California Energy Commission
January 24, 2024 Business Meeting
Backup Materials for Agenda Item No 09c:
Enchanted Rock, LLC

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

1. Proposed Resolution
2. Grant Request Form
3. Scope of Work

RESOLUTION NO: 24-0124-09c

STATE OF CALIFORNIA

STATE ENERGY RESOURCES
CONSERVATION AND DEVELOPMENT COMMISSION

RESOLUTION: **Enchanted Rock, LLC**

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 agreement PIR-23-011 with Enchanted Rock, LLC for a $2,142,968 grant to develop and demonstrate a gas-fired power generation technology in San Marcos that can run efficiently on high blends of renewable hydrogen (exceeding 30 percent by volume) in the fuel stream while mitigating greenhouse gas emissions and criteria pollutants; 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 January 24, 2024.

AYE:
NAY:
ABSENT:
ABSTAIN:

Dated:

_____
Kristine Banaag
Secretariat

STATE OF CALIFORNIA
CALIFORNIA ENERGY COMMISSION

CEC-270 (Revised 9/2022)

GRANT REQUEST FORM (GRF)

A. New Agreement Number

IMPORTANT: New Agreement # to be completed by Contracts, Grants, and Loans Office.

New Agreement Number: PIR-23-011

B. Division Information

1. Division Name: ERDD
2. Agreement Manager: Baldomero Lasam
3. MS-:43
4. Phone Number: 916-776-0784

C. Recipient's Information

1. Recipient's Legal Name: Enchanted Rock LLC
2. Federal ID Number: 37-1901367

D. Title of Project

Title of project: H2NG-RICE0 - Hydrogen Natural Gas Reciprocating Internal Combustion Engine Generator with near Zero emissions

E. Term and Amount

1. Start Date: 2/26/2024
2. End Date: 7/30/2027
3. Amount: $2,142,968.00

F. Business Meeting Information

1. Are the ARFVTP agreements $75K and under delegated to Executive Director? No
2. The Proposed Business Meeting Date: 1/24/2024 .
3. Consent or Discussion? Discussion
4. Business Meeting Presenter Name: Nadia Richards
5. Time Needed for Business Meeting: 10 minutes.
6. The email subscription topic is: NaturalGas (NG Research Program).

Agenda Item Subject and Description:

Enchanted Rock, LLC
Proposed resolution approving agreement PIR-23-011 with Enchanted Rock, LLC for a $2,142,968 grant to develop and demonstrate a gas-fired power generation technology that can run efficiently on high blends of renewable hydrogen (exceeding 30 percent by volume) in the fuel stream while mitigating greenhouse gas emissions and criteria pollutants such as oxides of nitrogen emissions and carbon monoxide, and adopting staff's determination that this project is exempt from CEQA. (Gas R&D funding) Contact: Nadia Richards

G. California Environmental Quality Act (CEQA) Compliance

1. Is Agreement considered a "Project" under CEQA?
Yes

If yes, skip to question 2.

2. If Agreement is considered a "Project" under CEQA answer the following questions.

a) Agreement **IS** exempt?

Yes

Statutory Exemption?
No

If yes, list PRC and/or CCR section number(s) and separate each with a comma. If no, enter "None" and go to the next question.

PRC section number: None

CCR section number: None

Categorical Exemption?
Yes

If yes, list CCR section number(s) and separate each with a comma. If no, enter "None" and go to the next question.

CCR section number: Cal. Code Regs., tit. 14, §15306; Cal. Code Regs., tit. 14, §15311; C.C.R., tit. 14 §15301

Common Sense Exemption? 14 CCR 15061 (b) (3)
No

If yes, explain reason why Agreement is exempt under the above section. If no, enter "Not applicable" and go to the next section.

The project will develop and demonstrate a 450-kW electric gas-fired power generation technology that can run efficiently with high blends of hydrogen. The power generation system consists of a gas-fueled generator, dynamic fuel control system, exhaust gas recirculation system, air injection system, ignition system, fuel system and an after-treatment technology. The lab-scale work for the project will be for testing and system development at an existing research facility at the University of California, Riverside. The system will be demonstrated at an existing community college in San Marcos, CA. The demonstration system will be fully contained in a package that is approximately 10 feet long by 10 feet wide by 10 feet high and weighs less than 20,000 pounds. A concrete pad not exceeding 2 feet high will act as a foundation to the power generator package. Electrical wiring will be attached in a load bank or to the facility's main breaker. A mobile hydrogen fuel storage in parallel with existing natural gas lines will be used to power the system. Final lengths of these gas lines will be determined during the design phase of the project. The power generation system to be used in this test is a CARB DG-certified solution and holds certification to the UL2200 standard, which is a comprehensive safety standard encompassing the design, construction and performance of stationary generators. This power generation system will undergo safety testing prior to installation at the demonstration site to ensure compliance with relevant environmental codes and

standards. In addition, the local air district will be notified, and appropriate air permits will be obtained prior to system demonstration. The demonstration will be located at an existing yard in a community college, which is away from traffic and will not have any significant impact on noise. The proposed project will not expand the use of either existing facilities or have any alterations of existing public or private structures, facilities, or topographical features. For these reasons, the project will not have a significant effect on the environment and falls under the categorical exemptions listed in 14 C.C.R. Sections 15301, Existing Buildings, and 15311, Accessory Structures.

Finally, the work at both project locations will involve basic data collection, research, and analysis to determine the performance of the system. This work includes computer modeling to estimate the energy balance of the system and the economic impact if the system is widely adopted in California. For these reasons, the project will not have a significant effect on the environment and falls under the categorical exemption listed in 14 C.C.R. 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.

b) Agreement **IS NOT** exempt.

IMPORTANT: consult with the legal office to determine next steps.

No

If yes, answer yes or no to all that applies. If no, list all as “no” and “None” as “yes”.

Additional Documents	Applies
Initial Study	No
Negative Declaration	No
Mitigated Negative Declaration	No
Environmental Impact Report	No
Statement of Overriding Considerations	No
None	Yes

H. Subcontractors

List all Subcontractors listed in the Budget (s) (major and minor). Insert additional rows if needed. If no subcontractors to report, enter “No subcontractors to report” and “0” to funds. **Delete** any unused rows from the table.

Subcontractor Legal Company Name	CEC Funds	Match Funds
The Regents of the University of California on behalf of the Riverside campus	$ 680,968	$0
TBD - Site Construction	$ 80,000	$0
TBD - Equipment Placement	$ 80,000	$0
TBD - Gas Connection and Hydrogen Blending Solution	$ 80,000	$0

I. Vendors and Sellers for Equipment and Materials/Miscellaneous

List all Vendors and Sellers listed in Budget(s) for Equipment and Materials/Miscellaneous. Insert additional rows if needed. If no vendors or sellers to report, enter "No vendors or sellers to report" and "0" to funds. **Delete** any unused rows from the table.

Vendor/Seller Legal Company Name	CEC Funds	Match Funds
No vendors to report	$	$

J. Key Partners

List all key partner(s). Insert additional rows if needed. If no key partners to report, enter "No key partners to report." **Delete** any unused rows from the table.

Key Partner Legal Company Name
Palomar Community College District

K. Budget Information

Include all budget information. Insert additional rows if needed. If no budget information to report, enter "N/A" for "Not Applicable" and "0" to Amount. **Delete** any unused rows from the table.

