California Energy Commission
May 31, 2023 Business Meeting
Backup Materials for Agenda Item No 03g:
Department of Energy (DOE) Lawrence Berkeley National Laboratory (LBNL)

The following backup materials for the above-referenced agenda item are available in this PDF packet as listed below:

1. Proposed Resolution
2. Contract Amendment Request Form
3. Scope of Work

RESOLUTION NO: 23-0531-03g

STATE OF CALIFORNIA

STATE ENERGY RESOURCES
CONSERVATION AND DEVELOPMENT COMMISSION

RESOLUTION: Department of Energy (DOE) - Lawrence Berkeley National Laboratory (LBNL)

RESOLVED, that the State Energy Resources Conservation and Development Commission (CEC) adopts the staff CEQA findings contained in the Agreement or Amendment Request Form (as applicable); and

RESOLVED, that the CEC approves amendment 3 to Agreement 600-19-005 with DOE LBNL to increase funding by $1,150,000, extend the agreement term to December 31, 2026, and revise the Scope of Work to expand analysis to off-road vehicles and equipment, charging infrastructure needs for Assembly Bill 2127 (Ting, 2018) reporting, modeling medium- and heavy-duty fuel cell vehicles for SB 643 (Archuleta, 2021), and assessing non-road sectors (such as aviation, maritime, rail, and emerging technologies); and

FURTHER BE IT RESOLVED, that the Executive Director or their designee shall execute the same on behalf of the CEC.

CERTIFICATION

The undersigned Secretariat to the CEC does hereby certify that the foregoing is a full, true, and correct copy of a resolution duly and regularly adopted at a meeting of the CEC held on May 31, 2023.

AYE:
NAY:
ABSENT:
ABSTAIN:

Dated:

_____
Liza Lopez
Secretariat

STATE OF CALIFORNIA

CONTRACT AMENDMENT REQUEST FORM (CARF)

CEC-276 (Revised 12/2019) CALIFORNIA ENERGY COMMISSION

Original Agreement # 600-19-005 Amendment # 03

Division	Agreement Manager:	MS-	Phone
600 Fuels and Transportation Division	Micah Wofford	19	916-776-7198

Recipient's Legal Name	Federal ID #
Department of Energy - Lawrence Berkeley National Laboratory	94-2951741

Revisions: (check all that apply)	Additional Requirements
☒ Term Extension New End Date: 12 / 31 / 2026	Include revised schedule and complete items A, B, C, D, & H below.
☒ Budget Augmentation Amendment Amount: $ 1,150,000	Include revised budget and complete items A, B, C, D, E, F, & H below.
☐ Budget Reallocation	Include revised budget and complete items A, B, C, D, & H below.
☒ Scope of Work Revision	Include revised scope of work and complete items A, B, C, D, & H below.
☐ Change in Project Location or Demonstration Site	Include revised scope of work and complete items A, B, C, D, G, & H below.
☐ DVBE Replacement	Include revised scope of work and complete items A, B, C, D, F & H below.
☐ Novation/Name Change of Prime Recipient	Include novation documentation and complete items A, B, D, & H below.
☐ Terms and Conditions Modification	Include applicable exhibits with bold/underline/ strikeout and complete items A, B, C, D & H below.

A) Business Meeting Information

Business Meeting approval is not required for the following types of Agreements:

☐ Minor amendments delegated to Executive Director per December 2013 Resolution

Proposed Business Meeting Date 05 / 31 / 2023 ☐ Consent ☒ Discussion

Business Meeting Presenter Micah Wofford Time Needed: 5 minutes

Please select one list serve. Altfuels (AB118- ARFVTP)

Agenda Item Subject and Description:

Department of Energy (DOE) Lawrence Berkeley National Laboratory (LBNL). Proposed resolution approving Amendment 3 to Agreement 600-19-005 with DOE LBNL to increase funding by $1,150,000, extend the agreement term to December 31, 2026, and revise the Scope of Work to include new tasks that expand the scope of the model by analyzing off-road

vehicles and equipment, updating charging infrastructure needs for AB 2127 (Ting, 2018) and modeling medium- and heavy-duty fuel cell vehicles for SB 643 (Archuleta, 2021), and assessing non-road sectors (such as aviation, maritime, rail, and emerging technologies). (CTP Funding) Contact: Micah Wofford (Staff Presentation: 5 minutes)

B) Amendment Justification (For contract amendments only)

☐ Non Competitive Bid (Attach DGS-GSPD-09-007) https://www.dgs.ca.gov/PD/Forms

☒ Exempt Other Governmental Entity

C) List all subcontractors (major and minor) and equipment vendors: (attach additional sheets as necessary)

Legal Company Name:	**Budget**
	$ 0.00
	$ 0.00
	$ 0.00

D) List all key partners: (attach additional sheets as necessary)

Legal Company Name:

E) Budget Information (only include amendment amount information)

Funding Source	Funding Year of Appropriation	Budget List Number	Amount
ARFVTP	21/22	600.118K	$1,150,000
Funding Source			$
Funding Source			$
Funding Source			$
Funding Source			$

R&D Program Area: Select Program Area TOTAL: $1,150,000

Explanation for “Other” selection

Reimbursement Contract #:

Federal Agreement #:

F) Disabled Veteran Business Enterprise Program (DVBE)

1. ☒ Exempt (Interagency/Other Government Entity)
2. ☐ Meets DVBE Requirements DVBE Amount:$_____ DVBE %:_____
   a) ☐ Contractor is Certified DVBE
   b) ☐ Contractor is Subcontracting with a DVBE:
3. ☐ Contractor selected through CMAS or MSA with no DVBE participation
4. ☐ Requesting DVBE Exemption (attach CEC 95)

G) California Environmental Quality Act (CEQA) Compliance

1 Is Agreement considered a "Project" under CEQA?
☒ Yes (skip to question 2) ☐ No (complete the following (PRC 21065 and 14 CCR 15378)):

Explain why Agreement is not considered a "Project":

Agreement will not cause direct physical change in the environment or a reasonably foreseeable indirect physical change in the environment because .

2 If Agreement is considered a "Project" under CEQA:

c) ☒ Agreement **IS** exempt.

