

State of California  
AIR RESOURCES BOARD

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

RESEARCH CONTRACT AUGMENTATION

Resolution 17-38

**October 26, 2017**

Agenda Item No.: 17-10-3

WHEREAS, the California Air Resources Board (CARB 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 have reviewed Contract No. 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 amount not to exceed \$74,900;

WHEREAS, the Research Division finds that in accordance with Health and Safety Code section 39701, the results of the research study augmentation will allow the Board to assess the emissions impacts of high-power cold start events in plug-in hybrid electric vehicles and help guide the Board in developing future clean car standards and the zero-emission vehicle program; and

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

NOW, THEREFORE BE IT RESOLVED, that CARB, pursuant to the authority granted by Health and Safety Code sections 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 \$74,900.

I hereby certify that the above is a true and correct copy of Resolution 17-38 as adopted by the California Air Resources Board.

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Rana McReynolds, Clerk of the Board

October 26, 2017

**Identification of Attachments to Board Resolution 17-38**

**Attachment A:** “Advanced Plug-in Electric Vehicle Travel and Charging Behavior”  
Summary and Budget Summary

## ATTACHMENT A

### Advance Plug-In Electric Vehicle Travel and Charging Behavior

#### Background

This project's overall objective is to collect and analyze in-use vehicle data from a variety of plug-in electric vehicle (PEV) types in a household context to improve estimates of vehicle emissions and provide insights into their real-world benefits. PEVs constitute a growing share of new light-duty vehicle sales, but their environmental benefits vary depending on consumer usage and charging behavior. Recently it was found that a subset of PEVs called "blended" plug-in hybrid electric vehicles (PHEVs) had high cold-start emissions under high power demand conditions, (such as on-ramp acceleration or steep hill climbs), and that these PHEV engine start events could produce higher emissions than traditional internal combustion engine (ICE) cold starts. Data already collected under contract no. 12-319 offer a unique opportunity to assess the emissions impact of these blended PHEV high-power engine starts. The additional funds will be used to mine activity data to identify conditions leading to these high-power starts and estimate their emissions impacts. The results of this project will be used to update emission inventories as well as inform future policy related to the Advanced Clean Car regulation.

#### Objective

The objective of this project augmentation is to characterize the engine start activity profiles of all logged vehicle types, including blended PHEVs, by: 1) defining the characteristics associated with engine start events for all vehicle types and categorizing the estimated emission impacts of those starts; 2) identifying conditions -- including driving behavior, road grade, battery level, and other factors -- that trigger high-power cold start events; and 3) determining the frequency of occurrence of various types of engine starts. The results of these analyses of activity data will be combined by CARB with previous emissions test results to better characterize real-world PEV emissions levels and improve future versions of CARB's EMFAC vehicle emission inventory model. This contract augmentation is needed to support the contractor's time and effort to analyze the very large data set collected as part of the overall contract. The analyses required are complementary to those of the original contract, thus requiring additional resources.

#### Methods

The funds for this augmentation will provide the necessary resources to pay for additional staff time to analyze the data collected under the original 12-319 contract. A new task added to the original proposal includes the following contractor subtasks:

1. Mine the data to identify and characterize engine start events in all logged vehicle types, classifying start events by power demand and examining the triggering factors;
2. Analyze GPS location data and compare it to road network data to derive high-resolution road grade values that impact PHEV cold start events;

3. Provide representative 1-Hz (one cycle per second) data on power draw, vehicle, and engine characteristics for each engine start category so that CARB staff can simulate conditions preceding and following cold starts on chassis dynamometers;
4. Provide statistics on cold start events relevant to EMFAC modeling needs; and,
5. Provide CARB with real-time 1-Hz activity data on all monitored vehicles to support a parallel project on braking activity.

Given the large volume of data generated by this project, database management software and geographic information systems are being used to process the data and describe PEV household vehicle use dynamics and charging, as well as the interaction between charging infrastructure and electric vehicle miles traveled (eVMT). Similar methods will be used to provide the analysis defined in this augmentation.

### **Expected Results**

This project will allow researchers to identify conditions which lead to high-power cold starts and determine the frequency of these events. The statistical analysis will allow CARB staff to determine the overall emissions impact this fraction of the fleet will have on community air. The results of this study will be used to improve the emission inventory model's (EMFAC) estimation of PHEV engine start emissions.

### **Significance to the Board**

This research will allow the Board to better evaluate the emissions impact of PHEV vehicles and will help guide the Board in the developing the Advanced Clean Car regulation and the ZEV program.

### **Contractor:**

University of California, Davis

### **Contract Period:**

18 months

### **Principal Investigator (PI):**

Gil Tal, Ph.D.

### **Contract Amount:**

\$74,900

### **Basis for Indirect Cost Rate:**

The State and the UC system have agreed to a 25 percent indirect cost rate.

### **Past Experience with this Principal Investigator:**

The project will be conducted by Dr. Gil Tal who is leading two other electric vehicle instrumentation and survey research projects funded by CARB. Through these, he has demonstrated the ability to receive and process large volumes of data. Dr. Tal has thus far

successfully delivered results and reports related to these contracts. In addition, he has conducted extensive research on travel behavior and charging infrastructure that will complement the interpretation of the vehicle and survey data. Dr. Tal is part of the Institute of Transportation Studies (ITS), which has been investigating consumer behavior related to alternative fuel vehicles for decades and currently serves as the State's primary research center on plug-in hybrid and electric vehicles. ITS also demonstrated an ability to leverage existing partnerships with industry and other government agencies to enhance the quality of final deliverables.

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

Year	2016	2015	2014
Funding	\$ 650,000	\$1,468,460	\$2,249,136

## B U D G E T   S U M M A R Y

Contractor: University of California, Davis

“Advanced Plug-in Electric Vehicle Travel and Charging Behavior”

<b><u>DIRECT COSTS AND BENEFITS</u></b>	<b>Original Budget</b>	<b>Augmented Budget</b>
1. Labor and Employee Fringe Benefits	\$ 539,301	\$ 598,763
2. Subcontractors	\$ 234,485	\$ 234,485
3. Equipment	\$ 0	\$ 0
4. Travel and Subsistence	\$ 41,401	\$ 41,421
5. Electronic Data Processing	\$ 23,155	\$ 23,155
6. Reproduction/Publication	\$ 3,580	\$ 3,580
7. Mail and Phone	\$ 13,133	\$ 13,133
8. Supplies	\$ 1,308	\$ 1,425
9. Analyses	\$ 0	\$ 0
10. Miscellaneous	<u>\$ 140,675</u>	<u>\$ 140,976<sup>1</sup></u>
Total Direct Costs	\$ 997,038	1,056,938
<b><u>INDIRECT COSTS</u></b>		
1. Indirect (F&A) Costs <sup>2</sup>	<u>\$ 95,315</u>	<u>\$ 110,315</u>
Total Indirect Costs	<u>\$ 95,315</u>	<u>\$ 110,315</u>
<b><u>TOTAL PROJECT COSTS</u></b>	<b><u>\$1,092,353</u></b>	<b><u>\$1,167,253</u></b>

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<sup>1</sup> 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.

<sup>2</sup> Facilities & Administrative costs.