State of California
AIR RESOURCES BOARD

ADVANCED PLUG-IN ELECTRIC VEHICLE TRAVEL AND CHARGING BEHAVIOR

RESEARCH CONTRACT AUGMENTATION

Resolution 15-24

July 23, 2015

Agenda Item No.: 15-6-2

WHEREAS, the Air Resources Board (ARB or Board) has been directed to carry out an effective research program in conjunction with its efforts to combat air pollution, pursuant to Health and Safety Code sections 39700 through 39705;

WHEREAS, the Research Division staff has reviewed this Contract Number 12-319, titled "Advanced Plug-in Electric Vehicle Travel and Charging Behavior," and recommended a contract augmentation for approval to the University of California, Davis, for a total not to exceed $442,356;

WHEREAS, the Research Division finds that in accordance with Health and Safety Code section 39701 research is needed to improve emissions estimates at the vehicle, household, and fleet levels. The results of the study will provide insight into potential plug-in vehicle demand on the electrical grid, and the need for potential future supporting infrastructure, and will be valuable to ARB's Advanced Clean Cars program; and

WHEREAS, in accordance with Health and Safety Code section 39705, the Research Screening Committee has reviewed and recommends funding the following augmentation:

> Contract Number 12-319 titled "Advanced Plug-in Electric Vehicle Travel and Charging Behavior," submitted by the University of California, Davis, will be co-funded through the California Energy Commission, for a total amount not to exceed $442,356.

NOW, THEREFORE BE IT RESOLVED that the Air Resources Board, pursuant to the authority granted by Health and Safety Code section 39700 through 39705, hereby accepts the recommendations of the Research Screening Committee and staff and approves the augmentation.

BE IT FURTHER RESOLVED that the Executive Officer is hereby authorized to initiate administrative procedures and execute all necessary documents and contracts for the

augmentation proposed herein, and as described in Attachment A, in an amount not to exceed $442,356.

I hereby certify that the above is a true and correct copy of Resolution 15-24 as adopted by the Air Resources Board.

Tracy Jensen

Tracy Jensen, Clerk of the Board

ATTACHMENT A

"Advanced Plug-in Electric Vehicle Travel and Charging Behavior"

Background
This project was approved by the Board in December 2012 to address the need to study consumers' actual usage of plug-in electric vehicles, identified during the January 2012 meeting of ARB's Board when the Advanced Clean Car standards were approved. Consumer usage and charging habits of plug-in electric vehicle (PEV) owners remain ambiguous due to limited data availability and the diversity of PEV attributes. However, these behaviors will have significant implications for statewide emissions, energy consumption, and electrical grid management based on the total miles these vehicles travel using off-board electricity sources (eVMT). As PEVs are expected to become an increasing share of the light-duty fleet, understanding these behaviors will be important for appropriately projecting fleet emissions and estimating consumer impacts as well as efficiently planning future resources.

This augmentation will allow ARB to accept co-funding from the California Energy Commission (CEC) to significantly expand this study to include newer vehicle technologies, additional households, a project manager, and interviews with PEV-owning households, which will improve the robustness and richness of the results. The original study aimed to recruit 108 households to participate, spread over three vehicle types: Nissan Leaf, Chevrolet Volt, and Toyota Prius plug-in hybrid. Ford recently provided supplementary funding directly to the University of California, Davis (UC Davis) to allow inclusion of the Ford Fusion and C-Max plug-in hybrids. This augmentation will increase the number of households to a total of 252 households and will allow inclusion of the BMW i3 Rex (range-extended battery electric vehicle [BEV]) and the Tesla Model S (long-range BEV).

Objective
The objective of this research project is to collect and analyze longitudinal and spatial in-use vehicle data from households that own PEVs. A wide array of data will be collected from all vehicles within the households – both PEV and non-PEV – in order to improve emissions estimates at the vehicle, household, and fleet levels. The data will also be used to inform potential demand on the electrical grid as well as the need for potential future supporting infrastructure.

Methods
The primary data collection method will be through instrumentation with a customized data logging device that captures vehicle location, operations, and charging data transmitted to a server via a cellular network. UC Davis has selected FleetCarma as the vendor for the loggers for the households in the original study scope, and has deployed the loggers in test vehicles with plans for deployment in the first wave of study households in early summer 2015.

Data will be collected from all vehicles within the household for up to twelve months, with the entire data collection period spanning approximately two years. Collecting data over two years has the benefit of eliminating seasonal effects as well as providing insights into how households adapt their travel patterns and vehicle trip assignments as they become more familiar with their PEVs or as public charging infrastructure expands and becomes more congested. The data will be highly resolved – many parameters collected at a frequency as high as one-second intervals – which will provide opportunities for future studies to improve understanding of travel behavior in general and further refine emissions estimates.

