STATE OF CALIFORNIA

GRANT REQUEST FORM (GRF)

CEC-270 (Revised 12/2019) CALIFORNIA ENERGY COMMISSION

A) New Agreement # PIR-22-003 (to be completed by CGL office)

B) Division	Agreement Manager:	MS-	Phone
ERDD	Yahui Yang		916-776-0827

C) Recipient's Legal Name	Federal ID Number
The Regents of the University of California, on behalf of the Los Angeles Campus	95-6006143

D) Title of Project
Pilot Testing and Assessment of Safety and Integrity of Targeted Hydrogen Blending in Gas Infrastructure for Decarbonization

E) Term and Amount

Start Date	End Date	Amount
10/3/2022	3/31/2026	$ 5,658,000

F) Business Meeting Information

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

Proposed Business Meeting Date 9/14/2022 ☒ Consent ☐ Discussion

Business Meeting Presenter Yahui Yang Time Needed: 5 minutes

Please select one list serve. NaturalGas (NG Research Program

Agenda Item Subject and Description:

The Regents of the University of California, on behalf of the Los Angeles Campus Proposed resolution approving Agreement PIR-22-003 with The Regents of the University of California, on behalf of the Los Angeles Campus for a $5,658,000 grant to assess the feasibility and safety of targeted hydrogen blending in gas infrastructure to support decarbonization, and adopting staff's determination that this action is exempt from CEQA. This project will study hydrogen impacts on materials, components and systems under various blend levels, develop risk assessment models, and evaluate decarbonization scenarios for target use cases. (Gas R&D) Contact: Yahui Yang

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":

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

   a) ☒ Agreement **IS** exempt.

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

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

   ☐ Common Sense Exemption. 14 CCR 15061 (b) (3)

   Explain reason why Agreement is exempt under the above section: Cal. Code Regs., tit. 14 Section 15306 provides that projects which consist of basic data

collection, research, experimental management, and resource evaluation activities, and which do not result in a serious or major disturbance to an environmental resource are categorically exempt from the provisions of the California Environmental Quality Act. The research activities under this project include comprehensive risk modeling and laboratory tests at material, component and system levels of gas infrastructure using blends of hydrogen and gas including 100% hydrogen. The risk modeling will be performed on computers, and laboratory tests will be done in controlled environment of lab facilities. Hydrogen gas storage safety protocols will be followed. Based on these characteristics, the project is exempt under Section 15306.

The project will not impact an environmental resource of hazardous or critical concern where designated, precisely mapped, and officially adopted pursuant to law by federal, state, or local agencies; does not involve any cumulative impacts of successive projects of the same type in the same place that might be considered significant; does not involve unusual circumstances that might have a significant effect on the environment; will not result in damage to scenic resources within a highway officially designated as a state scenic highway; the project sites are 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. (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) List all subcontractors (major and minor) and equipment vendors: (attach additional sheets as necessary)

Legal Company Name:	**Budget**
U.S. Department of Energy, Sandia National Laboratories	$ 1,349,852
DNV GL USA, Inc.	$ 1,281,134
Institute of Gas Technology dba Gas Technology Institute	$ 450,000
MC Consult LLC	$ 225,000
The Regents of the University of California, Irvine Campus	$ 528,100
System Safety LLC	$ 60,000
Sacramento Municipal Utility District	$ 50,000 (match only)
Solar Turbines Incorporated	$ 50,000 (match only)
Capstone Green Energy Corporation	$ 78,100

Legal Company Name:	Budget
Linde Gas & Equipment Inc.	$ 3,500
Southern California Gas Company	match only TBD
The Williams Companies, Inc.	match only TBD

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

Legal Company Name:
Granite Rock Company dba Graniterock

J) Budget Information

Funding Source	Funding Year of Appropriation	Budget List Number	Amount
NG Subaccount, PIERDD	20-21	501.001O	$5,658,000
			$
			$
			$
			$
			$

R&D Program Area: ESRO: ETSI TOTAL: $ 5,658,000

Explanation for "Other" selection

Reimbursement Contract #: Federal Agreement #:

