STATE OF CALIFORNIA

CONTRACT AMENDMENT REQUEST FORM (CARF)

CEC-276 (Revised 02/13) CALIFORNIA ENERGY COMMISSION

Original Agreement #	500-10-053	Amendment #	1

Division	Agreement Manager:	MS-	Phone
ERDD	Pilar Magana	43	916-327-2216

Contractor's Legal Name	Federal ID Number
DOE- National Renewable Energy Laboratory	44-0545878

Revisions: (check all that apply)

☒ Term Extension	New End Date: 3/30/2015	Include revised schedule and complete items A, B, C, D, & H below.
☐ Budget Augmentation	Amendment Amount: $ 0	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 Contractor/Recipient		Include novation documentation and complete items A, C, 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:

☐ Operational agreement (see CAM Manual for list) to be approved by Executive Director

☐ ARFVTP agreements under $75K delegated to Executive Director.

Proposed Business Meeting Date	6/18/2014	☐ Consent	☒ Discussion
Business Meeting Presenter	Pilar Magana	Time Needed:	5 minutes

Please select one list serve. Research (Energy RDD/PIER Program)

Agenda Item Subject and Description

NATIONAL RENEWABLE ENERGY LABORATORY. Proposed resolution approving Amendment 1 to contract 500-10-053 with the U.S. Department of Energy's National Renewable Energy Laboratory to extend the term date by nine months to 3/30/15, revise the scope of work and reallocate the budget to account for additional research being conducted, vehicle application modifications, and subcontractor partner changes. (PIER natural gas funding) Contact: Pilar Magana. (5 minutes)

B) Amendment Justification (For contract amendments only)

☐ Non Competitive Bid *(Attach CEC 96)*

☒ Exempt Other Governmental Entity

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

Legal Company Name:	Budget	SB	MB	DVBE
Cummins Westport, Inc.	$ 1,202,048	☐	☐	☐
Southwest Research Institute	$ 2,427,553	☐	☐	☐

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

Legal Company Name:

E) Budget Information

Funding Source	Funding Year of Appropriation	Budget List No.	Amount
			$
R&D Program Area:	EGRO: Transportation	TOTAL:	$
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 %: _____
   - ☐ Contractor is Certified DVBE
   - ☐ 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:
   ☒ a) Agreement **IS** exempt. (Attach draft NOE)
   - ☐ Statutory Exemption. List PRC and/or CCR section number: _____
   - ☐ Categorical Exemption. List CCR section number: _____
   - ☒ Common Sense Exemption. 14 CCR 15061 (b) (3)

   Explain reason why Agreement is exempt under the above section:
   The activity is covered by the general rule that CEQA applies only to projects which have the potential for causing a significant effect on the environment. Where it can be seen with certainty that there is no possibility that the activity in question may have a significant effect on the environment, the activity is not subject to CEQA.

   ☐ b) 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 CRF (as applicable)

1. Exhibit A, Scope of Work	☐ N/A	☒ Attached
2. Exhibit B, Budget Detail	☐ N/A	☒ Attached
3. CEC 96, 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

Agreement Manager	Date	Office Manager	Date	Deputy Director	Date

Department of Energy

Funds-In Agreement for Research and Development
FIA-11-1762

Appendix A—California Energy Commission

Exhibit A - Statement of Work
Exhibit B - Task Deliverables, Schedule,
Exhibit C - Budget
Exhibit D - List of Contacts And Addresses
Exhibit E - Confidential Deliverables and Intellectual Property Lists

I. Title of project

Natural Gas Engine and Vehicle Integration Research

II. Energy Commission RFP identification

N/A

III. Background

The U.S. Department of Energy (DOE) has directed the Alliance for Sustainable Energy, LLC to perform the work stated in this Appendix A for the Energy Commission. The National Renewable Energy Laboratory (NREL), a laboratory owned by DOE, is located at 15013 Denver West Parkway, Golden, CO 80401. The Alliance for Sustainable Energy, a not-for-profit corporation organized under the laws of the State of Delaware, with its principal place of business at 15013 Denver West Parkway, Golden CO 80401, manages and operates NREL under DOE Contract No. DE-AC36-08GO28308.

The State Energy Resources Conservation and Development Commission (Energy Commission) is an agency organized under the laws of the State of California with a principal place of business at 1516 Ninth Street, Sacramento, California 95814.

IV. Project Goals and Objectives

Problem Statement

DOE, through NREL, has been funding research, development and demonstration (RD&D) projects to facilitate the deployment of alternative fuels into the marketplace in order to achieve three objectives: 1) enhance the reduction of mobile source emissions in California and the United States; 2) increase U.S. competitiveness and economic prosperity; and 3) preserve the environment through the reduction of emissions and toxins from the motor vehicle population. Transportation is the largest contributor to greenhouse gas (GHG) emissions in California, accounting for 39% of the total emissions in the state.

In addition to having significant emissions challenges, California is also the third largest consumer of transportation fuels in the world. The State Alternative Fuels Plan identifies certain alternative fuels, including natural gas, which can substantially reduce GHG emissions while reducing petroleum dependence.

The Natural Gas Vehicle Technology Forum and DOE's Clean Cities Program have identified a lack of heavy-duty engine sizes as a significant barrier to increased natural gas vehicle penetration in the marketplace. The purpose of this research is to increase the use of natural gas as a transportation fuel by developing advanced natural gas engine and vehicle technologies to address regulatory and economic barriers.

DOE, through NREL, released a competitive solicitation for the development and demonstration of advanced natural gas engines and vehicles. To make awards to as many qualified recipients as possible, DOE leveraged their funding with that of the Energy Commission and the South Coast Air Quality Management District. The collaboration between the agencies will further accelerate this technology into the marketplace. NREL, acting as program integrator for the agencies, will perform project management, budget tracking, and outreach activities for the research activities.