☐ Statutory Exemption. List PRC and/or CCR section number:

☒ Categorical Exemption. List CCR section number: Cal. Code Regs., tit 14, § 15306

☐ Common Sense Exemption. 14 CCR 15061 (b) (3) Explain reason why Agreement is exempt under the above section:

Cal. Code Regs., tit. 14, Section 15306 provides that projects which consist of basic data collection, research, experimental management, and resource evaluation activities, and which do not result in a serious or major disturbance to an environmental resource are categorically exempt from the provisions of the California Environmental Quality Act. This project involves computer modeling and paper studies. Amendment 3 expands the scope of work, but does not differ from the original contract in the types of activities to be performed.

The project is and will be performed at existing offices and labs. This work will not result in a serious or major disturbance to an environmental resource. For these reasons, the proposed project will have no significant effect on the environment and is categorically exempt under section 15306.

The project will not impact an environmental resource of hazardous or critical concern where designated, precisely mapped, and officially adopted pursuant to law by federal, state, or local agencies; does not involve any cumulative impacts of successive projects of the same type in the same place that might be considered significant; does not involve unusual circumstances that might have a significant effect on the environment; will not result in damage to scenic resources within a highway officially designated as a state scenic highway; the project site is not included on any list compiled pursuant to Government Code section 65962.5; and the project will not cause a substantial adverse change in the significance of a historical resource. Therefore, none of the exceptions to categorical exemptions listed in CEQA Guidelines section 15300.2 apply to this project, and this project will not have a significant effect on the environment.

d) ☐ Agreement **IS NOT** exempt. (consult with the legal office to determine next steps)

Check all that apply

☐ Initial Study

- ☐ Negative Declaration
- ☐ Mitigated Negative Declaration
- ☐ Environmental Impact Report
- ☐ Statement of Overriding Considerations

H) The following items should be attached to this CARF (as applicable)

1. Exhibit A, Scope of Work	☐ N/A	☒ Attached
2. Exhibit B, Budget Detail	☐ N/A	☒ Attached
3. DGS-GSPD-09-007, NCB Request	☒ N/A	☐ Attached
4. CEC 95. DVBE Exemption Request	☒ N/A	☐ Attached
5. CEQA Documentation	☒ N/A	☐ Attached
6. Novation Documentation	☒ N/A	☐ Attached
7. CEC 105, Questionnaire for Identifying Conflicts		☒ Attached

Mirl Wahlstrom — 4/19/2023
Agreement Manager **Date**

Office Manager **Date**

Melanie Vail — 04/20/2023
Deputy Director **Date**

Exhibit A – Scope of Work

TASK LIST

Task #	Task Name
1	Agreement Management
2	Medium- and Heavy-Duty Electric Vehicle Infrastructure Projections for 20~~30~~**45 and Beyond**
3	Electric Vehicle Charging Load and Flexibility Quantification, Scoping Analysis of High-Resolution Statewide Planning for Medium and Heavy-Duty Electric Vehicle-Grid Integration, and Model Harmonization Between **HEVI-LOAD** and EVI-Pro
4	Participate in Infrastructure Assessment Workshops
5	**Off-Road Vehicle and Equipment Infrastructure Projections**
6	**Hydrogen Refueling Demand and Infrastructure Assessment for On-Road FC-MHDVs**
7	**Non-Road Transportation Sector Decarbonization: Aviation, Maritime, and Rail**
8	**Emerging Modes of Electrification**
9	**Augment HEVI-LOAD Software with Off-Road, Hydrogen, and Non-Road Module**
10	**Report, Presentation, and Workshops**

ACRONYMS/GLOSSARY

Specific acronyms and terms used throughout this scope of work are defined as follows:

Acronym	Definition
BEAM	Behavior, Energy, Autonomy, and Mobility
BEV	Battery Electric Vehicle
CAM	Commission Agreement Manager
Contractor	Lawrence Berkeley National Laboratory
EDGE	**EVSE Deployment and Grid Evaluation Tool**
Energy Commission	California Energy Commission
EVI-Pro	Electric Vehicle Infrastructure Projection Tool
FCEV	**Fuel Cell Electric Vehicle**
FC-MHDV	**Fuel Cell Medium- or Heavy-Duty Vehicle**

HDV	Heavy-Duty Vehicle
HEVI-~~Pro~~**LOAD**	Medium- and Heavy-Duty Electric Vehicle Infrastructure ~~Projections~~**: Load, Operation, and Deployment**
LBNL	Lawrence Berkeley National Laboratory
LDV	**Light-Duty Vehicle**
MDV	Medium-Duty Vehicle
MHDV	**Medium- or Heavy-Duty Vehicle**
PHEV	Plug-In Hybrid Electric Vehicle (Category includes hydrogen fuel cell + battery electric PHEVs.)
TAZ	**Traffic Analysis Zone**
V2G Sim	Vehicle-to-Grid Simulator
WIRED	**Widespread Infrastructure for Ride-Hailing EV Deployment**

BACKGROUND / PROBLEM STATEMENT

The 2018 ZEV Action Plan Priorities Update tasked the California Energy Commission ~~staff have been tasked~~ with providing statewide electric vehicle infrastructure projections ~~under the 2018 ZEV Action Plan Priorities Update at page 6 to~~**:** "Use the Electric Vehicle Infrastructure Projection (EVI-Pro) … models to build on the 2025 infrastructure need projections … to further forecast the charging and fueling needs to support 5 million ZEVs by 2030. Develop innovative infrastructure deployment strategies and 2030 infrastructure need projections that spur greater private investment in the construction of infrastructure."