K) Recipient's Contact Information

1. Recipient's Administrator/Officer

Name: Flora O'Brien

Address: 10889 Wilshire Blvd Suite 700 Mail Code: 140648

City, State, Zip: Los Angeles, CA 90095-1406

Phone:

E-Mail: flora.obrien@research.ucla.edu

2. Recipient's Project Manager

Name: Ali Mosleh

Address: UCLA Garrick Institute for the Risk Sciences, Box 951595, 3111 Engineering V

City, State, Zip: Los Angeles, CA 90095-1595

Phone:

E-Mail: mosleh@ucla.edu

L) Selection Process Used

☒ Competitive Solicitation Solicitation #: GFO-21-507

☐ First Come First Served Solicitation Solicitation #:

STATE OF CALIFORNIA

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☐ Non-Competitive Bid Follow-on Funding (SB 115)

M) The following items should be attached to this GRF

1.	Exhibit A, Scope of Work		☒ Attached
2.	Exhibit B, Budget Detail		☒ Attached
3.	CEC 105, Questionnaire for Identifying Conflicts		☒ Attached
4.	Recipient Resolution	☐ N/A	☐ Attached
5.	CEQA Documentation	☐ N/A	☐ Attached

_____ _____

Agreement Manager **Date**

_____ _____

Office Manager **Date**

_____ _____

Deputy Director **Date**

Scope of Work Template
The Regents of the University of California, on behalf of the Los Angeles Campus

I. TASK ACRONYM/TERM LISTS

A. Task List

Task #	CPR[1]	Task Name
1		General Project Tasks
2	X	Target System Definition, Gap Analysis, and Data Gathering
3		Development of Materials and Component Performance Models
4	X	System Wide Quantitative Risk Analysis (QRA) and Performance Assessment
5	X	Development of Strategic Experimental Program
6		Targeted Use Case Analysis
7		Technoeconomic Analysis and Pathway to Decarbonization
8		Evaluation of Project Benefits
9		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
CRADA	Cooperative Research and Development Agreements (DOE)
FMEA	Failure Mode and Effects Analysis
HyRAM+	Hydrogen Risk Assessment Models Plus
MS	Microsoft
TAC	Technical Advisory Committee
QRA	Quantitative Risk Analysis
UCLA	University of California Los Angeles

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

A. Purpose of Agreement

The purpose of this Agreement is to fund pilot testing and assessment of safety and integrity of targeted hydrogen blending in gas infrastructure for decarbonization.

[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.

B. Problem/ Solution Statement

Problem
Blending pipeline gas with hydrogen is still in the early stages of development and use. Research is required to evaluate hydrogen compatibility with pipeline materials, ensure system safety and integrity of the gas grid and hydrogen transport.

Solution
The knowledge gaps existing in these domains and their interfaces will be addressed in this project through a multi-disciplinary team conducting experimental tasks, model development derived from the experiments and broader knowledge, and validation of the analyses through component and system-level testing.

C. Goals and Objectives of the Agreement

Agreement Goals
The broader goal of this Agreement is to reduce the gap in critical knowledge to help gas IOUs introduce hydrogen in the current California gas pipeline network, and therefore help California meet its decarbonization goals. To achieve this goal, multiple attainable objectives are set in place:

- Design and execute a hydrogen blending testing program at material, component, and system levels, informed by and in support of selected Use Cases, and possible generalization
- Create a repository of hydrogen blending data and technology assessment literature and similar information produced in this agreement. This will include information on the characteristics and technical assessment of the pipeline systems in the Use Cases
- Develop models and computational capabilities to conduct Use Case system risk and performance assessments
- Apply the system risk and performance assessments to Use Cases
- Create a comprehensive integrity management approach and quantitative risk analysis, for selected Use Cases, and possible generalization
- Perform techno-economic analyses of multiple decarbonization scenarios, selected Use Cases, and possible generalizations

Ratepayer Benefits: This agreement will result in the ratepayer benefits of lower costs, greater energy reliability, and increased safety.