V. Technical and economic/cost performance objectives

A. The overall technical goal of this project is to develop new medium- to heavy-duty natural gas engines, with vehicle integration and on-road demonstration, targeting commercialization within 5 years.

The specific, technical objectives upon which this project's success will be evaluated are:

- Develop a new natural gas fueled medium- or heavy-duty engine that meets or exceeds 2010 emissions requirements.
- Develop a natural gas fueled engine that has no greater than 20% fuel economy penalty compared to a comparable conventionally-fueled diesel engine.
- Integrate the engine into a suitable chassis for a complete vehicle package.
- Demonstrate the integrated engine and chassis in real-world operation for 6-12 months.

B. The overall economic/cost goal of this project is to commercialize new natural gas fueled engines to provide additional options for alternative fueled vehicles.

The specific, economic/cost objectives upon which the project's success will be evaluated are:

- Advancement of advanced alternative fueled transportation engines and vehicles to reduce GHG emissions and displace imported petroleum.

VI. Preliminary Activities

1.1 Attend Kick Off Meeting

The Facility Operator's Project Manager (Principal Investigator) shall attend a "kick off" meeting with the Commission Contract Manager to review the Energy Commission's expectations for: accomplishing tasks described in the work statement; administrative requirements in the terms and conditions of the contract (e.g., invoicing, statements vesting title, prior approvals, data disclosure limitations, monthly progress reporting format and content, etc.); and the Energy Commission's roles and responsibilities. The location of this meeting shall be designated by the Commission Contract Manager.

1.2 Describe Synergistic Projects

There are no synergistic projects.

1.3 Identify Required Permits

No permits are required for this project.

1.4 Obtain Required Permits

Not applicable.

1.5 Prepare Production Readiness Plan

(Note: This activity does not apply to projects which do not involve the design, development, or demonstration of energy-related technology.)

Prepare a written production readiness plan that includes:

- Identification of critical production processes, equipment, facilities, manpower, and support systems that will be needed to produce a commercially viable product;
- Capacity constraints imposed by the design under consideration for internal manufacturing capabilities, as well as suppliers. The project manufacturing effort may include "proof of production processes;"
- Identification of hazardous or non-recyclable materials;
- A projected "should cost" for the product in production at some expected rate;

- The expected investment threshold required to launch the commercial product;

- An implementation plan to ramp up to full production.

(Note: The degree of detail in the production readiness discussion should be proportional to the complexity of producing the proposed product and its state of development.)

(Note: The Production Readiness Plan shall be reviewed by the Commission Contract Manager. If the Commission Contract Manager determines that the plan is unsatisfactory, Facility Operator shall revise it until it meets the Commission Contract Manager's reasonable requirements.)

VII. Description of tasks to be performed

TECHNICAL TASKS

GLOSSARY

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

BSFC	Brake specific fuel consumption
CAD	Computer aided design
CARB	California Air Resources Board
CNG	Compressed natural gas
CO	Carbon monoxide
CO_2	Carbon dioxide
CPR	Critical Project Review
DOE	U.S. Department of Energy
DVP&R	Design Verification Plan and Report
ECU	Engine control unit
EGR	Exhaust gas recirculation
EMI	Electromagnetic Interference
Energy Commission	California Energy Commission
FTP	Federal Test Procedure
GHG	Greenhouse gas

NG	Natural gas
NH_3	Ammonia
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
NREL	National Renewable Energy Laboratory
OBD	On-Board Diagnostics
OEM	Original Equipment Manufacturer
PIER	Public Interest Energy Research
PTO	Power take-off
RD&D	Research, Development & Demonstration
TWC	Three-way catalyst
U.S. EPA	United States Environmental Protection Agency

SCOPE OF WORK

This Agreement includes a set of administrative tasks and a set of technical tasks. The remainder of this work statement defines these technical tasks. Task descriptions include goals, Contractor activities, and deliverables. The deliverables, such as test plans, technical reports and other interim deliverables, for each task are defined to the extent possible, but are subject to change based on recommendations from the Project Manager and the approval of the Commission Contract Manager. The Contractor shall submit a draft of each deliverable, unless described differently in the technical tasks, to the Commission Contract Manager for review and comment in accordance with the approved Schedule of Deliverables. Deliverables not requiring a draft version are indicated by marking "(no draft)" after the deliverable name.

The Commission Contract Manager will provide written comments back to the Contractor on the draft deliverable within 10 working days of receipt. Once agreement has been reached on the draft, the Contractor shall submit the final deliverable to the Commission Contract Manager. The Commission Contract Manager shall provide written approval of the final deliverable within 5 working days of receipt. Key elements from this deliverable shall be included in the Final Report for this project.

When creating technical deliverables, the Facility Operator shall use and follow, unless otherwise instructed in writing by the Commission Contract Manager, the latest version of the PIER Style Manual published on the Energy Commission's web site:

http://www.energy.ca.gov/contracts/pier/contractors/index.html

Technical Task List

Task 2.1	**Engine Development**
Task 2.1.1	11L Stoichiometric CNG Engine for **Transit Bus** ~~Refuse~~ Industry
~~Task 2.1.2~~	~~13L CNG Re-power/Diesel Conversion~~
Task ~~2.1.3~~ **2.1.2**	11.9L New CNG Engine for Refuse and Class 8 Tractor Industry
Task 2.2	**Vehicle Integration**
Task 2.2.1	11L Stoichiometric CNG Engine for **Transit Bus** ~~Refuse~~ Industry
~~Task 2.2.2~~	~~11.9L New CNG Engine for Refuse and Class 8 Industry~~
Task 2.3	**On-Road Demonstration**
Task 2.3.1	11L Stoichiometric CNG Engine for **Transit Bus** ~~Refuse~~ Industry
Task 2.3.2	11.9L New CNG Engine for Refuse and Class 8 Industry

Task 2.1 Engine Development

The goal of this task is to develop a natural gas engine that complies with California Air Resources Board (CARB) and Environmental Protection Agency (EPA) 2010 on-road emissions regulations with no more than a 20% fuel economy penalty compared to a similar displacement and horsepower diesel engine for same duty cycle application and product class.