Funding Source	Funding Year of Appropriation	Budget List Number	Amount
NG Subaccount, PIERDD	21-22	501.001	$ 2,142,968

TOTAL Amount: $ 2,142,968

R&D Program Area: EGRB: Renewables

Explanation for "Other" selection Not applicable

Reimbursement Contract #: Not applicable

Federal Agreement #: Not applicable

L. Recipient's Contact Information

1. Recipient's Administrator/Officer

Name: Lavanya Bhenderu

Address: 8477 S Airport Way

City, State, Zip: Stockton, CA 95206-3970

Phone: 832-757-3250

E-Mail: lbhenderu@enchantedrock.com

2. Recipient's Project Manager

Name: Lavanya Bhenderu

Address: 8477 S Airport Way

City, State, Zip: Stockton, CA 95206-3970

Phone: 832-757-3250

E-Mail: lbhenderu@enchantedrock.com

M. Selection Process Used

There are three types of selection process. List the one used for this GRF.

Selection Process	Additional Information
Competitive Solicitation #	GFO-22-504
First Come First Served Solicitation #	Not applicable
Other	Not applicable

N. Attached Items

1. List all items that should be attached to this GRF by entering "Yes" or "No".

Item Number	Item Name	Attached
1	Exhibit A, Scope of Work/Schedule	Yes
2	Exhibit B, Budget Detail	Yes
3	CEC 105, Questionnaire for Identifying Conflicts	Yes
4	Recipient Resolution	No.
5	Awardee CEQA Documentation	No.

Approved By

Individuals who approve this form must enter their full name and approval date in the MS Word version.

Agreement Manager: Baldomero Lasam

Approval Date: 12/13/2023

Branch Manager: Kevin Uy

Approval Date: Branch Manager's Approval Date

Director: Delegated to Branch Manager

Approval Date: N/A

Exhibit A
Scope of Work
Enchanted Rock, LLC

I. TASK ACRONYM/TERM LISTS

A. Task List

Task #	CPR[1]	Task Name
1		General Project Tasks
2		Measurement and Verification Plan and Report
3		Hydrogen Fuel Procurement Plan
4		Reciprocating Engine Emission Baseline Test on Dyno with 10% Hydrogen Blend Increments Starting at 40%
5	X	Engine Emission Optimization Using In-Cylinder Combustion Optimization and High-pressure Exhaust Gas Recirculation
6		Engine Emission Optimization with Secondary Catalyst
7	X	On site Demonstration of the Final Solution
8		Life Cycle Assessment
9		Techno-Economic Assessment
10		Evaluation of Project Benefits
11		Technology/Knowledge Transfer Activities

B. Acronym/Term List

Acronym/Term	Meaning
CAM	Commission Agreement Manager
CAO	Commission Agreement Officer
CEC	California Energy Commission
CPR	Critical Project Review
EGR	Exhaust Gas Recirculation
GHG	Greenhouse Gas
H2	Hydrogen
ICE	Internal Combustion Engine
NO_X	Oxides of Nitrogen
TAC	Technical Advisory Committee
TRL	Technology Readiness Level

[1] Please see subtask 1.3 in Part III of the Scope of Work (General Project Tasks) for a description of Critical Project Review (CPR) Meetings.

Exhibit A
Scope of Work
Enchanted Rock, LLC

II. PURPOSE OF AGREEMENT, PROBLEM/SOLUTION STATEMENT, AND GOALS AND OBJECTIVES

A. Purpose of Agreement

The purpose of this Agreement is to fund the development and demonstration of an internal combustion engine generator with emissions-mitigating technology that can run efficiently on high blends of hydrogen (H_2), exceeding 30% by volume in fossil gas, in the fuel stream while mitigating greenhouse gas (GHG) and criteria pollutants such as nitrogen oxides (NOx) emissions. This Agreement will support using increasingly higher blends of H_2 without compromising performance to support meeting California's goals for carbon neutrality and improving public health and safety.

B. Problem/ Solution Statement

Problem

H_2-gas-fired generation systems improve public health and safety, particularly the ways in which they are able to reduce oxides of nitrogen (NO_x) and meet California's air quality standards.[2] While hydrogen holds great promise as an energy source and primary fuel for internal combustion engines (ICE) generators, challenges still exist when examining the adoption of hydrogen-blend technologies.[3] One of these challenges is the increase of GHG and NO_x emissions when blending hydrogen beyond 30 percent by volume with fossil gas, compared to using 100 percent fossil fuel as the base case. In addition, there is also a greater risk of engine knock. Engine knock occurs when the air-fuel mixture in the combustion chamber detonates prematurely, which can cause engine damage and decrease engine performance.

The problems associated with testing hydrogen blending have posed technical challenges that are costly and in need of closer examination to compete with incumbent technologies and move California closer to a clean hydrogen blending standard.

Solution

Enchanted Rock will use In-cylinder Combustion Optimization and Cooled High-pressure Exhaust Gas Recirculation (EGR) advanced technology setup to optimize it with hydrogen blend and fossil gas. In-cylinder combustion optimization is a critical process in the development of internal combustion engines. It focuses on maximizing the efficiency and performance of the combustion process within the engine's cylinders. This optimization aims to achieve complete and controlled combustion, ensuring that the fuel-air mixture burns thoroughly and releases the maximum amount of energy, while minimizing the emissions. Lastly, the cooled high-pressure EGR will reduce combustion temperatures and flame speed that ultimately reduce engine knock.

[2] California Air Resources Board. Air District Rules, (https://ww2.arb.ca.gov/air-district-rules)
[3] U.S. Department of Energy. 2020. Hydrogen Program Plan. (https://www.hydrogen.energy.gov/pdfs/hydrogen-program-plan-2020.pdf)

Specifically, the project will develop an ICE generator with higher hydrogen blending that will achieve a technology readiness level (TRL) of 8, making it readily available for end-users. Developing this level of technology will contribute to the progress in the state of California to meet the emission goals and legal requirements while also promoting the use of hydrogen as a clean and sustainable energy source in ICE generators.

C. Goals and Objectives of the Agreement

Agreement Goals:
The goals of this Agreement are to:

- Develop a state-of-the-art ICE generator that uses In-cylinder Combustion Optimization and Cooled High-pressure EGR to blend high percentages of hydrogen and to reduce GHG and NO_x emissions.
- Address technical challenges, such as engine knock and reduced thermal efficiency, that are associated with blending hydrogen with fossil-based fuel.
- Develop a microgrid system that can provide a reliable and resilient source of electricity during times of grid outages due to wildfires and extreme weather events.
- Implement technical outreach via peer-reviewed publications, and participation in technical and trade conferences to advance the public's knowledge about the technology and to further its commercial appeal and implementation.

Ratepayer Benefits:
This Agreement will provide a clean-power generation technology that produces near zero carbon and low NO_x emissions using high blends of hydrogen. The technology will provide backup power, reduced electricity cost, increased safety of hydrogen-blend use, and lower harmful emissions compared to current fossil-based power generation systems.

Technological Advancement and Breakthroughs:
Enchanted Rock's 450-kilowatt electrical power generator is a state-of-the-art system that is equipped with advanced engine controls that utilize oxygen sensor monitoring to dynamically optimize the engine combustion process. The generators also come with a dynamic fuel control system. This system can respond quickly and with high accuracy to changes in load demand, ensuring that the engine is always running at the optimal fuel-to-air ratio. The combination of these advanced controls and dynamic fuel system means that Enchanted Rock's Generators can operate at the highest possible performance, while also maintaining the lowest possible emissions.

Agreement Objectives
The objectives of this Agreement are to:

- Demonstrate emissions mitigation for GHG and NOx using a combination of mitigation techniques before combustion using pre-intake strategies, during combustion using combustor control strategies, and after combustion using emissions-mitigation technologies.