The tangible and immediate benefits include:

First, it's challenging to scale up California solar and wind farms without energy storage. National Renewable Energy Laboratory estimates the cost of renewable energy curtailment at $300/MWh[2]. California curtailed approximately 1.5 million MWh of utility scale solar in 2020. This curtailment

[2] National Renewable Energy Laboratory. Operational Benefits of Meeting California's Energy Storage Targets. May 2016. https://www.nrel.gov/docs/fy17osti/66517.pdf

represents $450 million/year[3] in energy lost. This project will address the distribution of hydrogen and therefore help increase current and future hydrogen production. Potential savings are much larger than the current $450 million/year curtailment costs.

Second, hydrogen production near solar and wind farms will help decentralize the production of energy. The current California gas pipeline system is dependent on a few key pipelines, and a single point of failure can have catastrophic consequences. The decentralization of energy production will greatly improve the resiliency of the pipeline energy network infrastructure. The reduction in risk of pipelines through the project results will improve pipeline resiliency. This will improve deliverability of hydrogen blends.

Third, the project could have some immediate benefits to at least one of the partners to this project (Industrial Use Case, a cement plant). Converting the gas pipeline network will take time but providing hydrogen to key customers can be achieved in a much shorter period of time. For example, according to climateworks.org "California's nine cement plants together produced about 10 million metric tons (mT) of cement and emitted 7.9 Mt of CO2 pollution in 2015". Therefore, if by the end of this project even one plant converts to hydrogen usage, the benefits would be 0.9 million mT of CO2 which is equivalent to $44 million/year[4].

Fourth, the change to another energy source will stimulate growth in other market sectors (*i.e.*, solar panels, windmills) and new jobs will be created, thus helping disadvantaged communities.

Technological Advancement and Breakthroughs:
This Agreement will lead to technological advancement and breakthroughs to overcome barriers to the achievement of the State of California's statutory energy goals by bridging many critical knowledge gaps that stand as a barrier to achieving these goals. The knowledge gaps existing in relevant domains and their interfaces will be addressed in this project through a multi-disciplinary team conducting experimental tasks, model development derived from the experiments and available literature, and validation of the analyses through component and lab-scaled system-level testing.

Agreement Objectives
In the context of the high-level goal of helping gas IOUs introduce hydrogen in the current California gas pipeline network, the main objectives of this Agreement are to:

- Bridge knowledge gaps in understanding the behavior of relevant materials and components under applicable conditions and in a system context
- Develop necessary experimental data, models, and computational capabilities to aid in understanding and prediction of component and system-level failures
- Provide guidance to end users to reduce costs, downtime, and emissions under various hydrogen blending scenarios

III. TASK 1 GENERAL PROJECT TASKS

PRODUCTS

Subtask 1.1 Products

[3] $300/MWh * 1.5 million MWh = 450M$/year
[4] 7.9 million mT of CO2 / 9 plants * 51 $/mT of CO2 = $44,7M$/year

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:

For products that require a draft version, including the Final Report Outline and Final Report

- 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

REPORTS AND INVOICES

Subtask 1.5 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 monthly *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 preceding month, 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. See the Progress Report Format Attachment for the recommended specifications.
- Submit a monthly or quarterly *Invoice* that follows the instructions in the "Payment of Funds" section of the terms and conditions, including a financial report on Match Funds and in-state expenditures.

Products:
- Progress Reports
- Invoices

Subtask 1.6 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 1.6.1 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 Product:

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

Subtask 1.6.2 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* 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
- Draft Final Report
- Written Responses to Comments *(if applicable)*
- Final Report

CAM Product:
- Written Comments on the Draft Final Report

MATCH FUNDS, PERMITS, AND SUBCONTRACTS

Subtask 1.7 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. The Recipient may only spend match funds during the Agreement term, either concurrently or prior to the use of CEC funds. 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 proposal 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 proposal 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 1.8 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 1.9 Subcontracts
The goals of this subtask are to: (1) procure subcontracts required to carry out the tasks under this Agreement; and (2) ensure that the subcontracts are consistent with the terms and conditions of this Agreement.

The Recipient shall:
- Manage and coordinate subcontractor activities in accordance with the requirements of this Agreement.
- Incorporate this Agreement by reference into each subcontract.
- Include any required Energy Commission flow-down provisions in each subcontract, in addition to a statement that the terms of this Agreement will prevail if they conflict with the subcontract terms.
- If required by the CAM, submit a draft of each *Subcontract* required to conduct the work under this Agreement.
- Submit a final copy of each executed subcontract.
- Notify and receive written approval from the CAM prior to adding any new subcontractors (see the discussion of subcontractor additions in the terms and conditions).