Task 2.1.1 11L Stoichiometric Compressed Natural Gas (CNG) Engine for Transit Bus ~~Refuse~~ Industry

The subcontractor, under the direction of the Facility Operator, shall:

- Conduct a feasibility and risk analysis to convert a lean burn engine to stoichiometric operation with exhaust gas recirculation (EGR). The analysis shall include, but not be limited to, the following areas:
    - Engine components, such as piston, cylinder head, exhaust manifold, and EGR system
    - Control system
    - Three way catalyst (TWC) performance
    - Engine and vehicle interface
    - Diagnostic and maintenance systems
    - Emissions certification strategy
- ~~Prepare a Feasibility and Risk Report on conversion of the engine from lean burn to stoichiometric operation.~~
- Develop a GT Power model of the engine to assess the impact of various hardware designs on engine performance and utilize the model for turbo matching, EGR design, and intake and exhaust manifold design. Incorporate new engine parts and components into existing models of the engine and vehicle to ensure compatibility and conduct testing as necessary for calibration and validation of component analysis.

- ~~Prepare a GT Power Model Report that discusses the results and actions identified from the GT Power simulation of engine design.~~
- Build two prototype engines based on the computer aided design (CAD) designs, including any new parts and TWC.
- ~~Prepare a Prototype Engine Report that includes photographs of prototype engine builds and any identified challenges and resolutions encountered during the builds.~~
- Perform testing on prototype engines for emissions and performance at various speed and load conditions and optimize performance by changing EGR and spark timing.
- Evaluate the performance of the control system, EGR system, and associated sensors and actuators. Modify and enhance, if necessary.
- **Conduct a Mid-Project Review on-site of project status, including review of engine hardware design changes, development, and durability testing. Prepare an On-Site Mid-Project Review Summary.**
- **Prepare an Engine Design Summary Report discussing the hardware design and control system changes from the production lean-burn engine, with references to the feasibility and risk analysis GT Power modeling, development testing for emissions and performance, and preliminary durability testing.**
- Test production intent engines by thermal cycling, durability testing to identify component failure modes, and engine life and maintenance requirements. Validate parts and aftertreatment life.
- Prepare a Production Intent Engine Testing Report that includes test results, recommendations for improvement, and maintenance requirements.
- Conduct Federal Test Procedure (FTP) tests to ensure that the engine and after treatment system are capable of meeting 2010 EPA and CARB emissions requirements and fuel economy targets. Testing will measure the unregulated emissions profile. Unregulated emissions include nitrous oxide (N_2O), nitrogen oxide/dioxide (NO/NO_2) split, ammonia (NH_3), and ultrafine particulate emissions.
- Prepare an FTP Testing Report that summarizes results from FTP tests, including emissions levels, brake specific fuel consumption (BSFC), and comparison to similar displacement and horsepower diesel engine.
- Install ~~two (2)~~ **one (1)** production intent ~~engines~~ **engine** into a durability test cell for hours accumulation and deterioration factor determination.
- Prepare an Hours Accumulation Report on results of **ongoing** hours accumulation, noting successes and challenges, and recommending remedies if necessary.

Deliverables:

- ~~Feasibility and Risk Report~~
- ~~GT Power Model Report~~
- ~~Prototype Engine Report~~
- **On-Site Mid-Project Review Summary**

- **Engine Design Summary Report**
- Production Intent Engine Testing Report
- FTP Testing Report
- Hours Accumulation Report

~~Task 2.1.2 13L CNG Re-power/Diesel Conversion~~

~~The subcontractor, under the direction of the Facility Operator, shall:~~

- ~~Modify and/or augment cylinder head to accept spark ignition components and modify engine parameters such as boost pressure and temperatures, add a twin turbo design, and design and optimize a TWC.~~
- ~~Prepare a 13L Diesel Engine Modification Report discussing the modifications necessary to convert the 13L diesel engine to natural gas operation, including TWC catalyst design.~~
- ~~Adapt sensors, actuators, ignition system and controls, and an electronic control unit (ECU). Ensure that the control system is fully compliant with On-Board Diagnostic (OBD) II requirements for warning light illumination and diagnostic code display. Develop a new wiring harness.~~
- ~~Modify ECU programming to alter, at a minimum:~~
    - ~~Fuel injection~~
    - ~~Timing~~
    - ~~Speed~~
    - ~~Boost~~
    - ~~Temperature compensation~~
    - ~~Compression ratio~~
    - ~~Air intake~~
    - ~~Torque~~
    - ~~Sensors and feedback sensors and instrumentation~~
- ~~Prepare an ECU Programming Impact Report on the impact of ECU programming changes on engine operation and emissions over a variety of test cycles.~~
- ~~Build a prototype engine using the redesigned engine and parts, optimized ECU program, and TWC.~~
- ~~Develop a control strategy to meet 2010 CARB and EPA emissions requirements over the FTP.~~
- ~~Conduct FTP tests to assess regulated and unregulated emissions and measure BSFC.~~
- ~~Prepare an FTP Testing Report on the results of FTP testing, including regulated and unregulated emissions and BSFC measurements, compared to a similar displacement and horsepower diesel engine.~~
- ~~Conduct a complete engine tear down and assess component wear.~~
- ~~Build and test two (2) pre-production engines and perform long term durability testing to determine final design and build specifications for production engines.~~
- ~~Prepare an Engine Tear Down Report on the results of the engine tear down, including photographs of relevant parts, and provide recommendations for~~

~~final engine design.~~

~~**Deliverables:**~~

- ~~13L Diesel Engine Modification Report~~
- ~~ECU Programming Impact Report~~
- ~~FTP Testing Report~~
- ~~Engine Tear Down Report~~