- Comply with the applicable electric generation emissions standards set by the local air district in which the demonstration is located, or by the California Air Resources Board for technology power sizes that would normally be exempt from the local air district standards.
- Generate 450 kW electricity using a hydrogen blend percentage exceeding 30% by volume while meeting NOx and GHG emissions targets.
- Demonstrate the system for a minimum of 500 cumulative hours of testing using the blended fuel that includes at least 300 continuous hours of operation (as part of the 500 cumulative hours) and assess the performance degradation and fuel impact on the power output (derating).
- Demonstrate an increase in maturity from TRL 5 at the beginning of the project to TRL 8 at the end of the project.
- Conduct a techno-economic analysis and a carbon intensity analysis that uses key factors in the cost of H_2 based on the U.S. DOE's Hydrogen Shot goal for the procurement and generation costs.[5]

III. TASK 1 GENERAL PROJECT TASKS

PRODUCTS

Subtask 1.1 Products

The goal of this subtask is to establish the requirements for submitting project products (e.g., reports, summaries, plans, and presentation materials). Unless otherwise specified by the Commission Agreement Manager (CAM), the Recipient must deliver products as required below by the dates listed in the **Project Schedule (Part V).** All products submitted which will be viewed by the public, must comply with the accessibility requirements of Section 508 of the federal Rehabilitation Act of 1973, as amended (29 U.S.C. Sec. 794d), and regulations implementing that act as set forth in Part 1194 of Title 36 of the Federal Code of Regulations**.** All technical tasks should include product(s). Products that require a draft version are indicated by marking **"(draft and final)"** after the product name in the "Products" section of the task/subtask. If "(draft and final)" does not appear after the product name, only a final version of the product is required. With respect to due dates within this Scope of Work, **"days"** means working days.

The Recipient shall:

<u>For products that require a draft version, including the Final Report Outline and Final Report</u>

- Submit all draft products to the CAM for review and comment in accordance with the Project Schedule (Part V). The CAM will provide written comments to the Recipient on the draft product within 15 days of receipt, unless otherwise specified in the task/subtask for which the product is required.
- Consider incorporating all CAM comments into the final product. If the Recipient disagrees with any comment, provide a written response explaining why the comment was not incorporated into the final product.

- Submit the revised product and responses to comments within 10 days of notice by the CAM, unless the CAM specifies a longer time period, or approves a request for additional time.

For products that require a final version only

- Submit the product to the CAM for acceptance. The CAM may request minor revisions or explanations prior to acceptance.

For all products

- Submit all data and documents required as products in accordance with the following.

  Instructions for Submitting Electronic Files and Developing Software:

  - **Electronic File Format**
    - Submit all data and documents required as products under this Agreement in an electronic file format that is fully editable and compatible with the California Energy Commission's (CEC) software and Microsoft (MS)-operating computing platforms, or with any other format approved by the CAM. Deliver an electronic copy of the full text of any Agreement data and documents in a format specified by the CAM, such as memory stick.

    The following describes the accepted formats for electronic data and documents provided to the CEC as products under this Agreement, and establishes the software versions that will be required to review and approve all software products:
    - Data sets will be in MS Access or MS Excel file format (version 2007 or later), or any other format approved by the CAM.
    - Text documents will be in MS Word file format, version 2007 or later.
    - Project management documents will be in Microsoft Project file format, version 2007 or later.

  - **Software Application Development**

    Use the following standard Application Architecture components in compatible versions for any software application development required by this Agreement (e.g., databases, models, modeling tools), unless the CAM approves other software applications such as open source programs:
    - Microsoft ASP.NET framework (version 3.5 and up). Recommend 4.0.
    - Microsoft Internet Information Services (IIS), (version 6 and up) Recommend 7.5.
    - Visual Studio.NET (version 2008 and up). Recommend 2010.
    - C# Programming Language with Presentation (UI), Business Object and Data Layers.
    - SQL (Structured Query Language).
    - Microsoft SQL Server 2008, Stored Procedures. Recommend 2008 R2.

- Microsoft SQL Reporting Services. Recommend 2008 R2.
- XML (external interfaces).

Any exceptions to the Electronic File Format requirements above must be approved in writing by the CAM. The CAM will consult with the CEC's Information Technology Services Branch to determine whether the exceptions are allowable.

MEETINGS

Subtask 1.2 Kick-off Meeting

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

The Recipient shall:

- Attend a "Kick-off" meeting with the CAM, the Commission Agreement Officer (CAO), and any other CEC staff relevant to the Agreement. The Recipient will bring its Project Manager and any other individuals designated by the CAM to this meeting. The administrative and technical aspects of the Agreement will be discussed at the meeting. Prior to the meeting, the CAM will provide an agenda to all potential meeting participants. The meeting may take place in person or by electronic conferencing (e.g., WebEx), with approval of the CAM.

  The administrative portion of the meeting will include discussion of the following:
  - Terms and conditions of the Agreement;
  - Invoicing and auditing procedures;
  - Administrative products (subtask 1.1);
  - CPR meetings (subtask 1.3);
  - Match fund documentation (subtask 1.7);
  - Permit documentation (subtask 1.8);
  - Subcontracts (subtask 1.9); and
  - Any other relevant topics.

  The technical portion of the meeting will include discussion of the following:
  - The CAM's expectations for accomplishing tasks described in the Scope of Work;
  - An updated Project Schedule;
  - Technical products (subtask 1.1);
  - Progress reports (subtask 1.5);
  - Final Report (subtask 1.6);
  - Technical Advisory Committee meetings (subtasks 1.10 and 1.11); and
  - Any other relevant topics.

- Provide *Kick-off Meeting Presentation* to include but not limited to:
  - Project overview (i.e. project description, goals and objectives, technical tasks, expected benefits, etc.)

  - Project schedule that identifies milestones
  - List of potential risk factors and hurdles, and mitigation strategy

- Provide an *Updated Project Schedule, Match Funds Status Letter,* and *Permit Status Letter*, as needed to reflect any changes in the documents.

The CAM shall:
- Designate the date and location of the meeting.
- Send the Recipient a *Kick-off Meeting Agenda*.

Recipient Products:
- Kick-off Meeting Presentation
- Updated Project Schedule *(if applicable)*
- Match Funds Status Letter (subtask 1.7) *(if applicable)*
- Permit Status Letter (subtask 1.8) *(if applicable)*

CAM Product:
- Kick-off Meeting Agenda

Subtask 1.3 Critical Project Review (CPR) Meetings
The goal of this subtask is to determine if the project should continue to receive CEC funding, and if so whether any modifications must be made to the tasks, products, schedule, or budget. CPR meetings provide the opportunity for frank discussions between the CEC and the Recipient. As determined by the CAM, discussions may include project status, challenges, successes, advisory group findings and recommendations, final report preparation, and progress on technical transfer and production readiness activities (if applicable). Participants will include the CAM and the Recipient and may include the CAO and any other individuals selected by the CAM to provide support to the CEC.

CPR meetings generally take place at key, predetermined points in the Agreement, as determined by the CAM and as shown in the Task List on page 1 of this Exhibit. However, the CAM may schedule additional CPR meetings as necessary. The budget will be reallocated to cover the additional costs borne by the Recipient, but the overall Agreement amount will not increase. CPR meetings generally take place at the CEC, but they may take place at another location, or may be conducted via electronic conferencing (e.g., WebEx) as determined by the CAM.

The Recipient shall:
- Prepare and submit a *CPR Report* for each CPR meeting that: (1) discusses the progress of the Agreement toward achieving its goals and objectives; and (2) includes recommendations and conclusions regarding continued work on the project.
- Attend the CPR meeting.

- Present the CPR Report and any other required information at each CPR meeting.