Products:
- Subcontracts *(draft if required by the CAM)*

TECHNICAL ADVISORY COMMITTEE

Subtask 1.10 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 1.11.
- 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 1.11 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 1.12 Project Performance Metrics
The goal of this subtask is to identify key performance targets for the project. 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 draft *Project Performance Metrics Questionnaire* to the CAM prior to the Kick-off Meeting.
- Present the draft *Project Performance Metrics Questionnaire* 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 final *Project Performance Metrics Questionnaire*.
  - TAC comments the recipient does not propose to incorporate with and explanation why.
- Submit a final *Project Performance Metrics Questionnaire* with incorporated TAC feedback.
- 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*

Performance Metrics Questionnaire.
- Discuss the final *Project Performance Metrics Questionnaire* and *Project Performance Metrics Results* at the Final Meeting.

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

IV. TECHNICAL TASKS

*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.* ***Subtask 1.1 (Products)*** *describes the procedure for submitting products to the CAM.*

TASK 2: TARGET SYSTEM DEFINITION, GAP ANALYSIS, AND DATA GATHERING

The goals of this task and corresponding subtasks are to (a) finalize selection of the targeted Use Cases, define boundaries and characteristics of the systems, make detailed engineering evaluation including but not limited to energy delivery requirement, operational requirements, and design for hydrogen injection and blending, existing gas asset condition, and hydrogen supply chain for the target Use Cases; (b) gather existing data, and knowledge related to the subject; (c) assess knowledge gaps that need to be filled in order to make various assessments and answer questions posed in subsequent tasks, particularly the scope of needed experiments.

This task starts with an initial workshop (Workshop 1) with all the stakeholders and subsequent focus group meetings as needed to: (1) make final determination of the boundaries and characteristics of the Use Case system to be analyzed; (2) discuss existing data and knowledge gaps; and (3) define the needed data.

Task 2.1: Define Target Use Case Systems Boundaries and Characteristics

The Recipient shall:

- Hold a workshop (Workshop 1) with all stakeholders, and additional focused meetings as needed
- Make a final determination of the boundaries and characteristics of the Use Case systems to be analyzed
- Develop in-depth understanding of the gas systems in the selected Use Cases in terms of system design, energy delivery requirement, operational requirements, and design for hydrogen injection and blending, existing gas asset condition, maintenance, and inspection and hydrogen supply chain
- Discuss existing data and knowledge sources and gaps, and obtain input on needed data.
- Prepare a *Report on Target Use Case Systems Boundaries, Design, and Operational Characteristics* to summarize the outcomes from above activities

Products:

- Report on Target Use Case Systems Boundaries, Design, and Operational Characteristics

Task 2.2: Data Gathering and Knowledge Gap Analysis

The Recipient shall:

- Prepare a *Report on Assessment of Knowledge Gaps and Collected Information (data and models)* that includes:
    - Conducting a systematic search of the available literature to gather existing data and models related to the subject and to identify knowledge gaps that need to be filled in order to make various assessments and answer questions posed in subsequent tasks, particularly in defining the scope of the experimental tasks.

  - Leveraging data collected and models in other programs, including those involving partner organizations, to the maximum extent possible.
  - Mapping collected information to the project objectives to identify key knowledge gaps.
  - Developing a plan to address the identified knowledge gaps.
- Prepare a *CPR Report #1* and participate in CPR Meeting, per subtask 1.3.

Products:
- Report on Assessment of Knowledge Gaps and Collected Information (data and models)
- CPR Report #1

TASK 3: DEVELOPMENT OF MATERIALS AND COMPONENT PERFORMANCE MODELS
The goal of this task is to develop and iteratively improve models to predict system-level issues for performance, reliability, and safety, and relate them to component-level and material-level performance, reliability, and safety. The assembled information will be included in the project database from Task 2 and incorporated into the assessment computational tool to be used in subsequent tasks. (This is an iterative task).