Additionally, Assembly Bill 2127 (Ting, Statutes of 2018, Chapter 365, Public Resources Code Section 25229)~~ and~~**,** Senate Bill 1000 (Lara, Statutes of 2018, Chapter 368, Public Resources Code Section 25231), and **Senate Bill 643 (Archuleta, Statutes of 2021, Chapter 646, Health and Safety Code Section 43871)** direct the Energy Commission to complete infrastructure assessment activities~~, which this contract will facilitate~~. **This agreement will facilitate this work.**

Further developing the Energy Commission and National Renewable Energy Laboratory-developed Electric Vehicle Infrastructure Projections (EVI-Pro) tool for 2030 will require quantifying charging infrastructure needs for medium-duty vehicles (MDVs) and heavy-duty vehicles (HDVs) operating on roads in California. Air pollution and climate change regulations are inducing electrification of these sectors and creating new demand for charging **and hydrogen fueling** infrastructure. MDV and HDV ~~charging~~ infrastructure in both private and public ~~charging applications~~ **settings** will be necessary to support reliable on-road fleet operations. **For electric MDVs and HDVs,** the required charging capabilities may exceed the capacity of existing electric utility distribution systems and require grid upgrades before deployment is possible. Projections for the

electrification of on-road MDVs and HDVs will also consider transportation and electricity system interactions with light-duty vehicles **(LDVs) and harmonization with their associated infrastructure projection models**.

GOALS AND OBJECTIVES OF THE AGREEMENT

The goal of this agreement is to perform a ~~two~~**multi**-year research effort to support the Energy Commission's work to design and implement new modeling efforts that complement the existing **infrastructure projection modeling tools:** EVI-Pro ~~tool~~**, EVI-RoadTrip, Widespread Infrastructure for Ride-Hailing EV Deployment (WIRED), and the version of Medium- and Heavy-Duty Electric Vehicle Infrastructure: Load, Operation, and Deployment (HEVI-LOAD) developed in the first phase of this agreement modeling on-road electric MDV and HDV charging infrastructure. These new modeling efforts will leverage and refine the data and methods that supported the first phase and will also expand the analysis to incorporate off-road (e.g., cargo handling equipment) and non-road (aviation, maritime, and rail) sectors, emerging modalities for charging, hydrogen infrastructure as applicable to these sectors, and a longer future projection timeframe. The efforts will** ~~to~~ assess optimal deployment of ~~MDV and HDV charging~~ infrastructure **for these zero-emission transportation sectors** in California. Work under this agreement will include **further** development of quantitative tools to assess ~~on-road medium- and heavy-duty commercial~~ mobility demands, charging **and hydrogen fueling** infrastructure, and grid impacts using data and research from Lawrence Berkeley National Laboratory (Contractor) and in coordination with other Energy Commission contractors. This Agreement will provide scenarios, datasets, inputs, and results including but not limited to:

- Public and private charging infrastructure requirements for battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) operating in on-road medium-~~duty~~ and heavy-duty applications in 20~~30~~**45 and beyond, as feasible**.
- **Public and private hydrogen refueling requirements for fuel-cell electric vehicles (FCEVs) operating in the on-road medium- and heavy-duty applications in 2045 and beyond, as feasible.**
- **Charging and hydrogen refueling infrastructure requirements to support BEVs, PHEVs, and FCEVs operating in off-road applications.**
- **Charging and hydrogen refueling infrastructure requirements to support zero-emission aviation, maritime, and rail i.e., non-road applications.**
- **Geographically-resolved** scenarios for the ~~geographic~~ adoption of medium- and heavy-duty BEVs ~~and~~**,** PHEVs**, and FCEVs.**
- Archetypical grid infrastructure upgrade requirements for various medium- and heavy-duty**, hydrogen refueling, and off-road, and non-road equipment** applications, using grid capacity analyses available from electric utilities **and the CEC's grid impact assessment via integration with the EVSE Deployment and Grid Evaluation (EDGE) tool**.

- Electricity consumption profiles, with sensitivities for unmanaged charging, smart charging, **parking flexibility, dynamic pricing,** and trip dispatch coordination across on-road vehicle classes (light-, medium-, and heavy-duty vehicles).

FORMAT/REPORTING REQUIREMENTS

Deliverables/Reports

When creating reports, the Contractor shall use and follow, unless otherwise instructed in writing by the Commission Agreement Manager (CAM), the latest version of the Consultant Reports Style Manual published on the Energy Commission's website:

http://www.energy.ca.gov/contracts/consultant_reports/index.html

Each final deliverable shall be delivered as one original, reproducible, 8 ½" by 11", camera-ready master in black ink. Illustrations and graphs shall be sized to fit an 8 ½" by 11" page and readable if printed in black and white.

Electronic File Format

The Contractor shall deliver an electronic copy (CD ROM or memory stick or as otherwise specified by the CAM) of the full text in a compatible version of Microsoft Word (.doc).

The following describes the accepted formats of electronic data and documents provided to the Energy Commission as contract deliverables and establishes the computer platforms, operating systems and software versions that will be required to review and approve all software deliverables.

- Datasets shall be in Microsoft (M.S.) Access or M.S. Excel file format.
- PC-based text documents shall be in M.S. Word file format.
- Documents intended for public distribution shall be in PDF file format, with the native file format provided as well.
- Project management documents shall be in M.S. Project file format.

TASK 1- AGREEMENT MANAGEMENT

Task 1.1 Kick-off Meeting

The goal of this task is to establish the lines of communication and procedures for implementing this Agreement.

The Contractor shall:

- Attend a "kick-off" meeting with the CAM, the Contracts Officer, and a representative of the Accounting Office. The meeting will be held via webinar or teleconference. The Contractor shall include their Project

Manager, Contracts Administrator, Accounting Officer, and others designated by the CAM in this meeting. The administrative and technical aspects of this Agreement will be discussed at the meeting.

- If necessary, prepare an updated Schedule of Deliverables based on the decisions made in the kick-off meeting.

The CAM shall:

- Arrange the meeting including scheduling the date and time.
- Provide an agenda to all potential meeting participants prior to the kick-off meeting.

Deliverables:

- Updated Schedule of Deliverables
- Kick-Off Meeting Agenda (Energy Commission)

Task 1.2 Invoices

The Contractor shall:

- Prepare invoices for all reimbursable expenses incurred performing work under this Agreement in compliance with the Exhibit B of the Terms and Conditions of the Agreement. Invoices shall be submitted with the same frequency as progress reports (Task 1.4). Invoices must be submitted to the Energy Commission's Accounting Office.

Deliverables:

- Invoices

Task 1.3 Manage Subcontractors

The goal of this task is to ensure quality products, to enforce subcontractor Agreement provisions, and in the event of failure of the subcontractor to satisfactorily perform services, recommend solution to resolve the problem.