The CAM shall:

- Determine the location, date, and time of each CPR meeting with the Recipient's input.
- Send the Recipient a *CPR Agenda* with a list of expected CPR participants in advance of the CPR meeting. If applicable, the agenda will include a discussion of match funding and permits.
- Conduct and make a record of each CPR meeting. Provide the Recipient with a schedule for providing a Progress Determination on continuation of the project.
- Determine whether to continue the project, and if so whether modifications are needed to the tasks, schedule, products, or budget for the remainder of the Agreement. If the CAM concludes that satisfactory progress is not being made, this conclusion will be referred to the Deputy Director of the Energy Research and Development Division.
- Provide the Recipient with a *Progress Determination* on continuation of the project, in accordance with the schedule. The Progress Determination may include a requirement that the Recipient revise one or more products.

Recipient Products:

- CPR Report(s)

CAM Products:

- CPR Agenda
- Progress Determination

Subtask 1.4 Final Meeting

The goal of this subtask is to complete the closeout of this Agreement.

The Recipient shall:

- Meet with CEC staff to present project findings, conclusions, and recommendations. The final meeting must be completed during the closeout of this Agreement. This meeting will be attended by the Recipient and CAM, at a minimum. The meeting may occur in person or by electronic conferencing (e.g., WebEx), with approval of the CAM.

  The technical and administrative aspects of Agreement closeout will be discussed at the meeting, which may be divided into two separate meetings at the CAM's discretion.
  - The technical portion of the meeting will involve the presentation of findings, conclusions, and recommended next steps (if any) for the Agreement. The CAM will determine the appropriate meeting participants.
  - The administrative portion of the meeting will involve a discussion with the CAM and the CAO of the following Agreement closeout items:

  - Disposition of any procured equipment.
  - The CEC's request for specific "generated" data (not already provided in Agreement products).
  - Need to document the Recipient's disclosure of "subject inventions" developed under the Agreement.
  - "Surviving" Agreement provisions such as repayment provisions and confidential products.
  - Final invoicing and release of retention.
- Prepare a *Final Meeting Agreement Summary* that documents any agreement made between the Recipient and Commission staff during the meeting.
- Prepare a *Schedule for Completing Agreement Closeout Activities*.
- Provide copies of *All Final Products* on a USB memory stick, organized by the tasks in the Agreement.

Products:

- Final Meeting Agreement Summary *(if applicable)*
- Schedule for Completing Agreement Closeout Activities
- All Final Products

MONTHLY CALLS, REPORTS AND INVOICES

Subtask 1.5 Monthly Calls

The goal of this task is to have calls at least monthly between the CAM and Recipient to verify that satisfactory and continued progress is made towards achieving the objectives of this Agreement on time and within budget.

The objectives of this task are to verbally summarize activities performed during the reporting period, to identify activities planned for the next reporting period, to identify issues that may affect performance and expenditures, to verify match funds are being proportionally spent concurrently or in advance of CEC funds or are being spent in accordance with an approved Match Funding Spending Plan, to form the basis for determining whether invoices are consistent with work performed, and to answer any other questions from the CAM. Monthly calls might not be held on those months when a quarterly progress report is submitted or the CAM determines that a monthly call is unnecessary.

The CAM shall:

- Schedule monthly calls.
- Provide questions to the Recipient prior to the monthly call.
- Provide call summary notes to Recipient of items discussed during call.

The Recipient shall:

- Review the questions provided by CAM prior to the monthly call
- Provide verbal answers to the CAM during the call.

Product:

- Email to CAM concurring with call summary notes.

Subtask 1.6 Quarterly Progress Reports and Invoices
The goals of this subtask are to: (1) periodically verify that satisfactory and continued progress is made towards achieving the project objectives of this Agreement; and (2) ensure that invoices contain all required information and are submitted in the appropriate format.

The Recipient shall:

- Submit a *Quarterly Progress Report* to the CAM. Each progress report must:
  - Summarize progress made on all Agreement activities as specified in the scope of work for the reporting period, including accomplishments, problems, milestones, products, schedule, fiscal status, and an assessment of the ability to complete the Agreement within the current budget and any anticipated cost overruns. Progress reports are due to the CAM the 10th day of each January, April, July, and October. The Quarterly Progress Report template can be found on the ECAMS Resources webpage available at: https://www.energy.ca.gov/media/4691
- Submit a monthly or quarterly *Invoice* on the invoice template(s) provided by the CAM.

Recipient Products:

- Quarterly Progress Reports
- Invoices

CAM Product:

- Invoice template

Subtask 1.7 Final Report
The goal of this subtask is to prepare a comprehensive Final Report that describes the original purpose, approach, results, and conclusions of the work performed under this Agreement. When creating the Final Report Outline and the Final Report, the Recipient must use the CEC Style Manual provided by the CAM.

Subtask 1.7.1 Final Report Outline

The Recipient shall:

- Prepare a *Final Report Outline* in accordance with the *Energy Commission Style Manual* provided by the CAM.

Recipient Products:

- Final Report Outline (draft and final)

CAM Products:

- Energy Commission Style Manual
- Comments on Draft Final Report Outline
- Acceptance of Final Report Outline

Subtask 1.7.2 Final Report

The Recipient shall:

- Prepare a *Final Report* for this Agreement in accordance with the approved Final Report Outline, Energy Commission Style Manual, and Final Report Template provided by the CAM with the following considerations:
  - Ensure that the report includes the following items, in the following order:
    - Cover page (**required**)
    - Credits page on the reverse side of cover with legal disclaimer (**required**)
    - Acknowledgements page (optional)
    - Preface (**required**)
    - Abstract, keywords, and citation page (**required**)
    - Table of Contents (**required**, followed by List of Figures and List of Tables, if needed)
    - Executive summary (**required**)
    - Body of the report (**required**)
    - References (if applicable)
    - Glossary/Acronyms (If more than 10 acronyms or abbreviations are used, it is required.)
    - Bibliography (if applicable)
    - Appendices (if applicable) (Create a separate volume if very large.)
    - Attachments (if applicable)
- Submit a draft of the Executive Summary to the TAC for review and comment.
- Develop and submit a *Summary of TAC Comments on Draft Final Report* received on the Executive Summary. For each comment received, the Recipient will identify in the summary the following:
  - Comments the Recipient proposes to incorporate.
  - Comments the Recipient does propose to incorporate and an explanation for why.
- Submit a draft of the report to the CAM for review and comment. The CAM will provide written comments to the Recipient on the draft product within 15 days of receipt.
- Incorporate all CAM comments into the *Final Report*. If the Recipient disagrees with any comment, provide a *Written Responses to Comments* explaining why the comments were not incorporated into the final product.
- Submit the revised *Final Report* electronically with any Written Responses to Comments within 10 days of receipt of CAM's Written Comments on the Draft Final

Report, unless the CAM specifies a longer time period or approves a request for additional time.

Products:

- Summary of TAC Comments on Draft Final Report
- Draft Final Report
- Written Responses to Comments *(if applicable)*
- Final Report

CAM Product:

- Written Comments on the Draft Final Report

MATCH FUNDS, PERMITS, AND SUBAWARDS

Subtask 1.8 Match Funds

The goal of this subtask is to ensure that the Recipient obtains any match funds planned for this Agreement and applies them to the Agreement during the Agreement term.

While the costs to obtain and document match funds are not reimbursable under this Agreement, the Recipient may spend match funds for this task. Match funds must be identified in writing, and the Recipient must obtain any associated commitments before incurring any costs for which the Recipient will request reimbursement.

The Recipient shall:

- Prepare a *Match Funds Status Letter* that documents the match funds committed to this Agreement. If no match funds were part of the application that led to the CEC awarding this Agreement and none have been identified at the time this Agreement starts, then state this in the letter.