Task ~~2.1.3~~ 2.1.2 11.9L New CNG Engine for Refuse and Class 8 Tractor Industry

The subcontractor, under the direction of the Facility Operator, shall:

- Build ~~twenty-five (25)~~ alpha engines to be used in subsequent tasks.
- Develop and revise control and ignition system designs and concepts for the engines. Development and revision activities will include but not be limited to the following:
    - Validate electronic control and ignition systems to meet OBD requirements.
    - Validate and upgrade, if necessary, wire harnesses, sensors and ignition system components to ensure that designs meet installation, operation, and service-access requirements for commercialization.
    - Integrate the alpha engine into Cummins Inc.'s INSITE™ diagnostic software tool.
- ~~Prepare a Control and Ignition System Modification Report summarizing impacts of changes on control system and ignition system modifications and their impact on engine design from alpha to beta engine generation.~~
- Develop beta hardware, software, and calibrations and test in accordance with design verification plan and report (DVP&R) and reliability tests, including individual as well as vehicle and engine level testing and upfitting and/or recalibration of existing alpha engines.
- **Prepare a high-level Reliability Plan Summary summarizing the design methodology and testing plan to ensure engine component and system level performance will meet design expectations.**
- **Prepare a Preliminary Engine Specifications, Conceptual Design, and Risk / Feasibility Analysis Report.**
- ~~Prepare a Control/Ignition System Validation and Combustion/Performance Calibrations Report summarizing results of control and ignition system validation and combustion and performance calibrations on beta engine build and recommendations for future projects.~~
- Refine the preliminary engine combustion and performance strategies and preliminary emission durability testing.
    - Conduct pre-certification testing on multiple engines to quantify engine to engine and test to test emission variability.
    - Perform calibration development and engine testing.
    - Design, develop and test the TWC.
    - Evaluate engine braking performance.

- Utilize results from preliminary emission testing and DVP&R and Reliability Plan tests on alpha engines to develop the beta engines.
    - Develop detailed fuel maps and model engine fuel efficiency, targeting within 5-15% of comparable diesel efficiency.
    - Develop a suite of performance ratings.
    - Develop "end of line" engine dynamometer test cycle in preparation for validation testing of all engines and applicable pass/fail criteria.
- ~~Prepare a Regulated/Unregulated Emissions and BSFC Report on regulated and unregulated emissions and BSFC, compared to a comparable horsepower and displacement diesel engine.~~
- Build three (3) beta engines for engineering validation and approximately ten (10) engines for original equipment manufacturer (OEM) integration and testing prior to product launch.
- Validate the control and ignition systems and combustion and performance calibrations via testing of the complete engines from the beta build.
    - Conduct testing in accordance with the DVP&R and Reliability Plan.
- Demonstrate all product performance attributes relative to the specifications in the DVP&R.
- Perform additional tests, as needed, to evaluate and predict product reliability and durability versus the requirements in the Reliability Plan.
- **Conduct a Mid-Project Review of project status, including review of engine hardware design changes, development, and durability testing. Prepare a Mid-Project Review Summary.**
- Perform OBD certification.
- Ensure full compatibility with Cummins Inc.'s INSITE™ diagnostic tool.
- Conduct additional pre-certification emissions testing to further quantify engine to engine variability and test to test emission stability with beta engines. Assess fuel economy compared to comparable diesel engines over FTP test cycle.
- Demonstrate emissions stability and quantify the emission deterioration, if any, over the 435,000 mile useful life, including periodic emissions tests.
- Conduct FTP emissions testing for regulated emissions and unregulated emissions, including NO/NO_2 split, N_2O, ~~NH_3, and ultrafine particulate emissions~~ and BSFC calculations.
- ~~Prepare a Long-Term Durability and Emissions Testing Report on results of long term durability testing and emissions test results, and recommendations to further refine engine development.~~
- **Prepare an Emissions Certification Summary comparing the new natural gas engine to a comparable diesel engine.**
- Utilize engine performance and reliability results and field test data to assess the reliability of the engine.
- **Prepare an 11.9L Engine Development Final Report documenting the engine development process, highlighting technical challenges resolved, and emissions certification results.**

Deliverables:

- ~~Control and Ignition System Modification Report~~
- ~~Control/Ignition System Validation and Combustion/Performance Calibrations Report~~
- ~~Regulated/Unregulated Emissions and BSFC Report~~
- ~~Long-Term Durability and Emissions Testing Report~~
- **Reliability Plan Summary**
- **Preliminary Engine Specifications, Conceptual Design, and Risk / Feasibility Analysis Report**
- **Mid-Project Review Summary**
- **Emissions Certification Summary**
- **11.9L Engine Development Final Report**

Task 2.2 Vehicle Integration

The goal of this task is to integrate the developed compressed natural gas (CNG) engines into appropriate medium to heavy duty vehicles.

Task 2.2.1 11L Stoichiometric CNG Engine for Transit Bus ~~Refuse~~ Industry

The subcontractor, under the direction of the Facility Operator, shall:

- **Develop a detailed preliminary product specification and conceptual design to repower a 60-foot articulated transit bus with the engine and aftertreatment system developed in Task 2.1.1.**
- **Conduct a comprehensive feasibility and risk analysis of the conceptual design, considering the effects of converting to a stoichiometric-EGR strategy on the following:**
    - **Key vehicle integration components, including**
        - **Transmission**
        - **Radiator**
        - **EGR system**
        - **Aftertreatment**
    - **Control system sensors, actuators, valves, etc.**
    - **Aftertreatment performance**
    - **Engine to vehicle interface and packaging requirements**
    - **Emissions verification strategy**
    - **Diagnostic and maintenance systems**
- ~~Determine the following specifications for engine and chassis operation in the refuse industry:~~
    - ~~Startability~~
    - ~~Gradeability~~
    - ~~Power Take Off (PTO) capability~~
    - ~~Horsepower and torque requirements~~
    - ~~Engine shutdown strategy~~
    - ~~Engine mount locations~~
    - ~~Transmission interface~~
    - ~~Oil pan requirements~~