The Contractor shall:

- Manage and coordinate subcontractor activities. The Contractor is responsible for the quality of all subcontractor work and the Energy Commission will assign all work to the Contractor. If the Contractor decides to add new subcontractors, they shall 1) comply with the Terms and Conditions of the Agreement, and 2) notify the CAM who will follow the Energy Commission's process for adding or replacing subcontractors.

Deliverables:

- Letter describing the subcontracts needed, or stating that no subcontracts are required

- Draft subcontracts
- Final subcontracts

Task 1.4 Progress Reports
The goal of this task is to periodically verify that satisfactory and continued progress is made towards achieving the objectives of this Agreement.

The Contractor shall:
- Prepare progress reports which summarize all Agreement activities conducted by the Contractor for the reporting period, including an assessment of the ability to complete the Agreement within the current budget and any anticipated cost overruns. Each progress report is due within 15 calendar days after the end of the reporting period. The CAM will provide the format for the progress reports.

Deliverables:
- Quarterly Progress Reports

Task 1.5 Final Report
The goal of this task is to prepare a comprehensive written Final Report that describes the original purpose, approach, results and conclusions of the work completed under this Agreement. The Final Report shall be prepared in language easily understood by the public or layperson with a limited technical background.

The Final Report must be completed before the termination date of the Agreement in accordance with the Schedule of Deliverables.

The Final Report shall be a public document. If the Contractor has obtained confidential status from the Energy Commission and will be preparing both a public and a confidential version of the Final Report, the Contractor shall perform the following subtasks for both the public and confidential versions of the Final Report.

Task 1.5.1 Final Report Outline

The Contractor shall:
- Prepare and submit a draft outline of the Final Report for review and approval. The CAM will provide written comments to the Contractor on the draft outline. The Contractor shall review the comments and discuss any issues with the recommended changes with the CAM.
- Prepare and submit the final outline of the Final Report, incorporating CAM comments.

Deliverables:
- Draft Outline of the Final Report

- Final Outline of the Final Report

Task 1.5.2 Final Report

The Contractor shall:

- Prepare the draft Final Report for this Agreement in accordance with the approved outline.
- Submit the draft Final Report for review and comment. The CAM will provide written comments to the Contractor. The Contractor shall review the comments and discuss any issues with the recommended changes with the CAM.
- Prepare and submit the Final Report, incorporating CAM comments.

Deliverables:

- Draft Final Report
- Final Report

Task 1.6 Final Meeting

The goal of this task is to discuss closeout of this Agreement and review the project.

The Contractor shall:

- Meet with Energy Commission staff prior to the term end date of this Agreement. The meeting **may be held remotely** ~~will be held via webinar or teleconference~~. This meeting will be attended by the Contractor Project Manager and the CAM. The CAM will determine any additional appropriate meeting participants. The administrative and technical aspects of Agreement closeout will be discussed at the meeting.
- Present findings, conclusions, and recommended next steps (if any) for the Agreement, based on the information included in the Final Report.
- Prepare a written document of meeting agreements and unresolved activities.
- Prepare a schedule for completing the closeout activities for this Agreement, based on determinations made within the meeting.

Deliverables:

- Written documentation of meeting agreements
- Schedule for completing closeout activities

TECHNICAL TASKS

Task 2 – Medium- and Heavy-Duty Electric Vehicle Infrastructure Projections for 203045 and Beyond

The goal of this task is to develop a modeling tool to quantify charging infrastructure requirements for MDVs and HDVs operating on California roads ~~in 2030~~ **through 2045 and beyond, as feasible**. This task will inform the analysis and comparative efforts in Task 3.

The Contractor Shall:

- Work with the CAM to develop charging infrastructure modeling objective functions and to identify vehicle deployment trajectories and geographic adoption scenarios.
- Work with the CAM to assess literature and identify necessary data resources for analysis, including those from the Energy Commission's Transportation Energy Demand Forecast, and external data sources on MDV and HDV operational requirements and BEV and PHEV technology attributes from the California Air Resources Board and other sources.
- Leverage best practice charging infrastructure modeling techniques, including but not limited to the Contractor's Behavior, Energy, Autonomy, and Mobility (BEAM) Model, Contractor's Vehicle-to-Grid Simulator (V2G Sim) and the Energy Commission and National Renewable Energy Laboratory's Electric Vehicle Infrastructure Projections (EVI-Pro) tool to enable flexible scenario analysis for Medium- and Heavy-duty Electric Vehicle Infrastructure**: Load, Operations, and Deployment (HEVI-LOAD)** ~~Projections (HEVI-Pro)~~.
- Develop the HEVI-~~Pro~~**LOAD** tool.
- Quantify charging infrastructure requirements and uncertainties for California's on-road MDVs and HDVs ~~in 2030~~ **through 2045, and beyond, as feasible according to the input data sources**.

Deliverables:

- Draft of the HEVI-~~Pro~~**LOAD** modeling framework for consideration at the Infrastructure Assessment Workshops and revisions incorporating feedback
- Summary report documenting data sources, development of assumptions and scenarios, the model, and results quantifying charging infrastructure requirements by ~~2030~~ **2045 and beyond, as feasible**.
- Modeling tool (HEVI-~~Pro~~**LOAD**)**, including related documentation**

Task 3 – Electric Vehicle Charging Load and Flexibility Quantification, Scoping Analysis of High-Resolution Statewide Planning for Medium and Heavy-Duty Electric Vehicle-Grid Integration, and Model Harmonization Between ~~BEAM~~ HEVI-LOAD and EVI-Pro

The goal of this task is to conduct a thorough assessment of the data and modeling gaps in conducting a comprehensive statewide analysis of the grid infrastructure capacity requirements associated with MDV and HDV BEVs and PHEVs, in order to identify archetypical designs for assessing make-ready electrical equipment needed to support electrification of MDV and HDV applications. This task will also assess the needs for analyzing load flexibility from MDV and HDV electrification as it extends to smart charging and the coordination of on-road vehicle dispatch. This task will leverage the results of Task 2.