  If match funds were a part of the application that led to the CEC awarding this Agreement, then provide in the letter:
  - A list of the match funds that identifies:
    - The amount of cash match funds, their source(s) (including a contact name, address, and telephone number), and the task(s) to which the match funds will be applied.
    - The amount of each in-kind contribution, a description of the contribution type (e.g., property, services), the documented market or book value, the source (including a contact name, address, and telephone number), and the task(s) to which the match funds will be applied. If the in-kind contribution is equipment or other tangible or real property, the Recipient must identify its owner and provide a contact name, address, telephone number, and the address where the property is located.
    - If different from the solicitation application, provide a letter of

commitment from an authorized representative of each source of match funding that the funds or contributions have been secured.

- At the Kick-off meeting, discuss match funds and the impact on the project if they are significantly reduced or not obtained as committed. If applicable, match funds will be included as a line item in the progress reports and will be a topic at CPR meetings.
- Provide a *Supplemental Match Funds Notification Letter* to the CAM of receipt of additional match funds.
- Provide a *Match Funds Reduction Notification Letter* to the CAM if existing match funds are reduced during the course of the Agreement. Reduction of match funds may trigger a CPR meeting.

Products:

- Match Funds Status Letter
- Supplemental Match Funds Notification Letter *(if applicable)*
- Match Funds Reduction Notification Letter *(if applicable)*

Subtask 1.9 Permits

The goal of this subtask is to obtain all permits required for work completed under this Agreement in advance of the date they are needed to keep the Agreement schedule on track. Permit costs and the expenses associated with obtaining permits are not reimbursable under this Agreement, with the exception of costs incurred by University of California recipients. Permits must be identified and obtained before the Recipient may incur any costs related to the use of the permit(s) for which the Recipient will request reimbursement.

The Recipient shall:

- Prepare a *Permit Status Letter* that documents the permits required to conduct this Agreement. If no permits are required at the start of this Agreement, then state this in the letter. If permits will be required during the course of the Agreement, provide in the letter:
    - A list of the permits that identifies: (1) the type of permit; and (2) the name, address, and telephone number of the permitting jurisdictions or lead agencies.
    - The schedule the Recipient will follow in applying for and obtaining the permits.

  The list of permits and the schedule for obtaining them will be discussed at the Kick-off meeting (subtask 1.2), and a timetable for submitting the updated list, schedule, and copies of the permits will be developed. The impact on the project if the permits are not obtained in a timely fashion or are denied will also be discussed. If applicable, permits will be included as a line item in progress reports and will be a topic at CPR meetings.

- If during the course of the Agreement additional permits become necessary, then provide the CAM with an *Updated List of Permits* (including the appropriate information on each permit) and an *Updated Schedule for Acquiring Permits*.
- Send the CAM a *Copy of Each Approved Permit*.
- If during the course of the Agreement permits are not obtained on time or are denied, notify the CAM within 5 days. Either of these events may trigger a CPR meeting.

Products:

- Permit Status Letter
- Updated List of Permits *(if applicable)*
- Updated Schedule for Acquiring Permits *(if applicable)*
- Copy of Each Approved Permit *(if applicable)*

Subtask 1.10 Subawards

The goals of this subtask are to: (1) procure subawards required to carry out the tasks under this Agreement; and (2) ensure that the subawards are consistent with the terms and conditions of this Agreement.

The Recipient shall:

- Manage and coordinate subrecipients activities in accordance with the requirements of this Agreement.
- Incorporate this Agreement by reference into each subaward.
- Include any required Energy Commission flow-down provisions in each subaward, in addition to a statement that the terms of this Agreement will prevail if they conflict with the subaward terms.
- If requested by the CAM, submit a draft of each *Subaward* required to conduct the work under this Agreement.
- If requested by the CAM, submit a final copy of each executed subaward.
- Notify and receive written approval from the CAM prior to adding any new subrecipient (see the terms regarding of subrecipient additions in the terms and conditions).

Products:

- Subawards *(if requested by the CAM)*

TECHNICAL ADVISORY COMMITTEE

Subtask 1.11 Technical Advisory Committee (TAC)

The goal of this subtask is to create an advisory committee for this Agreement. The TAC should be composed of diverse professionals. The composition will vary depending on interest, availability, and need. TAC members will serve at the CAM's discretion. The purpose of the TAC is to:

- Provide guidance in project direction. The guidance may include scope and methodologies, timing, and coordination with other projects. The guidance may be based on:
  - Technical area expertise;
  - Knowledge of market applications; or
  - Linkages between the Agreement work and other past, present, or future projects (both public and private sectors) that TAC members are aware of in a particular area.
- Review products and provide recommendations for needed product adjustments, refinements, or enhancements.
- Evaluate the tangible benefits of the project to the state of California, and provide recommendations as needed to enhance the benefits.
- Provide recommendations regarding information dissemination, market pathways, or commercialization strategies relevant to the project products.
- Help set the project team's goals and contribute to the development and evaluation of its statement of proposed objectives as the project evolves.
- Provide a credible and objective sounding board on the wide range of technical and financial barriers and opportunities.
- Help identify key areas where the project has a competitive advantage, value proposition, or strength upon which to build.
- Advocate, to the extent the TAC members feel is appropriate, on behalf of the project in its effort to build partnerships, governmental support, and relationships with a national spectrum of influential leaders.
- Ask probing questions that insure a long-term perspective on decision-making and progress toward the project’s strategic goals.

The TAC may be composed of 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 project (e.g., designers, engineers, architects, contractors, and trade representatives);
- Public interest market transformation implementers;
- Product developers relevant to the project;
- U.S. Department of Energy research managers, or experts from other federal or state agencies relevant to the project;
- Public interest environmental groups;
- Utility representatives;
- Air district staff; and
- Members of relevant technical society committees.

The Recipient shall:

- Prepare a *List of Potential TAC Members* that includes the names, companies, physical and electronic addresses, and phone numbers of potential members. The

list will be discussed at the Kick-off meeting, and a schedule for recruiting members and holding the first TAC meeting will be developed.
- Recruit TAC members. Ensure that each individual understands member obligations and the TAC meeting schedule developed in subtask 1.12.
- Prepare a *List of TAC Members* once all TAC members have committed to serving on the TAC.
- Submit *Documentation of TAC Member Commitment* (such as Letters of Acceptance) from each TAC member.

Products:
- List of Potential TAC Members
- List of TAC Members
- Documentation of TAC Member Commitment

Subtask 1.12 TAC Meetings
The goal of this subtask is for the TAC to provide strategic guidance for the project by participating in regular meetings, which may be held via teleconference.

The Recipient shall:
- Discuss the TAC meeting schedule with the CAM at the Kick-off meeting. Determine the number and location of meetings (in-person and via teleconference) in consultation with the CAM.
- Prepare a *TAC Meeting Schedule* that will be presented to the TAC members during recruiting. Revise the schedule after the first TAC meeting to incorporate meeting comments.
- Prepare a *TAC Meeting Agenda* and *TAC Meeting Back-up Materials* for each TAC meeting.
- Organize and lead TAC meetings in accordance with the TAC Meeting Schedule. Changes to the schedule must be pre-approved in writing by the CAM.
- Prepare *TAC Meeting Summaries* that include any recommended resolutions of major TAC issues.

The TAC shall:
- Help set the project team's goals and contribute to the development and evaluation of its statement of proposed objectives as the project evolves.
- Provide a credible and objective sounding board on the wide range of technical and financial barriers and opportunities.
- Help identify key areas where the project has a competitive advantage, value proposition, or strength upon which to build.
- Advocate on behalf of the project in its effort to build partnerships, governmental support and relationships with a national spectrum of influential leaders.
- Ask probing questions that insure a long-term perspective on decision-making and progress toward the project’s strategic goals.
- Review and provide comments to proposed project performance metrics.

- Review and provide comments to proposed project Draft Technology Transfer Plan.