    - ~~Exhaust system configuration and layout~~
    - ~~Engine controls~~
    - ~~Industry expectations for maintenance intervals~~
- Prepare a Chassis/Engine Integration Specifications Report that contains the chassis integration specifications required above.
- **Design hardware necessary to integrate the engine and aftertreatment system developed in Task 2.1.1 into the articulated bus. Construct CAD models of new vehicle components to be built and add to existing models of the engine and vehicle, including:**
    - **Engine brackets**
    - **Transmission mating hardware**
    - **Cooling system layout**
    - **Aftertreatment system layout**
- **For newly designed parts, perform analysis to ensure component integrity, and conduct testing as necessary.**
- **Document and archive all required drawings, parts list, specifications, and integration details to facilitate future repowers and new builds.**
- ~~Produce a detailed CAD design for engine integration into the chassis, including the following items:~~
    - ~~Determination of optimal engine location~~
    - ~~Clearance to cab accessory systems~~
    - ~~Engine mounting components~~
    - ~~Sizing of engine coolpack for optimal performance, installation and plumbing~~
    - ~~Engine angle to optimize driveline angels for typical chassis~~
    - ~~Charge air piping~~
    - ~~Air conditioner system~~
    - ~~Air compressor drive and plumbing~~
    - ~~Air filtration~~
    - ~~Exhaust layouts~~
- Identify suppliers for any new components and prototype parts that shall be acquired and inspected.
- ~~Build a prototype chassis on the subcontractor production line.~~
- **Procure prototype parts based on the detailed design, and assemble with engine and aftertreatment system into one (1) prototype vehicle as a repower retrofit of an existing articulated bus.**
- **Prepare documentation, including photographs, of the prototype vehicle construction.**
- Validate~~, in the prototype engineering area,~~ the accuracy of the engine installation and parts previously identified, and evaluate if design changes are necessary.
- ~~Prepare a Validation Matrix Report.~~
- Review the integrity of the chassis and engine integration with the OEM and transmission manufacturer.
- **Validate the prototype vehicle by placing the vehicle into one (1) week of lightly loaded and one (1) week of highly loaded conditions where**

the prototype vehicle will shadow a regular bus that is in service.

- **Assess results of preliminary testing and perform design changes to prototype parts as necessary.**
- **Test the prototype vehicle for a minimum of one (1) week lightly loaded and one (1) week of highly loaded conditions where the prototype vehicle will shadow a regular bus that is in service.**
- ~~Conduct performance testing on the chassis, including a cooling test, Electromagnetic Interference (EMI) test, and production validation.~~
- Prepare a Prototype Chassis-Engine Integration and **Initial** Performance Test Results Report.
- **Make the prototype vehicle available for chassis-level emissions and fuel economy testing at the CARB laboratory located at LA Metro's maintenance facility. Provide up to two (2) weeks of on-site engineering support to facilitate the testing.**
- **Prepare a Final Vehicle Integration Report summarizing final integration configuration and results of any chassis-level emissions and fuel economy testing.**
- ~~Integrate the production intent engine into a prototype chassis and conduct final design testing with the integrated chassis and production-intent engine, including cooling system and noise.~~
- ~~Prepare documentation of installation of the production-intent engine into the chassis. This documentation shall include photos and a memorandum that describes the installation process.~~
- ~~Evaluate the design configuration with various commercially available body systems to ensure commercial compatibility.~~
- ~~Prepare Final Performance Testing Report.~~

Deliverables:

- Chassis/Engine Integration Specifications Report
- ~~Validation Matrix Report~~
- **Documentation of Prototype Vehicle Construction**
- Prototype Chassis-Engine Integration and **Initial** Performance Test Results Report
- ~~Documentation of installation of the production-intent engine into the chassis~~
- Final ~~Performance Testing~~ Vehicle Integration Report

~~**Task 2.2.2 11.9L New CNG Engine for Refuse and Class 8 Industry**~~

~~**The subcontractor, under direction of the Facility Operator, shall:**~~

- ~~Determine the following specifications for engine and chassis operation in the refuse industry:~~
  - ~~Startability~~
  - ~~Gradeability~~
  - ~~PTO capability~~
  - ~~Horsepower and torque requirements~~

- ~~Engine shutdown strategy~~
- ~~Engine mount locations~~
- ~~Transmission interface~~
- ~~Oil pan requirements~~
- ~~Exhaust system configuration and layout~~
- ~~Engine controls~~
- ~~Industry expectations for maintenance intervals~~

- ~~Prepare a Chassis/Engine Integration Specifications Report that contains the chassis integration specifications required above.~~
- ~~Produce a detailed CAD design for engine integration into the chassis, including the following items:~~
  - ~~Determination of optimal engine location~~
  - ~~Clearance to cab accessory systems~~
  - ~~Engine mounting components~~
  - ~~Sizing of engine coolpack for optimal performance, installation and plumbing~~
  - ~~Engine angle to optimize driveline angels for typical chassis~~
  - ~~Charge air piping~~
  - ~~Air conditioner system~~
  - ~~Air compressor drive and plumbing~~
  - ~~Air filtration~~
  - ~~Exhaust layouts~~
- ~~Identify suppliers for any new components and prototype parts that shall be acquired and inspected.~~
- ~~Build a prototype chassis on the subcontractor production line.~~
- ~~Prepare a Validation Matrix Report that validates, in the prototype engineering area, the accuracy of the engine installation and parts previously identified, and evaluate if design changes are necessary~~
- ~~Review the integrity of the chassis and engine integration with the OEM and transmission manufacturer.~~
- ~~Conduct performance testing on the chassis, including a cooling test, electromagnetic interference (EMI) test, and production validation.~~
- ~~Integrate the production intent engine into a prototype chassis and conduct final design testing with the integrated chassis and production-intent engine, including cooling system and noise.~~
- ~~Prepare documentation of installation of the production-intent engine into the chassis. This documentation shall include photos and a memorandum that describes the installation process.~~
- ~~Prepare a Prototype Chassis-Engine Integration and Performance Test Results Report.~~
- ~~Evaluate design configuration with various commercially available body systems to ensure commercial compatibility.~~
- ~~Prepare a Final Performance Testing Report.~~