The Contractor shall:

- Model and analyze use patterns for MDVs and HDVs to create a baseline load profile for BEVs and PHEVs by geographic area (e.g. county, utility, ~~and/or~~ forecast zone**, and/or traffic analysis zone (TAZ)**).
- Quantify possible load flexibility from managing charging with smart controls, while maintaining MDV and HDV operational requirements.
- In coordination with the CAM and Energy Commission contractors at the University of California at Davis, identify scenarios for automated vehicle growth in light-duty vehicles and potential implications for MDVs and HDVs.
- In coordination with the CAM and Energy Commission contractors at the National Renewable Energy Laboratory, identify scenarios for smart charging of light-duty vehicles and potential implications for MDVs and HDVs.
- In coordination with the CAM and Energy Commission contractors at the National Renewable Energy Laboratory, identify opportunities for model harmonization and linkages between EVI-Pro and ~~BEAM~~ **HEVI-LOAD**. Use findings from this work in quantifying smart charging of light-duty vehicles and the potential applicability for MDVs and HDVs.
- Create load profiles resolved by geographic area, using the HEVI-~~Pro~~**LOAD** tool.
- Working with the CAM, conduct a scoping analysis to assess data availability to integrate electric distribution grid information with HEVI-~~Pro~~**LOAD**, including the investor-owned utilities' Integration Capacity Analysis **and Grid Needs Assessment** Maps, parcel information, and other data to analyze the adequacy of distribution systems to support MDV and HDV electrification **and assist in integration of this work with the EDGE tool**. Obtain data from utilities.

- Include in the scoping analysis an estimate of the modeling and analytical development necessary to quantify the potential for coordinating trip and charging schedules of MDVs and HDVs with other on-road vehicles. Include example use cases and first order bounding estimates of the opportunity to enhance load flexibility via fleet coordination.
- Develop a proof-of-concept analytical framework for identifying and quantifying the types and components of make-ready electrical equipment for MDV and HDV applications with high potential for electrification by 2030. Leverage data from external sources, including the Energy Commission, the California Public Utilities Commission, other contractors, or other organizations to inform this framework.

Deliverables:

- Draft of the analyses for smart charging, automated vehicles, utility distribution system data integration, on-road vehicle dispatch coordination scenarios, and make-ready electrical equipment framework for consideration at the Infrastructure Assessment Workshops and revisions incorporating feedback.
- Draft ~~final~~ **first interim** report on ~~2030~~ **the expanded** HEVI-~~Pro~~**LOAD assessment that covers detailed analyses of on-road electric MHDVs** including ~~analyses for~~ smart charging, automated vehicles, utility distribution system data integration, grid impact studies, on-road vehicle dispatch coordination scenarios, and make-ready electrical equipment framework.
- Final **first interim** report on ~~2030~~ **the expanded** HEVI-~~Pro~~**LOAD assessment that covers detailed analyses of on-road electric MHDVs** including ~~analyses for~~ smart charging, automated vehicles, utility distribution system data integration, grid impact studies, on-road vehicle dispatch coordination scenarios, and make-ready electrical equipment framework.

Task 4 – Participate in Infrastructure Assessment Workshops

The goals of this task are to assist in identifying participants and developing schedules and agendas for at least two Energy Commission-led workshops, as well as to participate in the workshops and modify HEVI-~~Pro~~**LOAD** development based on feedback received from them. The workshops will provide a venue for discussion and collaboration among the Contractor, Energy Commission staff, Energy Commission contractors National Renewable Energy Laboratory and the University of California, Davis, invited professionals with expertise in infrastructure analysis, and public stakeholders. The workshops will collect expert guidance on the Contractor's progress and the Contractor's coordination with other projects.

The Contractor shall:

- Prepare for CAM's consideration a *List of Workshop Invited Participants* that includes the names, companies, physical and electronic addresses, and phone numbers of potential participants. The list will be discussed at the kick-off meeting.
    - Invitees to the workshops may include qualified professionals spanning the following types of disciplines:
        - Researchers knowledgeable about the project subject matter
        - Members of trades that will apply the results of the assessment (e.g., designers, engineers, architects, contractors, and trade representatives)
        - Public interest market transformation implementers
        - Product developers relevant to the assessment
        - US Department of Energy research managers, or experts from other federal or state agencies relevant to the assessment
        - Public interest environmental groups
        - Utility representatives
        - Air district staff
        - Members of relevant technical society committees
- Provide input to the CAM to assist with preparation of a workshop schedule, which will be based in part on Contractor's progress on this Contract. This includes:
    - Discuss the workshop schedule with the CAM at the kick-off meeting. Contractor's progress on this Agreement will inform schedule of workshops.
- Provide input to the CAM for preparation of agendas for each workshop. The agendas will include presentations, facilitated discussion with Workshop Invited Participants on modeling and assumptions, and opportunities for comments from public stakeholders.
- Prepare *Workshop Presentations and Back-up Materials* for each workshop. Present progress on the development of the HEVI-~~Pro~~**LOAD** modeling framework in Task 2 and the scoping and scenario analyses in Task 3. Coordinate materials with the Energy Commission's electric vehicle infrastructure analysis contractors at the National Renewable Energy Laboratory and University of California at Davis.
- Participate in at least two Energy-Commission led, in-person workshops.
- Receive, summarize, and incorporate Workshop Invited Participants' and public stakeholders' feedback on assumptions and modeling into analyses and draft reports**.**

- Contractor's participation in the workshops will allow for a review of issues that have the potential to influence and interact with Contractor's infrastructure assessment at the state and federal levels, regional and municipal jurisdictions, and electric utility service territories. After each workshop, the Contractor shall consider and discuss with the CAM information gathered during workshops for potential incorporation into technical task deliverables.

Deliverables:

- List of Workshop Invited Participants
- Workshop Presentations and Back-up Materials

Task 5 - Off-Road Vehicle and Equipment Infrastructure Projections

The goal of this task is to conduct a thorough assessment of the charging and fueling infrastructure needs for future off-road electric and hydrogen vehicle and equipment applications in California, leveraging the most up-to-date inventory and duty cycle datasets as well as the simulation framework developed in HEVI-LOAD. This task will also model the charging load profiles of the off-road electric vehicles and equipment and project the aggregated charging loads for strategic locations, California's counties, and the entire state.