Products:
- TAC Meeting Schedule (draft and final)
- TAC Meeting Agendas (draft and final)
- TAC Meeting Back-up Materials
- TAC Meeting Summaries

Subtask 1.13 Project Performance Metrics
The goal of this subtask is to finalize key performance targets for the project based on feedback from the TAC and report on final results in achieving those targets. The performance targets should be a combination of scientific, engineering, techno-economic, and/or programmatic metrics that provide the most significant indicator of the research or technology's potential success.

The Recipient shall:
- Complete and submit the project performance metrics section of the *Initial Project Benefits Questionnaire*, developed in the Evaluation of Project Benefits task, to the CAM.
- Present the draft project performance metrics at the first TAC meeting to solicit input and comments from the TAC members.
- Develop and submit a *TAC Performance Metrics Summary* that summarizes comments received from the TAC members on the proposed project performance metrics. The *TAC Performance Metrics Summary* will identify:
    - TAC comments the Recipient proposes to incorporate into the *Initial Project Benefits Questionnaire*, developed in the Evaluation of Project Benefits task.
    - TAC comments the Recipient does not propose to incorporate with and explanation why.
- Develop and submit a *Project Performance Metrics Results* document describing the extent to which the Recipient met each of the performance metrics in the *Final Project Benefits Questionnaire*, developed in the Evaluation of Project Benefits task.
- Discuss the *Project Performance Metrics Results* at the Final Meeting.

Products:
- TAC Performance Metrics Summary
- Project Performance Metrics Results

IV. TECHNICAL TASKS

TASK 2: MEASUREMENT AND VERIFICATION PLAN AND REPORT

The goal of this task is to describe how project benefits will be measured and quantified, and to report on the actual project benefits that were realized for the Enchanted Rock's system using high blends of H_2 for power generation.

The Recipient Shall:

- Prepare and provide a *Measurement and Verification Plan* to summarize the metrics that will be evaluated and used in determining benefits that includes but is not limited to:
    - Equipment and methodologies that will be used to gather performance data.
    - Environmental and equity benefits from reducing GHG emissions and mitigating increases in NOx emissions.
    - Technology potential benefits for the adoption of new technology, strategy, and research results through innovative component redesigns and parts materials.
    - Increased market connection benefits across a range of sectors that use fossil gas onsite (commercial, industrial, and electric power) for the potential adoption of H_2 blends.
    - Safety benefits through development and demonstration of standard procedures when handling and operating generation systems using H_2 fuel blends.
    - Electric generation efficiency improvement benefits (electrical output compared to fuel energy input) when using the H_2 fuel blend.
- Consult with TAC on draft *Measurement and Verification Plan* to verify technical feasibility in accordance with subtask 1.10 (Technical Advisory Committee). Incorporate TAC feedback into the final *Measurement and Verification Plan* as appropriate.
- Prepare and provide a *Measurement and Verification Report* to that evaluates the outcomes of implementing the Measurement and Verification Plan. The report includes but it not limited to:
    - Review of Measurement and Verification protocol employed.
    - Measurements and calculations from testing period.
    - Analysis of Measurement and Verification results and use in determining the project benefits.

Products:

- Measurement and Verification Plan (draft and final)
- Measurement and Verification Report (draft and final)

TASK 3: HYDROGEN FUEL PROCUREMENT PLAN

The goal of this task is to source and procure the H_2 to be used in this research Agreement.

The Recipient shall:

- Prepare and provide a *Fuel Procurement Plan* that shows the use of Match Funds or other non-CEC funds for procuring the H2 + methane blends from a gas supplier that will have H2 percentages greater than 30 percent volume. The Fuel Procurement Plan shall include but is not limited to the following:
    - Description of the approach for sourcing and procuring the H_2 to be used in the project.
    - Explanation of the process used to produce the H_2, or of the carbon intensity of the H_2 used in the fuel blend.
    - Explanation of how H_2 volumetric blend percentages will be measured and verified to remain accurate at the target blend percentage.

Products:

- Fuel Procurement Plan (Draft and Final)

TASK 4: RECIPROCATING ENGINE EMISSION BASELINE TESTS ON DYNO

The goal of this task is to test the Enchanted Rock Reciprocating Engine on the dynamometer prior to engine optimization to collect baseline data of the engine performance and emissions using 100% fossil gas fuel with four load percentages: 100% (450 kW), 75% (337 kW), 50% (225 kW), and 25% (112 kW). Analysis of various blends of fossil gas and hydrogen start at 40% H_2 by volume and increases in 10% increments, up to 100%.

The Recipient shall:

- Transport test engines(s) to site for testing work.
- Procure and transport portable hydrogen fuel cylinders to test site(s).
- Procure the hydrogen blending system.
- Set up test engines(s) for performance testing.

Subtask 4.1: Conduct Fossil Gas Baseline Testing

The goal of this subtask is to test the Enchanted Rock Reciprocating Engine at four load percentages at various blends of fossil gas and hydrogen. The tests serve as baseline measurements, with each test point taken once the engine has warmed up for 30min. To ensure accuracy, each test point will be recorded as an averaged number over a 20-minute period.

- Conduct baseline engine / fuel performance testing using 100% fossil gas, and collect performance and emissions data described in the metrics table, for the following scenarios:
    - Scenario 1: 100% load

        - Test the engine at 100% load with 100% fossil gas fuel.
        - Test the engine at 100% load with fossil gas blend with 40%-100% hydrogen, in 10% increments.
    - Scenario 2: 75% load
        - Test the engine at 75% load with 100% fossil gas fuel.
        - Test the engine at 75% load with fossil gas blend with 40%-100% hydrogen, in 10% increments.
    - Scenario 3: 50% load
        - Test the engine at 50% load with 100% fossil gas fuel.
        - Test the engine at 50% load with fossil gas blend with 40%-100% hydrogen, in 10% increments.
    - Scenario 4: 25% load
        - Test the engine at 25% load with 100% fossil gas fuel.
        - Test the engine at 25% load with fossil gas blend with 40%-100% hydrogen, in 10% increments.

Subtask 4.2: Prepare Baseline Performance and Emissions Report
The goal of this subtask is to compile and report on all testing data collected in Task 4.

The Recipient shall:

- Prepare and provide a *Baseline Comparison Performance and Emissions Report* with baseline testing data from each testing activity. The report will include but is not limited to:
    - Full description of what and how the baseline analysis was done.
    - Identification of engineering designs and standards that are applicable.
    - Discussion about designing for safety.
    - Equipment specifications.
    - A description of the challenges identified with the original design or analysis (if applicable).
    - Description of the Enchanted Rock Reciprocating Engine system and its component's functionality and operability.
    - System diagram showing mass balance.
    - Discussion and description of the outcome of performance and emissions test for each experiment or analysis.

Product:

- Baseline Comparison Performance and Emissions Report (Draft and Final)

TASK 5: ENGINE EMISSION OPTIMIZATION USING INCYLINDER COMBUSTION OPTIMIZATION AND HIGH-PRESSURE EXHAUST GAS RECIRCULATION
The goal of this task is to implement modifications to the unit by incorporating in-cylinder optimization and high-pressure EGR followed by retesting of the unit in order to optimize the GHG and NOx emissions performance of the ICE generator.

Subtask 5.1: Optimize Engine-out Emissions
The goal of this task is to optimize the engine-out emissions using controls to change in-cylinder combustion and various ratios of high-pressure EFR.

The Recipient shall:

- Analyze the advanced engine controls and enhanced sensors of the ICE generator to change the spark timing to accommodate various fuels.
- Adjust the ignition timing, air-fuel ratio, and other parameters to the combination of EGR ratio and spark timing to reduce engine-out emissions.