The Recipient shall:
- Perform a system-level failure mode and effects analysis (FMEA) on the Use Case systems, as designed, for various blending levels, and relate them to component-level performance, reliability, and safety.
- Build or use existing Predictive Failure Models and Life Prediction Models for each component failure mode that may be identified (including “function failure modes” such as leak or loss of integrity, and “physical failure modes” such as fatigue). The reliability analysis will combine theoretical, empirical, and expert-based information using Bayesian inference methods to minimize amount of data to be collected in tests.
- Update the model with additional data from the test program and other pertinent information from system-level risk and performance assessments and techno-economic/decarbonization insights
- Provide a *Methodology and Analysis Results Report*. The report will identify gaps in the data with recommendations for the experimental task, and include system-level FMEA, corresponding component level failure mechanisms, reliability, and safety issue for the target Use Cases.

Products:
- Methodology and Analysis Results Report

TASK 4: SYSTEM WIDE QUANTITATIVE RISK ANALYSIS (QRA) AND PERFORMANCE ASSESSMENT [ITERATIVE TASK]
The goals of this task are to develop system-level models for risk and performance assessment and integrity management to identify any additional knowledge and data gaps to be filled in Task 5, and to iteratively conduct needed analyses in support of various other project tasks.

The Recipient shall:

- Build a system-level Quantitative Risk and Performance Model based on results obtained from the material and component analyses performed in Task 3 to identify any additional knowledge and data gaps. As a reference point for comparison, a QRA of the existing Use Case systems will be performed. Performance evaluation model will include a hydraulic modeling to assess performance and operation.
- In each iteration, update the models and risk assessment with new knowledge and data gained through the test program.
- Perform sensitivity and "value of information" analyses to prioritize necessary experiments in the testing program.
- Develop computational capabilities as needed to enable project team conduct risk and performance assessment as well as integrity management for the target use cases, and also to support the techno-economic analyses of Task 7. The computational capabilities are solely for enabling the necessary calculations and assessment. They are expected to be built on existing foundations in software platforms previously developed or currently under development by the project team members (e.g. Public Sector Interpreting and Mediation Services (PSIM) developed by UCLA, HyRAM developed by Sandia National Lab) or partner IOUs).
- Prepare a *Report on Quantitative Risk and Performance Model and Analysis Results for Use Cases*, as a basis for recommendations on additional data needs that should be addressed by the experimental program.
- Use the final stage of iterative system-wide analysis to develop an integrity management program for the target use case systems. The final stage will be defined based on attainable level of confidence in the results given the available information. Prepare a *Report on Integrity Management Program and Requirements for Use Cases.*
- Prepare a CPR Report #2 and participate in CPR Meeting, per subtask 1.3.

Products:

- Report on Quantitative Risk and Performance Model and Analysis Results for Use Cases
- Report on Integrity Management Program and Requirements for Use Cases
- CPR Report #2

TASK 5: DEVELOPMENT OF STRATEGIC EXPERIMENTAL PROGRAM

The goals of this task are to fill major knowledge gaps through laboratory experiments and collect performance data to feed component-level reliability and system-level risk, performance and integrity assessments. The test program will form a basis for quantifiable evidence for safety and cost to support hydrogen blending up to 100 percent.

Subtask 5.1 Develop Experimental Program Specifications for Various Materials and Components

The goal of this subtask is to develop an initial experimental program to evaluate the extent to which various blending levels will meet the energy throughput needs of the system under typical operation, and how hydrogen injection might impact reliability, performance (efficiency, energy throughput needs of the system, carbon emission), and safety and integrity of the system and its key equipment. Materials and component tests will be planned in collaboration with end-users (Use Cases) to fit the needs of each application and will primarily be justified based on findings