The Contractor shall:

- **Collect inventory data, including surveys of off-road vehicle and equipment types, location information, and growth potential based on existing reports[1,2], equipment catalogs[3], and emission inventory models, e.g., CARB OFFROAD 2021[4].**
- **Identify off-road vehicle/equipment types for which inventory and duty cycle data have not been collected, or where data gaps exist. Survey additional data that represent emerging applications and critical electrification potential, such as construction equipment, agriculture vehicles, airport ground support equipment, port cargo handling equipment, etc.**
- **In coordination with the CAM and other Energy Commission contractors, collect duty cycle and energy usage datasets from multiple sources, including but not limited to organizations in California that have been collecting off-road duty cycles, such as UC Riverside and CARB. The vehicle instrument data will contain 1) GPS location data and the derived**

[1] https://steps.ucdavis.edu/files/01-07-2016-Miller_Electrification-of-Off-Road-Vehicles.pdf
[2] C. McCaffery et al., "Evaluation of small off-road diesel engine emissions and aftertreatment systems," Energy, vol. 251, p. 123903, Jul. 2022, doi: 10.1016/j.energy.2022.123903.
[3] https://californiacore.org/equipmentcatalog/
[4] https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/msei-road-documentation-0

second-by-second vehicle speed profiles and 2) energy usage information based on the ECU (Engine Control Unit) measurements. Explore the existing datasets that can be procured from commercial data vendors.

- **In coordination with the CAM and other Energy Commission contractors, reach out to organizations that operate and manage off-road vehicles/equipment, such as airports, construction equipment operators, and ports, and explore the existing datasets and the opportunity to collect additional data by installing GPS loggers and ECU loggers on vehicles/equipment.**
- **In coordination with the CAM and other state agencies, develop adoption scenarios and electrification pathways for the off-road vehicles/equipment leveraging the updated survey data:**
    - **Determine the electric, hybrid electric, and hydrogen fuel cell powertrain adoption rate for a variety of off-road vehicles/equipment in order to achieve state emission reduction goals.**
- **Conduct off-road vehicle infrastructure assessment, charging load quantification, and grid impacts analysis:**
    - **Build statistical models based on the collected vehicle instrument data to describe the duty-cycle patterns of off-road vehicles/equipment.**
    - **Combine empirical models for off-road applications without real-world datasets and the real-world, data-driven duty-cycle models as the inputs into the HEVI-LOAD simulation.**
    - **Conduct HEVI-LOAD top-down and bottom-up simulations to:**
        - **Determine the appropriate infrastructure attributes, such as power levels (Level 1, Level 2, direct current fast charge, hydrogen refueling flow rate, etc.), and portability (mobile or stationary), for various off-road applications.**
        - **Analyze the battery charging / hydrogen refueling demand.**
        - **Develop assumptions on the duty-cycle patterns of the selected off-road electric vehicles/equipment and simulate the battery charging / hydrogen refueling behaviors, including off-grid charging solutions.**
        - **Quantify the infrastructure needs at strategic locations and aggregate the needs at the county and state levels, using the developed adoption scenarios as inputs.**
    - **Quantify the electric charging load by off-road vehicles/equipment for strategic locations (site-level) and temporary project sites and aggregate the load profiles to county and state levels.**

- **Investigate the synergy (infrastructure needs and sharing) between the off-road vehicles/equipment and other sectors, such as LD/MD/HD electric vehicles.**
- **In coordination with the CAM and other Energy Commission contractors, analyze the impacts of off-road vehicle charging demand on the electricity distribution system via integration with the EDGE tool:**
  - **Verify whether the circuit hosting capacities at strategic locations suffice to support the emerging off-road charging loads at different times of the day in those locations and verify if there are violations with respect to grid reliability such as overloading, voltage drop, power quality degradation, etc. Summarize the statistics of the circuit capacity analysis at the TAZ, county, and state levels.**
  - **Determine the grid infrastructure upgrade needs in coordination with the integrated circuit load analysis and incorporate with the EDGE tool. Consider the grid impacts of hydrogen production if it uses electricity from the grid or on-site distributed energy resources.**
  - **Quantify the impact on energy and demand charge costs after integrating the off-road vehicle charging load, and explore operational strategies, such as managed/smart charging solutions, to mitigate the associated cost impacts while maintaining the business-as-usual duty cycles.**

Deliverables:

- **Updated off-road vehicle/equipment inventory dataset**
- **Off-road vehicle/equipment instrument dataset**
- **Draft analysis report of the zero-emission off-road vehicle/equipment inventory, duty cycle, and adoption scenarios for 2030, 2040, 2050**
- **Final analysis report of the zero-emission off-road vehicle/equipment inventory, duty cycle, and adoption scenarios for 2030, 2040, 2050**
- **Draft analysis report of the zero-emission off-road vehicle/equipment charging infrastructure projection, load profiles, and grid impacts**
- **Final analysis report of the zero-emission off-road vehicle/equipment charging infrastructure projection, load profiles, and grid impacts**

Task 6 - Hydrogen Refueling Demand and Infrastructure Assessment for On-Road FC-MHDVs

The goal of this task is to conduct a thorough assessment of the hydrogen refueling infrastructure needs by the future on-road fuel cell medium- and heavy-

duty vehicles (FC-MHDVs), based on the most up-to-date survey of the FC-MHDV technologies, adoption scenarios through 2050, and existing hydrogen refueling networks. Leveraging HEVI-LOAD simulations, this task will determine the optimal locations for hydrogen refueling infrastructure and quantify the refueling demand over the identified locations and the road segments. Analysis of the hydrogen production, supply, and potential grid impacts will also be conducted in this task.

