify when and where the study was performed, if it is important in interpreting the results.

The findings should not be mentioned in the Methods section.

THE RESULTS SECTION. The Results section should be a single paragraph in which the main findings are cited and their significance briefly discussed. The results should be presented as a narrative, not a list. This section must include a discussion of the implications of the work for the Board's relevant regulatory programs.

THE CONCLUSIONS SECTION. The Conclusions section should be a single short paragraph in which the results are related to the background, objectives, and methods. Again, this should be presented as a narrative rather than a list. Include a short discussion of recommendations for further study, adhering to the guidelines for the Recommendations section in the body of the Report.

Body of Report. The body of the Report should contain the details of the research, divided into the following sections:

INTRODUCTION. Clearly identify the scope and purpose of the project. Provide a general background of the project. Explicitly state the assumptions of the study.

Clearly describe the hypothesis or problem the research was designed to address. Discuss previous related work and provide a brief review of the relevant literature on the topic.

MATERIALS AND METHODS. Describe the various phases of the project, the theoretical approach to the solution of the problem being addressed, and limitations to the work. Describe the design and construction phases of the project, materials, equipment, instrumentation, and methodology. Describe quality assurance and quality control procedures used. Describe the experimental or evaluation phase of the project

RESULTS. Present the results in an orderly and coherent sequence. Describe statistical procedures used and their assumptions. Discuss information presented in tables, figures and graphs. The titles and heading of tables, graphs, and figures, should be understandable without reference to the text. Include all necessary explanatory footnotes. Clearly indicate the measurement units used.

DISCUSSION. Interpret the data in the context of the original hypothesis or problem. Does the data support the hypothesis or provide solutions to the research problem? If appropriate, discuss how the results compare to data from similar or related studies. What are the implications of the findings? Identify innovations or development of new techniques or processes. If appropriate, discuss cost projections and economic analyses.

SUMMARY AND CONCLUSIONS. This is the most important part of the Report because it is the section that will probably be read most frequently. This section should begin with a clear, concise statement of what, why, and how the project was done. Major results and conclusions of the study should then be presented, using clear, concise statements. Make sure the conclusions reached are fully supported by the results of the study. Do not overstate or overinterpret the results. It may be useful to itemize primary results and conclusions. A simple table or graph may be used to illustrate.

RECOMMENDATIONS. Use clear, concise statements to recommend (if appropriate) future research that is a reasonable progression of the study and can be supported by the results and discussion.

References. Use a consistent style to fully cite work referenced throughout the Report and references to closely related work, background material, and publications that offer additional information on aspects of the work. Please list these together in a separate section, following the body of the Report. If the Report is lengthy, you may list the references at the end of each chapter.

List of inventions reported and publications produced. If any inventions have been reported, or publications or pending publications have been produced as a result of the project, the titles, authors, journals or magazines, and identifying numbers that will assist in locating such information should be included in this section.

Glossary of terms, abbreviations, and symbols. When more than five of these items are used in the text of the Report, prepare a complete listing with explanations and definitions. It is expected that every abbreviation and symbol will be written out at its first appearance in the Report, with the abbreviation or symbol following in parentheses [i.e., carbon dioxide (CO_2)]. Symbols listed in table and figure legends need not be listed in the Glossary.

Appendices. Related or additional material that is too bulky or detailed to include within the discussion portion of the Report shall be placed in appendices. If a Report has only one appendix, it should be entitled "APPENDIX". If a Report has more than one appendix, each should be designated with a capital letter (APPENDIX A, APPENDIX B). If the appendices are too large for inclusion in the Report, they should be collated, following the binding requirements for the Report, as a separate document. The contract manager will determine whether appendices are to be included in the Report or treated separately. Page numbers of appendices included in the Report should continue the page numbering of the Report body. Pages of separated appendices should be numbered consecutively, beginning at "1".