from Gap Analysis, System FMEA, and Risk/Performance Assessments performed in previous tasks. Materials testing will consist of fatigue life, fracture toughness, and fatigue crack growth rate testing in hydrogen blends to characterize hydrogen degradation in gas network piping components and end uses as found in compressors, valves, regulators. This testing provides information for system design and evaluation. Component testing will leverage a new pressure cycling capability being developed under the Pipeline Blending Cooperative Research and Development Agreements (CRADA) (a HyBlend™ project). This capability will permit small-scale component testing to complement materials coupon testing. The intent of the pressure cycling loop is to induce failures in small diameter (2 in) steel pipe with engineered defects through pressure cycling with gaseous hydrogen. The capability is anticipated to be completed later in 2022. The pressure cycling system can be adapted for other components (valves, devices, etc.) and additional diagnostics can enable evaluation of the cycling system to identify system performance and failure criteria that can be extrapolated to real world applications. Tests will be planned in collaboration with end-users (Use Cases) to fit the needs of each application and will primarily be justified based on findings from Gap Analysis, System FMEA, and Risk/Performance Assessments performed in previous tasks.

At project completion the combined laboratories of the recipient and its subcontractor will possess methane/hydrogen (CH4/H2) system wide (pipeline loop) and component level (valve/flange/pipe/storage tank) testing (gas permeation/leaking/rupture) capabilities. It will incorporate both newly acquired and existing knowledge relevant to the creation of a CH4/H2 system, including access to the DOE labs' comprehensive database on H2 impacts on a wide range of materials. Hydrogen Infrastructure Risk Assessment and Management Platform (HIRAMP) will also be used to tailor the test program in the current effort to optimally develop materials properties of interest.

The Recipient shall:

- Develop a *Report on Experimental Program Plan* to provide the scope and requirements for conducting system level testing, critical component testing, and material testing. The plan will specify what to include in (a) lab scale system level testing, augmented with virtual testing (phenomenological modeling and simulation), (b) critical component testing, (c) and materials testing
- Identify appropriate materials relevant to gas pipeline systems and Use Cases such as:
    - Cast high-alloy materials in rotating components
    - Cast steels used in pressure boundary components
    - Wrought alloys (ferrous and non-ferrous)
    - Welds of cast and wrought materials
- Identify appropriate test methods to simulate operating conditions of Use Case systems as designed, their key components, and the corresponding materials. The operating conditions will include, for example, expected load cycles, gas quality, and pipeline material condition. The effects of hydrogen to be analyzed include but are not limited to:
    - Fatigue life, fracture toughness, and fatigue crack growth rates tests in high-pressure hydrogen gas to evaluate property degradation and system performance (e.g., structural integrity analysis)
    - Hydrogen permeation
    - Sealant performance
    - System operability
- At each testing level (i.e., system, component, material),
    - Develop metrics for pass/fail testing

- Identify how these tests can be accelerated
- Identify the type and quantity of the data/information required for QRA and Performance Assessment

Products:

- Report on Experimental Program Plan

Subtask 5.2 Conduct Laboratory Experiments

The goals of this task are to implement the Experimental Program Plan developed under Task 5.1, to perform material, component and system-level tests, and compile information in a database to be used in other tasks and added to the database developed under Task 2. The project team will leverage international experimental results as well as its own significant experience in testing pipeline materials and other structural materials; however, this project will expand beyond pipeline steels to a diverse set of materials found in regulators, compressors, and valves. Materials testing will be used to evaluate critical variables that affect fatigue and fracture behavior in hydrogen such as hardness, weld microstructures, pressure effects. For example, cast alloys are used in rotating equipment, yet their performance in gaseous hydrogen is not well documented. Fatigue and fracture tests will be performed in gaseous hydrogen to determine properties needed for design and evaluation of system (structural) performance. Then, the materials can be subjected to component level testing in the pressure loop system being developed under the Pipeline Blending CRADA (a HyBlend™ project). This system will be used to pressure cycle pipes and can be modified to examine small components to evaluate failure response in representative conditions and assess the conservatism of design strategies compared to materials coupon testing. These structural assessments are used to assess system performance. The Use Case industry partners will supply information on materials and components of interest for testing and identify usage conditions such that experiments can be tailored to be industrially relevant, such as stress and pressure environments. In all cases, when needed and is deemed feasible, accelerated conditions will be included to reduce test number and duration and allow for extrapolation to real operational conditions using Bayesian predictive models or simulations.