~~Deliverables:~~

- ~~Chassis/Engine Integration Specifications Report~~

- ~~Validation Matrix Report~~
- ~~Prototype Chassis-Engine Integration and Performance Test Results Report~~
- ~~Documentation of installation of the production-intent engine into the chassis~~
- ~~Final Performance Testing Report~~

Task 2.3 On-Road Demonstration

The goal of this task is to demonstrate the production-intent engine and chassis integration in real world operation. A secondary goal of the task is to collect robust field data on these vehicles.

Task 2.3.1 11L Stoichiometric CNG Engine for Transit Bus ~~Refuse~~ Industry

The subcontractor, under direction of the Facility Operator, shall:

- **Develop a demonstration and on-road development plan, including the rationale for selecting the chosen fleet, the duration of the demonstration and on-road development project, the specific monitoring and data collection plan (including the data to be collected, the methods of collection, and the responsible contacts), and details of the vehicle deployment strategy.**
- **Prepare an On-Road Demonstration Vehicle Plan for review and approval.**
- **Construct an additional two (2) prototype vehicles by repowering articulated buses, identical to the prototype vehicle constructed in Task 2.2.1. The resulting prototype fleet will be three (3) vehicles. The vehicles will be production intent, so that the engine OEM and chassis OEM can designate the findings to be representative of the planned commercial product.**
- **Deploy the three (3) vehicles in bus transit routes in the Los Angeles County Metropolitan Transportation Authority.**
- **Conduct at least twelve (12) months of field demonstration, including monitoring and support. While NREL and its subcontractors will operate the on-road demonstration for at least twelve (12) months, the CEC-supported portion of it will end by March 30, 2015.**
- ~~Deploy a minimum of two (2) vehicles to the field in a refuse capacity, within 30 miles of the ports of Los Angeles, CA or Long Beach, CA.~~
- ~~Conduct at least six (6) months of field demonstration, including monitoring and support.~~
- Prepare an On-Road Demonstration Vehicle Report discussing duty cycle selection, estimated mileage accumulation, and geographic location of vehicles selected for on-road demonstration, including photographs of vehicles.
- Identify, characterize, and resolve operational and/or performance issues ~~prior to~~ **in support of a potential** commercial product launch.
- Document the in-service performance of the demonstration fleet, including mileage accumulation, vehicle downtime, maintenance and repair frequency,

and operating costs.

- Prepare an **ongoing** On-Road Demonstration Issues Report on the operational and/or performance issues with on-road demonstration, including downtime, actual mileage accumulation, and operating costs over the full demonstration period. **Compare these results with baseline production bus with 8.9L natural gas engine over comparable duty cycles.**
- **Compare vehicle fuel efficiency to baseline production bus with 8.9L natural gas engine over comparable duty cycles.**
- ~~Validate vehicle fuel efficiency to within 5-15% of comparable diesel vehicles over comparable duty cycles.~~
- ~~Prepare an Emissions Testing and Fuel Economy Report on the chassis dynamometer testing of vehicle level tailpipe emissions and fuel economy for a representative vehicle.~~
- ~~Prepare an On-Board Fuel Storage and Delivery System Report on the compatibility results of the on-board fuel storage and delivery system with a variety of operating and ambient conditions, including lessons learned and recommendations for future designs.~~

Deliverables:

- **On-Road Demonstration Vehicle Plan**
- On-Road Demonstration Vehicle Report
- On-Road Demonstration Issues Report
- ~~Emissions Testing and Fuel Economy Report~~
- ~~On-Board Fuel Storage and Delivery System Report~~

Task 2.3.2 11.9L New CNG Engine for Refuse and Class 8 Industry

The subcontractor, under direction of the Facility Operator, shall:

- Deploy**, at minimum,** twelve (12) Class 8 trucks and tractors with production intent engines throughout the United States, with a minimum of three to be based in California.
- Conduct at least twelve (12) months of field demonstration, including monitoring and support.
- Identify, characterize, and resolve operational and/or performance issues prior to commercial product launch.
- Prepare an On-Road Demonstration Vehicle Report discussing duty cycle selection, estimated mileage accumulation, and geographic location of vehicles selected for on-road demonstration, including photographs of vehicles.
- Document in-service performance of demonstration fleet, including mileage accumulation, vehicle downtime, maintenance and repair frequency, and operating costs.
- ~~Prepare an On-Road Demonstration Issues Report on the operational and/or performance issues with on-road demonstration, including downtime, actual mileage accumulation, and operating costs over full demonstration period.~~

- ~~Validate~~ **Measure** vehicle fuel efficiency ~~to within 5-15% of~~ **and compare to** comparable diesel vehicles over comparable duty cycles.
- **Conduct a Mid-Project Review of project status, including review of fleet vehicle types, engine configurations, deployment locations, drive cycles, mileage accumulation, and development feedback. Prepare a Mid-Project Review Summary.**
- ~~Prepare a Fuel Efficiency Validation Report that summarizes fuel efficiency findings.~~
- ~~Measure vehicle tailpipe emissions, including regulated and unregulated emissions.~~
- ~~Prepare a Vehicle Tailpipe Emissions Report on the vehicle tailpipe emissions measurements.~~
- ~~Prepare an Emissions Testing and Fuel Economy Report on chassis dynamometer testing of vehicle level tailpipe emissions and fuel economy for a representative vehicle.~~
- Validate that on-board fuel storage and delivery systems are compatible with a variety of operating and ambient conditions.
- ~~Prepare an On-Board Fuel Storage and Delivery Report on the compatibility results of the on-board fuel storage and delivery system with a variety of operating and ambient conditions, including lessons learned and recommendations for future designs.~~
- **Prepare an 11.9L Engine On-Road Development and Demonstration Final Report documenting the final test fleet vehicle types, engine configurations, deployment locations, drive cycles, mileage accumulation, fuel economy, fuel storage issues, and development issues / resolution.**