The in-use vehicle data will be supplemented with two surveys of the participating households. The first survey was administered to eligible households to gather data on household characteristics, charger availability, important destinations, and expectations about their PEVs. As of mid-May 2015, over 4000 responses had been received. The results of this survey are being used to select households along the various dimensions of interest: PEV technology type, access to workplace charging, geographic diversity, utility service territory, and annual miles traveled, etc. The exit survey will be conducted at the conclusion of the household's data collection period to provide context for interpreting the vehicle data and capture relevant changes to the household (e.g. change in workplace location or household structure) and reflections on their experiences with the vehicle and charging infrastructure.

Given the large volume of data that will be generated from this project, database software and geographic information systems (GIS) are being used to process the data and to describe the current state of PEV household vehicle use dynamics and charging, and the interaction between charging infrastructure and eVMT. A project manager will also be funded by this augmentation, to install and remove logger equipment in vehicles, monitor data collection, trouble-shoot problems with the loggers or data transmission, and provide other project support. The results of this study will inform policymakers on strategies for increasing eVMT and the need for additional public charging infrastructure. The U.S. Department of Energy is also providing an additional $400,000 directly to UC Davis for data analysis.

Expected Results

This research will enhance ARB's understanding of PEV-owning households' travel and charging behavior. The additional funds from CEC for this augmentation will be used to add more PEV types to the study which will include long-range battery electric vehicles (BEV) and range-extended BEV (BEV_X) technologies that were either less common or nonexistent when the study was initiated; increase the number of households in the study to improve the robustness of the observations; and add interviews with a small set of households to provide richer insight into vehicle purchase decisions and the motivations that underlie travel and charging behavior.

Significance to the Board

The results of this study will improve emissions estimates at the vehicle, household, and fleet levels, will provide insight into potential plug-in vehicle demand on the electrical

grid, and the need for potential future supporting infrastructure, and will be valuable to ARB's Advanced Clean Cars program.

Contractor:
University of California, Davis
The California Energy Commission will provide co-funding to ARB for this project.

Contract Period:
56 months

Principal Investigators (PIs):
Dr. Thomas Turrentine, Ph.D.
Dr. Michael Nicholas, Ph.D.

Original contract amount:
$649,997

Co-funding:
California Energy Commission is funding the total $442,356 contract augmentation

Total contract amount:
$1,092,353

Basis for Indirect Cost Rate:
The State and the UC system have agreed to a ten percent indirect cost rate.

Past Experience with this Principal Investigator:
This research team has been investigating consumer behavior related to alternative fuel vehicles for decades and currently serves as the State's research center on plug-in hybrid and electric vehicles. They have led previous vehicle instrumentation research projects and demonstrated the ability to receive and process large volumes of data. In addition, they have conducted extensive research on charging infrastructure that will complement the interpretation of the vehicle and survey data. Additionally, they have demonstrated their ability to leverage existing partnerships with industry and other government agencies which are expected to enhance the quality of the final deliverables.

Prior Research Division Funding to the University of California, Davis:

Year	2014	2013	2012
Funding	$ 2,249,136	$ 1,131,716	$ 4,949,363

BUDGET SUMMARY

Contractor: University of California, Davis

Advanced Plug-in Electric Vehicle Travel and Charging Behavior

		Original Budget	Augmented Budget
DIRECT COSTS AND BENEFITS			
1.	Labor and Employee Fringe Benefits	$ 212,351	$ 539,227
2.	Subcontractors	$ 234,485	$ 234,485
3.	Equipment	$ 0	$ 0
4.	Travel and Subsistence	$ 12,511	$ 41,428
5.	Electronic Data Processing	$ 23,155	$ 23,155
6.	Reproduction/Publication	$ 3,580	$ 3,580
7.	Mail and Phone	$ 11,333	$ 13,133
8.	Supplies	$ 0	$ 1,354
9.	Analyses	$ 0	$ 0
10.	Miscellaneous	$ 97,481	$ 140,676[1]
	Total Direct Costs	$ 594,896	$ 997,038
INDIRECT COSTS			
1.	Overhead	$ 55,101	$ 95,315
2.	General and Administrative Expenses	$ 0	$ 0
3.	Other Indirect Costs	$ 0	$ 0
4.	Fee or Profit	$ 0	$ 0
	Total Indirect Costs	$ 55,101	$ 95,315
TOTAL PROJECT COSTS		**$ 649,997**	**$1,092,353**

[1] Miscellaneous expenses include incentives to persuade the households to participate in the research study and a completion incentive that will be provided to households when they return the logging device and complete the exit survey.