The Contractor shall:

- **In coordination with the CAM and other Energy Commission contractors, survey and analyze existing fuel cell technologies, powertrain component parameters, vehicle attributes such as weight, number of axles, speed limit, and driving range, etc., and market diffusions by FC-MHDV manufacturers.**
- **Develop assumptions of vehicle, powertrains, and refueling infrastructure parameters for FC-MHDVs**
- **Develop adoption scenarios of FC-MHDVs from 2022 to 2050, considering the aforementioned survey and assumptions of FC-MHDVs, California emission reduction goals, and the existing adoption scenarios by other state agencies, such as the split ratios between battery electric and fuel cell MHDVs in the CARB's State SIP Strategy (SSS), CARB's Advanced Clean Trucks (ACT)/Advanced Clean Fleets (ACF), Energy Commission's Additional Achievable Transportation Electrification (AATE3) scenarios, etc.**
- **In coordination with the CAM, Energy Commission's contractors and other state agency work[5,6,7,8] (mostly for FC-LDVs), survey the locations of the existing hydrogen refueling infrastructure in California, hydrogen transportation methods (gaseous pipelines or liquid tankers), refueling capacity (flow rate and numbers of plugs) and feasibility for FC-MHDVs.**
- **Identify candidate locations for the hydrogen refueling infrastructure for MHDVs using multiple datasets, including Jason's Law database, California Statewide Truck Parking Study, land use data, etc.**
- **Build an FC-MHDV trip database in California through 2050 based on the adoption scenarios and California Statewide Freight Forecast Model (CSFFM) as the inputs to the HEVI-LOAD simulation.**
- **Simulate the FC-MHDVs' refueling behaviors using the HEVI-LOAD bottom-up approaches and quantify the temporal-spatial refueling demand over 1) the identified locations and 2) road segments of the transportation networks.**

[5] https://its.ucdavis.edu/wp-content/uploads/hydrogen-study-working-paper-spring-report-18may2022.pdf
[6] https://www.icf.com/insights/energy/hydrogen-power-zero-carbon-future
[7] https://ww2.arb.ca.gov/sites/default/files/2021-09/2021_AB-8_FINAL.pdf
[8] https://ww2.arb.ca.gov/resources/documents/california-hydrogen-infrastructure-tool-chit

- **Conduct hydrogen refueling infrastructure assessment for FC-MHDVs:**
    - **Determine the optimal location(s) for infrastructure deployment (siting) and refueling capacity (sizing) of each refueling station, considering the simulated refueling demand, capital investment, maintenance cost, and other metrics provided by the CAM and other collaborators.**
    - **Determine the hydrogen supply options (centralized production with hydrogen transportation, onsite hydrogen generation, or hybrid modes) for the refueling infrastructure plans, and compare the economic benefits of each plan.**
    - **Assess the grid impacts for the onsite hydrogen production using electricity from the grid and co-located distributed energy resources.**

Deliverables:

- **Draft report of the existing and projected FC-MHDV technologies, vehicle attributes, and powertrain parameters**
- **Final report of the existing and projected FC-MHDV technologies, vehicle attributes, and powertrain parameters**
- **Draft report of FC-MHDV adoption scenarios and refueling infrastructure assessment**
- **Final report of FC-MHDV adoption scenarios and refueling infrastructure assessment**

Task 7 –Non-Road Transportation Sector Decarbonization: Aviation, Maritime, and Rail

The goal of this task is to investigate the decarbonization pathways for the non-road transportation sectors, aviation, maritime, and rail, and assess the infrastructure needs for these sectors based on the adoption scenarios of battery electric and hydrogen fuel cell technologies. This task will also analyze the feasibility of the battery charging/hydrogen refueling technologies for various non-road applications and provide an assessment to be combined with those for LD/MD/HD sectors, off-road sectors per Task 5, and hydrogen production load per Task 6 for a more comprehensive grid impact study.

The Contractor shall:

- **Survey the non-road sector vehicle category and inventory data in California, including aviation, rail, and maritime applications:**
    - **In coordination with the CAM and other state agencies, summarize the maritime vessel inventory, such as Class A, I, II, and III for small boats, large cargo vessels and passenger ferries, port tuggers, etc. Build and project the vessel trip demand through 2050 based on multiple data sources, including but not limited to the Freight**

Analysis Framework[9] (FAF), CARB's Ocean-Going Vessels (OGV) Emissions Inventories[10], Automatic Identification System (AIS) vessel traffic data[11], etc.

- **In coordination with the CAM and other state agencies, survey the cargo and passenger transportation demand by rail in California[12] and project the trend through 2050.**
- **In coordination with the CAM and other state agencies, survey the aircraft category, class rating, and inventory data with origin/destination at airports in California, such as flight data from airports[13] and county-level aircraft registration data from Federal Aviation Administration (FAA)[14]. Project the cargo and passenger travel demand by air through 2050.**

- **Develop zero-emission non-road electric vehicle adoption scenarios with battery electric and hydrogen combustion or fuel cell vehicles through 2050.**
- **Develop an infrastructure assessment for non-road applications that**
  - **Analyzes the duty cycles and energy usage patterns of the selected non-road applications and conduct the feasibility study of the battery and hydrogen combustion or fuel cell as the power sources, considering the technology maturity, cost, any payload loss, etc.**
  - **Extends the HEVI-LOAD simulation for non-road sectors using the developed adoption scenarios and calibrated duty cycle/energy usage patterns as inputs.**
  - **Quantifies the infrastructure needs by different non-road applications for the TAZ, county, and state levels as well as the strategic locations, such as airports, ports, railway stations, and intermodal centers, and considers off-grid solutions.**
  - **Studies the synergy between non-road vehicle infrastructure and the planned infrastructure for other sectors, such as LD/MD/HD vehicles.**
  - **Assesses the grid impacts at statewide, county, TAZ, and circuit level (for strategic locations), building off the approaches developed in Task 5 that**
    - **Consider off-grid solutions.**
    - **Verify circuit hosting capacities at strategic locations.**

[9] https://faf.ornl.gov/faf5/
[10] http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2022-air-quality-management-plan/combined-presentations-2022-aqmd-MS-group-for-ogv-08-24-21.pdf?sfvrsn=27
[11] https://marinecadastre.gov/ais/
[12] https://dot.ca.gov/programs/rail-and-mass-transportation
[13] https://openflights.org/data.html
[14] https://registry.faa.gov/aircraftinquiry/Search/StateCountyInquiry

- **Determine grid infrastructure upgrades needed to support the emerging load.**
- **Quantify the impact on energy and demand charge.**

Deliverables:

- **Draft report of vehicle category, inventory, duty cycles, and energy demand for aviation, maritime, and rail sectors**
- **Final report of vehicle category, inventory, duty cycles, and energy demand for aviation, maritime, and rail sectors**
- **Draft report of the trip demand projection and zero-emission adoption scenarios for aviation, maritime, and rail sectors**
- **Final report of the trip demand projection and zero-emission adoption scenarios for aviation, maritime, and rail sectors**
- **Draft report of zero-emission vehicle battery charging/hydrogen refueling infrastructure assessment and grid impact study for aviation, maritime, and rail sectors**
- **Final report of zero-emission vehicle battery charging/hydrogen refueling infrastructure assessment and grid impact study for aviation, maritime, and rail sectors**

Task 8 Emerging Modes of Electrification

The goal of this task is to investigate the emerging transportation electrification modes including battery swapping technology, dynamic wireless and bi-directional charging technologies, electric bikes and scooters, and shared and autonomous transportation of cargo and passengers. This task will also assess the impacts of such technologies on mobility, infrastructure needs and operational cost.

The Contractor shall:

- **Develop a battery swapping technology assessment that**
  - **Surveys and models battery-swapping logistics in the context of supply and demand at different locations and times of day, technology standards/interoperability, grid benefits in terms of battery charging load profiles, flexibility, renewable energy integration, and the options to provide grid services, and potential locations for battery swapping station deployment.**
  - **Models and simulates battery swapping logistics for selected MHDV applications using the HEVI-LOAD bottom-up simulations.**
  - **Quantifies the benefits or barriers of battery swapping technology including charging time saved, upfront investment and daily operational cost, and grid impacts,**

    - **Generates battery pack charging load profiles and analyzes associated grid impacts.**
- **Assess in-motion wireless and bi-directional charging solutions by**
    - **Surveying and modeling the wireless charging technologies, such as power transfer level, standards, efficiency and power factors, etc. and considering both stationary wireless charging stations (fleet depot, en-route, etc.) and in-motion wireless charging solution wherein the coils are buried underneath the roads/site surfaces (such as port cargo handling areas).**
    - **Modeling and simulating stationary and in-motion wireless charging solutions for selected MHDV applications using the HEVI-LOAD bottom-up simulations.**
    - **Quantifying the benefits and barriers compared with battery swapping and conductive chargers (Level 1, Level 2, direct current fast charge, and others).**
- **Develop an electric bike and scooter assessment that**
    - **Determines adoption scenarios for e-bikes and e-scooters in California leveraging existing studies and statistics from LBNL and the research community.**
    - **Studies the charging infrastructure needs and load profiles of e-bikes and e-scooters considering the infrastructure sharing potential with existing charging infrastructure for LD/MD/HD applications.**
- **Assess infrastructure needs, including consideration of wireless and other emerging modes of charging, for shared and autonomous electric vehicles for the transportation of cargo and passengers by**
    - **Considering shared, autonomous electric vehicles within future electrification scenarios, leveraging the ongoing Grid-Electrified Mobility (GEM) work at LBNL.**
    - **Integrating HEVI-LOAD and GEM[15] models to quantify the difference in peak load, operational cost, and infrastructure needs after considering shared autonomous operations.**

Deliverables:

- **Draft analysis report of the emerging transportation electrification technologies**
- **Final analysis report of the emerging transportation electrification technologies**
- **Draft assessment report on the benefits and barriers of the transportation electrification technologies**

- **Final assessment report on the benefits and barriers of the transportation electrification technologies**

Task 9 - Augment HEVI-LOAD Software with Off-Road, Hydrogen, and Non-Road Modules

The goal of this task is to develop the required functional modules and professionally-written codebases for the off-road sector, hydrogen refueling infrastructure, and non-road sectors, and integrate these new modules with the existing HEVI-LOAD software and standardize the software configurations. In addition, this task will develop a web-based user interface with visualization techniques to allow the CAM and Energy Commission staff to remotely edit and upload scenarios, execute HEVI-LOAD simulation, and export and visualize the simulation results.

The Contractor shall:

- **Develop functional modules for the off-road, hydrogen, non-road, and emerging modes professionally written in the Python and C++ coding languages.**
- **Integrate the new HEVI-LOAD modules with the existing codebase and standardize the software development including but not limited to software configuration, scenario template, external datasets, and interface (input/output) normalization.**
- **Develop a web-based interface to allow remote scenario editing and uploading, execution of HEVI-LOAD simulation, and capabilities to export and visualize the simulation results, and possibly other functions in coordination with the CAM.**
- **Conduct software packaging, testing, versioning, release, and maintenance.**

Deliverables:

- **Updated HEVI-LOAD codebase to include modules of the off-road, hydrogen, non-road sectors, and emerging modes.**
- **A web-based user interface with remote log-in, scenario editing/uploading, simulation, and result visualization capabilities.**

Task 10 - Report, Presentation, and Workshops

The goal of this task is to provide support from the LBNL team to the CAM and other Energy Commission staff with respect to report development, presentations, and workshop participation in addition to those listed in Task 4. This task will also include drafting a second interim report expanding upon the modeling activities covered in the first interim report as described in Task 3.

The Contractor shall:

- **Create a draft second interim report on the expanded HEVI-LOAD assessment that covers detailed analyses for infrastructure needs for off-road electric MHDVs, FC-MHDVs, non-road vehicles, and considers off-grid solutions and emerging technologies including smart charging, automated vehicles, utility distribution system data integration, grid impact studies, vehicle dispatch coordination scenarios, and make-ready electrical equipment framework.**
- **Create a final version of the second interim report described above.**
- **Prepare quarterly, yearly, and final reports for AB 2127 and SB 643 assessments.**
- **Respond to Energy Commission staff requests to prepare data, analytical results, and visualizations related to HEVI-LOAD project.**
- **Prepare presentations for periodical LBNL/Energy Commission project meetings in addition to the workshops listed in Task 4.**
- **Participate in other workshops organized by Energy Commission or other agencies and present the modeling approach, data analytics, and research findings.**

Deliverables:

- **Additional quarterly, yearly, and final reports for AB 2127 and SB 643 assessments**
- **Draft second interim report**
- **Final second interim report**
- **Data analytics and visualization results provided to the CAM and Energy Commission staff upon request**