The Recipient shall:

- Perform mechanical testing of materials based on input from Use Cases in a hydrogen environment to evaluate fatigue and fracture performance. While it is anticipated that the test plan will be updated during the project, a <u>preliminary plan</u> for materials testing includes:
  - Metallic
    - Pressure cycling of components to induce failure in pressure loop capability
    - Fracture toughness measurements in high pressure hydrogen blends
    - Fatigue crack growth rate testing in high pressure hydrogen blends
    - Stress-based fatigue life in high pressure hydrogen blends
  - Non-Metallic
    - Performance of polyamide pipe
    - Detailed constitutive models that capture plastic strain accumulation as a function of stress, temperature, and strain rate
- Perform component-level testing per Test Plan developed under Task 5.1.

  - This includes pressure cycling, in the pressure loop capability currently under development, of pipes or small components in gaseous hydrogen to induce failure to assess the potential gap between component/system performance and materials coupon testing (e.g. stress-life curves in hydrogen gas) for target system components which experience fatigue loading.
- Conduct lab-scale system testing with a range of hydrogen blends. System-level testing will include small scale line up of target Use Case system elements (or conceptually equivalent in relation to phenomena to be tested) to emulate target system behavior under scenarios identified in the Test Plan, informed by system-level FMEA and preliminary system Risk Analysis.
- Assess the performance of CH4/H2 system component additions to the existing systems. It is expected that many commonalities of local power grids and other regions will exist and so this work can be used to inform the more general situation, including the extent to which the materials and components of the two grids and adjacent gas lines are representative of the wider high and low-pressure distribution system. Many power plants, large industrial facilities and the high-pressure distribution system are supplied by the high-pressure transmission system. This makes it likely that hydrogen will be injected at the high-pressure transmission level to serve some of the load envisioned in the present study. This task will expand regional consideration of the gas grid to high-pressure transmission, geological storage and compression of hydrogen. The current end use region(s) can be expanded to the broader gas network with particular assessment.
- Document the test results (quantitative data and qualitative information that might help fundamental understanding and generalization beyond the Use Case systems) by preparing a *Report on Laboratory Tests Results of Materials, Components, and Systems*.
- Produce a Database of Compiled Information, incorporating new test results and prior collected data.
- Prepare a *CPR Report #3* and participate in CPR Meeting, per subtask 1.3.

Products:

- Report on Laboratory Tests Results of Materials, Components, and Systems
- CPR Report #3

TASK 6:TARGETED USE CASE ANALYSIS [ITERATIVE TASK]

The goal of this task is to perform risk and performance assessment of the target Use Cases in industrial and a power generation application (real or as designed) given the data, models, and insights from previous tasks. This will include critical components starting from the injection point to end use equipment, and as such it would also include portions of gas network pipeline and components. The analysis is intended to inform the owners of the Use Cases what are the associated risk for various scenarios of blending, what part(s) of the system should be replaced/upgraded, what modifications are needed for daily operation and integrity management practices, associated costs, and other factors critical to technical and economic decisions regarding hydrogen blending. This is an iterative task, as that the same target systems are subject of the preliminary assessments in previous tasks, updated as needed in this task. Task 6 tightly is linked to the system integrity management and techno-economic analyses in Task 7.

The Recipient shall:

- Conduct risk and performance assessment of the Industrial Use Case
- Conduct risk and performance assessment of the Power Generation Use Case.
- Produce QRA results and qualitative insights, as well as comprehensive integrity management approach for the above Use Cases to convert certain segments of the existing system for various concentrations of blended hydrogen and pure hydrogen.
- Write an *Analysis Report for Industrial Use Case*: The report will identify associated risks for various blending scenarios, necessary modifications and safety upgrades, and changes to inspections and maintenance schedules.
- Write an *Analysis Report for Power Generation Use Case*: The report will identify associated risks for various blending scenarios, necessary modifications and safety upgrades, and changes to inspections and maintenance schedules

Products:

- Analysis Report for Industrial Application Use Case
- Analysis Report for Power Generation Use Case

TASK 7: TECHNOECONOMIC ANALYSIS AND PATHWAY TO DECARBONIZATION [ITERATIVE TASK]