Subtask 5.2: Conduct Optimized Engine Testing
The goal of this subtask is to test the performance and emissions of the optimized engine with various fossil gas / hydrogen fuel blends starting at 40% hydrogen and increasing to 100% and the four load levels (100%, 75%, 50% and 25%).

The Recipient shall:

- Conduct engine performance and emissions testing for the following scenarios:
    - Scenario 1: 100% load
        - Test the engine at 100% load with 100% fossil gas fuel.
        - Test the engine at 100% load with fossil gas blend with 40%-100% hydrogen, in 10% increments.
    - Scenario 2: 75% load
        - Test the engine at 75% load with 100% fossil gas fuel.
        - Test the engine at 75% load with fossil gas blend with 40%-100% hydrogen, in 10% increments.
    - Scenario 3: 50% load
        - Test the engine at 50% load with 100% fossil gas fuel.
        - Test the engine at 50% load with fossil gas blend with 40%-100% hydrogen, in 10% increments.
    - Scenario 4: 25% load
        - Test the engine at 25% load with 100% fossil gas fuel.
        - Test the engine at 25% load with fossil gas blend with 40%-100% hydrogen, in 10% increments.

    - Conclude testing by evaluating the emissions performance with the integrated in-cylinder optimization and high-pressure EGR systems.
- Compare the emissions performance to that of the baseline results reported in *Baseline Comparison Performance and Emissions Report* (without the optimization and EGR systems).
- Develop and provide *Optimized Engine Performance and Emissions Testing Report* to determine the effectiveness of the systems in reducing emissions. The report will include but is not limited to the following:
    - Full description of what and how the emission tests were conducted.
    - Identification of engineering designs and standards that are applicable.

  - Equipment specifications.
  - A description of the challenges identified with the original design or analysis (if applicable).
  - System diagram showing mass balance.
  - Description of any changes made to successfully meet the objectives (if applicable).
  - Description the reason for changes (if applicable).
  - Discussion and description of the outcome of performance and emissions test for each experiment or analysis using the integrated in-cylinder optimization and high-pressure EGR system.
  - Comparison of the emissions performance to baseline results.
- Prepare a *CPR Report #1* and participate in CPR Meeting #1.

Product:
- Optimized Engine Performance and Emissions Testing Report (Draft and Final)
- CPR Report #1 (Draft and Final)

TASK 6: ENGINE EMISSION OPTIMIZATION WITH SECONDARY CATALYST
The goal of this task is to implement additional customizations to the engine to optimize the emissions performance of the hydrogen blend ICE and to determine the optimal fuel blend of fossil gas and hydrogen for use in the generator.

Subtask 6.1: Integrate Secondary Catalyst

The Recipient shall:
- Identify and procure a secondary catalyst [i.e., Selective catalytic reduction (SCR)] to reduce NO_X and CO_2 after optimization with EGR and in-cylinder combustion.
- Install secondary catalyst into the engine and integrate the engine into the generator.

Subtask 6.3: Test and Validate Final Optimized Generator Performance
The goal of this subtask is to test and validate the performance of the final optimized generator, evaluating transient response performance, emissions performance using 100% fossil gas fuel at load variations and then again with the different fossil gas / hydrogen fuel blends starting at 40% hydrogen and incrementing by 10% until 90%.

The Recipient shall:
- Conduct transient response performance testing and analyses.
- Conduct emissions performance testing and analyses of the optimized engine for the following scenarios:
  - Scenario 1: 100% load
    - Test the engine at 100% load with 100% fossil gas fuel.
    - Test the engine at 100% load with fossil gas blend with 40%-100% hydrogen, in 10% increments.

  - Scenario 2: 75% load
    - Test the engine at 75% load with 100% fossil gas fuel.
    - Test the engine at 75% load with fossil gas blend with 40%-100% hydrogen, in 10% increments.
  - Scenario 3: 50% load
    - Test the engine at 50% load with 100% fossil gas fuel.
    - Test the engine at 50% load with fossil gas blend with 40%-100% hydrogen, in 10% increments.
  - Scenario 4: 25% load
    - Test the engine at 25% load with 100% fossil gas fuel.
    - Test the engine at 25% load with fossil gas blend with 40%-100% hydrogen, in 10% increments.
- Conduct performance / emissions testing and analyses of the final optimized generator for the following scenarios:
  - Scenario 1: 100% load
    - Test the engine at 100% load with 100% fossil gas fuel.
    - Test the engine at 100% load with fossil gas blend with 40%-100% hydrogen, in 10% increments.
  - Scenario 2: 75% load
    - Test the engine at 75% load with 100% fossil gas fuel.
    - Test the engine at 75% load with fossil gas blend with 40%-100% hydrogen, in 10% increments.
  - Scenario 3: 50% load
    - Test the engine at 50% load with 100% fossil gas fuel.
    - Test the engine at 50% load with fossil gas blend with 40%-100% hydrogen, in 10% increments.
  - Scenario 4: 25% load
    - Test the engine at 25% load with 100% fossil gas fuel.
    - Test the engine at 25% load with fossil gas blend with 40%-100% hydrogen, in 10% increments.
- Prepare and provide a *Testing and Optimization Report* on the performance of the generator by collecting data on the transient response performance and emissions performance. This report will include but is not limited to the following:
  - Comparison of performance results of the secondary catalyst with the emissions performance of the baseline results (without the secondary catalyst).
  - Characterization of the effectiveness of the secondary catalyst in reducing emissions.
  - Performance results using the secondary catalyst.
  - Optimal blend of fossil gas with hydrogen with the highest percentage of hydrogen that provides best engine / generator performance and emissions results.

- Prepare and provide an *Engine and Generator Performance Evaluation Report* that combines all findings.
    - Comprehensive discussion and description of the results of each Tasks.
    - Conduct comprehensive engine and generator performance evaluations based on the collected data and test results.
    - Analyze and compare the baseline test results with the expected performance parameters to identify any deviations or improvements.
    - Include detailed information on engine warm-up times and the stability of performance over the 20-minute test intervals.
    - Summarize the average performance metrics, such as power output, fuel consumption, efficiency, and emissions levels.
    - Provide a breakdown of individual test points and their corresponding averaged numbers to offer a clear understanding of the overall performance trends.
    - Highlight any significant findings or discrepancies between the expected and observed performance, backed by supporting data.
    - Propose recommendations and potential adjustments to optimize engine and generator performance based on the evaluation results.

Products:

- Testing and Optimization Report (Draft and Final)
- Engine and Generator Performance Evaluation Report (Draft and Final)

TASK 7: ON SITE DEMONSTRATION OF THE FINAL SOLUTION

The goal of this task is to conduct a comprehensive demonstration of the final solution at full-scale, under static, dynamic, and stochastic operating conditions and testing the generators in the field with actual loads.

The Recipient shall:

- Confirm and prepare one demonstration site.
- Provide an updated *Host Site Commitment Letter* signed by an authorized representative of the host sites that includes but is not limited to:
    - Identifying the location of the host site.
    - An explanation of the suitability for testing the Field Unit using H2 fuel at the site.
    - A commitment to providing the site for demonstration.
- Transport the demonstration generators to the demonstration sites.
- Purchase equipment to be installed at each site.
- Install equipment at both sites.
- Conduct demonstration experiments of the gas connection and hydrogen blend solution for at least 500 hours of total operation and including 300 continuous hours of operation at each site using the most optimized hydrogen / fossil gas fuel blend using simulated load bank.