Deliverables:

- On-Road Demonstration Vehicle Report
- ~~On-Road Demonstration Performance Report~~
- ~~Fuel Efficiency Validation Report~~
- ~~Vehicle Tailpipe Emissions Report~~
- ~~Emissions Testing and Fuel Economy Report~~
- ~~On-Board Fuel Storage and Delivery Report~~
- **Mid-Project Review Summary**
- **11.9L Engine On-Road Development and Demonstration Final Report**

Task 3.0 Reporting Tasks

All reports shall be delivered to:

Accounting Office, MS-2
California Energy Commission
1516 9th Street, 1st Floor
Sacramento, CA 95814

Task 3.1 Quarterly Progress Reports

The Contractor shall submit *written Quarterly* Progress Reports to the Commission Contract Manager by the 30th of the following month, starting after the Department of General Service's contract approval date and continuing each month until the Final Report has been accepted by the Commission Contract Manager. Attachment A-1 provides a recommended format and content requirements for the Quarterly Progress Report.

Task 3.2 Final Report

The Final Report shall be a public document. If the Facility Operator will be preparing a confidential version of the final report as well, the Facility Operator shall perform the following tasks for both the public and confidential versions of the Final Report. When creating the Final Report, the Facility Operator shall use and follow, unless otherwise instructed in writing by the Commission Contract Manager, the latest version of the PIER Style Manual published on the Energy Commission's web site:

http://www.energy.ca.gov/contracts/pier/contractors/index.html

Subtask 3.2.1 Final Report Outline

- Facility Operator shall prepare and submit to the Commission Contract Manager for review an outline of the Final Report describing the original purpose, approach and results of the project.

- The outline shall be submitted to the Commission Contract Manager for review. The Commission Contract Manager shall determine if the outline is satisfactory. If the Commission Contract Manager determines that the outline is unsatisfactory, he or she will, in a timely manner, provide to the Facility Operator written comments, which indicate how the outline can be improved. The Contractor shall revise the outline to meet the Commission Contract Manager's requirements. Upon finding the final report outline satisfactory, the Commission Contract Manager shall provide to the Facility Operator written approval of it.

Subtask 3.2.2 Draft Final Report for Comment

- The Facility Operator shall prepare and submit to the Commission Contract Manager a draft Final Report on the project. The format of the report shall follow the approved outline.
- The draft final report shall be submitted to the Commission Contract Manager for review and to determine, in a timely manner, if it is satisfactory. If the Commission Contract Manager determines that it is unsatisfactory, he or she will, provide to the Facility Operator written comments, which indicate how it can be improved. The Contractor shall revise the draft final report incorporating the Commission Contract Manager's corrections and required changes. Upon finding the revised draft to be satisfactory, the Commission Contract Manager shall provide to the Facility Operator written approval of it.

Subtask 3.2.3 Final Report

- The Facility Operator shall prepare a Final Report and submit it to the Commission Contract Manager after receiving the Commission Contract Manager's written approval of the draft Final Report. This task shall be deemed complete and accepted by the Commission only when the Commission Contract Manager approves the Final Report in writing. Upon approval, the Facility Operator shall submit two unbound copies of the Final Report to the Commission Contract Manager.

Task 3.3 Final Meeting

Facility Operator shall meet with the Commission Contract Manager to present findings, conclusions, and recommended next steps (if any) for the project.

Facility Operator will also discuss with the Commission Contract Manager the following contract close-out items:

- What to do with any state-owned equipment (Options), if applicable
- Commission's request for specific "generated" data (not already provided in contract deliverables)
- Need to document Contractor's disclosure of "subject inventions" developed under the contract
- Need to file UCC-1 form re: Commission's interest in patented technology
- Other "surviving" contracts provisions.

VIII. Critical Project Reviews

The Energy Commission will conduct critical project reviews at the conclusion of the following tasks:

- ~~Task 2.1: Engine Development~~
- ~~Task 2.2: Vehicle Integration~~
- ~~Task 2.3: On-Road Demonstration~~
- **Tasks 2.1.2 Engine Development and 2.3.2 On-Road Demonstration for 11.9L New CNG Engine for Refuse and Class 8 Industry**
- **Task 2.1.1 Engine Development for 11L Stoichiometric CNG Engine for Transit Bus Industry**
- **Tasks 2.2.1 Vehicle Integration and 2.3.1 On-Road Demonstration for 11L Stoichiometric CNG Engine for Transit Bus Industry**

(Note: Critical project reviews are meetings between the Contractor, the Energy Commission Contract Manager and other individuals selected by the Commission Contract Manager to provide objective, technical support to the Energy Commission. The purpose of these meetings to discuss with the Contractor the status of the project and its progress toward achieving its goals and objectives. These meetings may take place at the Energy Commission offices in Sacramento, or at another, reasonable location determined by the Commission Contract Manager.)

(Note: Prior to the critical project review meeting, the Facility Operator will provide the task deliverable(s) to the Commission Contract Manager sufficiently in advance to allow the Contract Manager's review of the deliverable document(s) before the review meeting. If not already defined in the Work Statement, the Commission Contract Manager shall specify the contents of the deliverable document(s).)

(Note: At the project review meeting, the Contractor shall present the required technical information and participate in a discussion about the project with the Commission Contract Manager and other meeting attendees, if any.

(Note: Following the project review meeting, the Energy Commission will determine whether the Contractor is complying satisfactorily with the Work Statement and whether the project is demonstrating sufficient progress toward achieving its goals and objectives to warrant continued PIER financial support for the project.)