The goals of this task are to determine the technoeconomic feasibility of introducing hydrogen into the existing pipeline network and achieving 100% hydrogen conversion for the two use cases using the result of corresponding analysis in Task 6. This task will utilize the analysis performed in previous tasks to investigate the technoeconomic feasibility of introduction of hydrogen in the existing pipeline network, safely and cost-efficiently, and achieve 100 percent hydrogen conversion (again in the context of targeted Use Cases), while meeting operational needs and maintaining performance. Techno-economic analysis (TEA) and techno-economic optimization (TEO) studies will be carried out, to first identify and then optimize capital and operating costs for a variety of subtasks, including identifying and optimizing the extent and location of H_2 injection into the gas network; identifying and optimizing the CCS and NO_x capture/destruction (NCD) systems for various levels of CH_4/H_2 blending. Network analysis and optimization techniques will be employed to determine H_2 injection sites, and pure H_2 and blended CH_4/H_2 network flow paths. Geospatial data layers representing the gas grid, the electric grid and land-use zoning will be incorporated in the network model, to properly account for production, transportation, delivery costs and topological network restrictions related to zoning (e.g. industrial, residential, commercial, etc.), and proximity to production/consumption sites. The project team will conduct an assessment of different pathways to 100 percent decarbonization. The analysis will first enumerate possible pathways by convening a dedicated workshop (Workshop 2) of experts and stakeholders where the results from previous tasks and also preliminary results of the techno-economic analysis conducted by the project team will be presented. The list will at a minimum include: (a) Retrofit of existing gas pipelines, (b) New purpose-built hydrogen pipelines, and (c) Hydrogen conversion to improve energy delivery.

The Recipient shall:

- Determine needed updates to integrity management practices to ensure risks can be managed and controlled for the two use cases
- Conduct a hydrogen readiness assessment for the two use cases
- Develop deployment strategies for pilot demonstrations of the two use cases

- Hold a dedicated workshop (Workshop 2) of experts and stakeholders to discuss:
    - Retrofit of existing gas pipelines. This option may explore the potential to retrofit targeted segments existing pipelines (as defined in relation to Use Cases), for instance without excavation using sleeving or other technologies to line pipelines with material compatible with hydrogen. Cost will be analyzed and compared to new purpose-built hydrogen pipelines
    - New purpose-built hydrogen pipelines. The research will reference existing industry practice for technical standards and costs of pure hydrogen pipelines that have been in use for years in chemical and petroleum refining industries. The application will evaluate options to replace portions of the gas system for pure hydrogen use by building new pipelines. The research will define the technical requirements and estimate the cost of these approaches
    - Hydrogen conversion to improve energy delivery. This pathway will explore the use of various hydrogen chemical carrier molecules (e.g., ammonia, formic acid) to deliver the energy of hydrogen but with increased energy density. The cost, conversion efficiency, and impact to energy carrying capacity of each option will be evaluated as well as compatibility with existing pipelines and end use conversion equipment, such as burners or turbines.
- Write a *Technoeconomic Analysis Report* covering each of the Use Cases including proposed network description that identifies the location and carrying capacity of the injection/production/consumption sites and associated network flowpaths.

Products:

- Technoeconomic Analysis Report

TASK 8: 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 9 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 (Draft/Final)* 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 (Draft/Final)* 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/Final)
- Summary of TAC Comments
- Technology Transfer Summary Report (Draft/Final)
- High Quality Digital Photographs

V. PROJECT SCHEDULE

Please see the attached Excel spreadsheet.

RESOLUTION NO: 22-0914-01g

STATE OF CALIFORNIA

STATE ENERGY RESOURCES
CONSERVATION AND DEVELOPMENT COMMISSION

RESOLUTION: The Regents of the University of California, on behalf of the Los Angeles Campus

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-22-003 with The Regents of the University of California, on behalf of the Los Angeles Campus for a $5,658,000 grant to assess the feasibility and safety of targeted hydrogen blending in gas infrastructure to support decarbonization. This project will study hydrogen impacts on materials, components, and systems under various blend levels, develop risk assessment models, and evaluate decarbonization scenarios for target use cases; 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 September 14, 2022.

AYE:
NAY:
ABSENT:
ABSTAIN:

Dated:

_____
Liza Lopez
Secretariat