- Conduct testing of the generators using actual live loads from the demonstration sites facilities while islanded from the utility grid using the most optimized hydrogen / fossil gas fuel blend and collect data to evaluate performance.
- Collect data on the operation of the generator at each site in each test or demonstration.
- Analyze data from both sites to assess GHG and NOx emission and engine knock.
- Analyze fuel impact on capacity factor.
- Prepare and provide a *Demonstration Site Technical Specifications Report* describing the technical specifications for the development of each demonstration site, including site photos. The report will include but is not limited to:
    - Provide a detailed description of each demonstration site's location, including GPS coordinates, address, and accessibility information.
    - Outline the purpose and objectives of each demonstration site, explaining how it fits into the overall project goals.
    - Describe the physical characteristics of each site, such as terrain, elevation, and surrounding environment, which may influence the project's implementation.
    - Present the available resources at each site, including water supply, electrical grid connectivity, and any existing infrastructure that can be utilized or integrated.
    - Specify the dimensions and layout of each demonstration site, detailing the available space for the proposed development.
    - Include technical specifications for the required equipment and installations, such as generators, any additional electrical systems.
    - Provide details on the power capacity and output expected from each demonstration site's energy generation setup.
    - Outline the environmental considerations and any potential challenges or risks associated with the site's development.
    - Include site photos, capturing different angles and perspectives to give a visual representation of the site's current condition.
    - Address any regulatory requirements or permits necessary for the development of each site, ensuring compliance with local laws and regulations.
- Prepare and provide an *Onsite Generator Performance and Emissions Report* reflecting the ad-hoc indicators of the generator post demonstration experiment. The report will include but is not limited to:
    - Gather data from the onsite generator post demonstration experiment, focusing on ad-hoc indicators such as power output, fuel consumption, temperature readings, and emissions levels.
    - Analyze the data to assess the generator's overall performance during the demonstration, comparing it with the expected values or baseline metrics.
    - Include a detailed description of the experimental setup, operating conditions, and any adjustments made to the generator during the demonstration.

  - Highlight any noteworthy findings or anomalies observed during the installation, providing insights into potential areas for improvement or optimization.
  - Present a comprehensive overview of the generator's power generation capabilities, including load handling capacity and stability.
  - Evaluate the generator's fuel efficiency, assessing how effectively it converts fuel into electrical energy.
  - Assess emissions data, including nitrogen oxides (NOx), carbon monoxide (CO), particulate matter (PM), and other relevant pollutants, to gauge environmental impact.
  - Include visual aids, such as graphs and charts, to illustrate performance trends and make the data more accessible to stakeholders.
- Prepare a *CPR Report #2* and participate in CPR Meeting #2.

Products:
- Host Site Commitment Letter
- Demonstration Site Technical Specifications Report (Draft and Final)
- Onsite Generator Performance and Emissions Report (Draft and Final)
- CPR Report #2

TASK 8: LIFE CYCLE ASSESSMENT
The goals of this task are (**1**) to assess the lifecycle emissions (LCE) and water consumption of operating the technology on the proposed fuel blend(s) and (**2**) to perform a comparative analysis with its conventional gas-fired counterpart.

The Recipient shall:

- Prepare and provide a *Life Cycle Assessment Report* following a relevant LCA templates that includes but is not limited to:

  - An overview of the LCA template used that includes explanations on any assumptions, public policies, or future environmental or economic goals used in the assessment.
  - A definition of the system boundaries in coordination with all project stakeholders.
  - A comparison between the technology's environmental impacts and that of its conventional gas fired counterpart.

Products:
- Life Cycle Assessment Report (draft and final)

TASK 9: TECHNO-ECONOMIC ANALYSIS

The goal of this task is to evaluate the feasibility, cost-effectiveness, and overall performance of In-cylinder Combustion Optimization and Cooled High-Pressure EGR advanced technology in a reciprocating internal combustion engine generator.

The Recipient shall:

- Prepare and provide Techno-Economic Analysis Report describing assumptions, cost basis, and results that include but are not limited to:
    - A description of the cost-estimate approach.
    - The results from conducting a Techno-Economic Analysis (TEA) based on the Field Unit design, performance, and bill of materials (BOM) list.
    - A description of the approach used for a break-even analysis, sensitivity analysis, assessment on the return on investment, payback period, and replicability of the project.

- Consult with TAC on draft Techno-Economic Analysis Report to verify technical feasibility in accordance with subtask 1.10 (Technical Advisory Committee). Incorporate TAC feedback into the final Techno-Economic Analysis Report as appropriate.

Products:

- Techno-Economic Analysis Report (draft and final)

TASK 10: EVALUATION OF PROJECT BENEFITS
The goal of this task is to report the benefits resulting from this project.

The Recipient shall:

- Complete *the Initial Project Benefits Questionnaire*. The Initial Project Benefits Questionnaire shall be initially completed by the Recipient with 'Kick-off' selected for the 'Relevant data collection period' and submitted to the CAM for review and approval.
- Complete the *Annual Survey* by December 15th of each year. The Annual Survey includes but is not limited to the following information:
    - Technology commercialization progress
    - New media and publications
    - Company growth
    - Follow-on funding and awards received
- Complete the *Final Project Benefits Questionnaire*. The Final Project Benefits Questionnaire shall be completed by the Recipient with 'Final' selected for the 'Relevant data collection period' and submitted to the CAM for review and approval.
- Respond to CAM questions regarding the questionnaire drafts.

- Complete and update the project profile on the CEC's public online project and recipient directory on the Energize Innovation website (www.energizeinnovation.fund), and provide *Documentation of Project Profile on EnergizeInnovation.fund*, including the profile link.
- If the Prime Recipient is an Innovation Partner on the project, complete and update the organizational profile on the CEC's public online project and recipient directory on the Energize Innovation website (www.energizeinnovation.fund), and provide *Documentation of Organization Profile on EnergizeInnovation.fund*, including the profile link.

Products:

- Initial Project Benefits Questionnaire
- Annual Survey(s)
- Final Project Benefits Questionnaire
- Documentation of Project Profile on EnergizeInnovation.fund
- Documentation of Organization Profile on EnergizeInnovation.fund

TASK 11: TECHNOLOGY/KNOWLEDGE TRANSFER ACTIVITIES

The goal of this task is to conduct activities that will accelerate the commercial adoption of the technology being supported under this agreement. Eligible activities include, but are not limited to, the following:

- Scale-up analysis including manufacturing analysis, independent design verification, and process improvement efforts.
- Technology verification testing, or application to a test bed program located in California.
- Legal services or licensing to secure necessary intellectual property to further develop the technology.
- Market research, business plan development, and cost-performance modeling.
- Entry into an incubator or accelerator program located in California.

The Recipient Shall:

- Develop and submit a *Technology Transfer Plan* that identifies the proposed activities the recipient will conduct to accelerate the successful commercial adoption of the technology.
- Present the *Draft Technology Transfer Plan* to the TAC for feedback and comments.
- Develop and submit a *Summary of TAC Comments* that summarizes comments received from the TAC members on the *Draft Technology Transfer Plan*. This document will identify:
    - TAC comments the recipient proposes to incorporate into the *Final Technology Transfer Plan*.
    - TAC comments the recipient does not propose to incorporate with and explanation why.

- Submit the *Final Technology Transfer Plan* to the CAM for approval.
- Implement activities identified in *Final Technology Transfer Plan.*
- Develop and submit a *Technology Transfer Summary Report* that includes high level summaries of the activities, results, and lessons learned of tasks performed relating to implementing the *Final Technology Transfer Plan*. This report should not include any proprietary information.
- When directed by the CAM, develop presentation materials for an CEC-sponsored conference/workshop(s) on the project.
- Provide at least (6) six *High Quality Digital Photographs* (minimum resolution of 1300x500 pixels in landscape ratio) of pre and post technology installation at the project sites or related project photographs.

Products:

- Technology Transfer Plan (draft and final)
- Summary of TAC Comments
- Technology Transfer Summary Report (draft and final)
- High Quality Digital Photographs

V. PROJECT SCHEDULE

Please see the attached Excel spreadsheet.