IX. Sponsor's Key personnel and Agreement Management

A. The name and area code/phone number of the California Energy Commission's Contract Manager is listed on Exhibit D and is the official technical contact for the Energy Commission.

The Sponsor's Contract Manager is responsible for the day to day project status, decisions and communications with the Facility Operator Project

Manager (Principal Investigator). The Commission Contract Manager will review and approve all project deliverables, reports, and invoices.

The Sponsor may change the Contract Manager by notice given to the Facility Operator at any time signed by the Contract Officer of the Energy Commission.

B. The name and area code/phone number of the California Energy Commission's Contract Officer is listed on Exhibit D and will be the Contract Officer for the Agreement and is the official administrative contact for the Energy Commission.

X. Facility Operator's Key Personnel and Agreement Administration

The Facility Operator is obligated to comply with the terms and conditions of its Management and Operating (M&O) Contract with the DOE when performing work under this agreement. The DOE may require substitution of the named "key personnel" under this agreement should the DOE determine that the services of the Project Manager (Principal Investigator) or other named key personnel are necessary to meet the Facility Operator's M&O Contract obligations to the DOE. Should the DOE direct the Facility Operator to substitute the named key personnel under this agreement, the Facility Operator shall inform the Energy Commission of the directed substitution in accordance with paragraphs A and B below. In the event that the Energy Commission does not concur with the substitution of named key personnel as directed by the DOE, this agreement shall be terminated under Article XX, Termination, of the modified terms and conditions.

A. The name and area code/phone number of the National Laboratory's Project Manager (Principal Investigator) is on Exhibit D and will be the Project Manager (Principal Investigator) for this project and is the official technical contact for the National Renewable Energy Laboratory.

The Facility Operator's Project Manager (Principal Investigator) is responsible for the day to day project status, decisions, and communications with the Sponsor's Contract Manager. The Facility Operator's Project Manager (Principal Investigator) will review and approve all project deliverables and reports.

The Facility Operator's Project Manager (Principal Investigator) is designated as "key personnel" under the Agreement. The Energy Commission reserves the right to prior written concurrence of any substitution of the Project Manager (Principal Investigator).

B. The key personnel are listed on Exhibit D in this agreement.

Facility Operator's key personnel may not be substituted without the

Commission Contract Manager's prior written concurrence. Such concurrence shall not be unreasonably withheld. All other personnel may be substituted by Facility Operator, with written notification made to the Commission Contract Manager.

C. The name and area code/phone number of National Laboratory Agreement Administrator is on Exhibit D and will be the Agreement Administrator for this Agreement and is the official administrative contact for the National Renewable Energy Laboratory.

XI. Facility Operator's key subcontractors

The Facility Operator's key subcontractors are listed on Exhibit D in this agreement.

Facility Operator's key subcontractors may not be substituted without the Commission Contract Manager's prior written concurrence. Such concurrence shall be timely provided and not unreasonably withheld. Delay in written concurrence may result in a work stoppage of subcontract work. All other subcontractors may be substituted by Facility Operator, with written notification made to the Commission Contract Manager.

XII. Report standards

A. The report outline and format will be provided by the Sponsor's Contract Manager to the Facility Operator's Project Manager (Principal Investigator).

B. All reports shall be delivered to the Accounting address shown on Exhibit D.

C. Progress Reports. The Facility Operator shall prepare a Progress Report that summarizes all Agreement activities conducted by the Facility Operator to date, with an assessment of ability to complete the project within the current budget and any anticipated cost overruns. Each Progress Report is due to the Commission Contract Manager within 30 days after the end of the reporting period. The Commission Contract Manager will specify the report format and contents and the number of copies to be submitted.

D. Final Report and Final Meeting. At the conclusion of the Agreement's technical work as provided for this Appendix A Statement and revised project plan, Facility Operator shall prepare a comprehensive written Final Report, including an Executive Summary. The Commission Contract Manager will review and approve the Final Report.

XIII. Schedule

The program will continue until June 30, 2015. This Agreement is effective the later date of (1) the date on which it is signed by the last of the parties thereto, or (2) the

date on which it is approved by the California Department of General Services as noted on the Standard Agreement, or (3) the date on which the Facility Operator receives advance funding from the Sponsor.

XIV. Budget

SOW Appendix A, Exhibit C shows Energy Commission's Reimbursable Budget.

SOW Appendix A, Exhibit C shows the assessed value of the Federal Administrative Charge not charged to this project.

SOW Appendix A, Attachment A-2 shows assessed value of synergistic projects. The assessed value of such synergistic projects does not constitute a funding contribution or obligation (either cash or in-kind) on the part of the DOE or the Facility Operator.

RESOLUTION NO:

STATE OF CALIFORNIA

STATE ENERGY RESOURCES
CONSERVATION AND DEVELOPMENT COMMISSION

RESOLUTION - RE: DOE- NATIONAL RENEWABLE ENERGY LABORATORY

RESOLVED, that the State Energy Resources Conservation and Development Commission (Energy Commission) adopts the staff CEQA findings contained in the CEC 94 Contract Request Form or CEC 270 Grant Request Form (as applicable).

RESOLVED, that the Energy Commission approves Amendment 1 to Agreement 500-10-053 with **DOE- National Renewable Energy Laboratory** to extend the term date by nine months to 3/30/15, revise the scope of work and reallocate the budget to account for additional research being conducted, vehicle application modifications, and subcontractor partner changes.

FURTHER BE IT RESOLVED, that the Executive Director shall execute the same on behalf of the Energy Commission.

CERTIFICATION

The undersigned Secretariat to the Commission 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 California Energy Commission held on June 18, 2014.

AYE: [List of Commissioners]
NAY: [List of Commissioners]
ABSENT: [List of Commissioners]
ABSTAIN: [List of Commissioners]

_____
Harriet Kallemeyn,
Secretariat