STATE OF CALIFORNIA

GRANT REQUEST FORM (GRF)

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

A) New Agreement # PIR-22-001 (to be completed by CGL office)

B) Division	Agreement Manager:	MS-	Phone
ERDD	Jason Tancher		916-776-0693

C) Recipient's Legal Name	Federal ID Number
Institute of Gas Technology dba Gas Technology Institute	36-2170137

D) Title of Project
Decarbonizing Large Commercial and Industrial Equipment with Hydrogen

E) Term and Amount

Start Date	End Date	Amount
7/30/2022	6/30/2026	$ 1,770,000

F) Business Meeting Information

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

Proposed Business Meeting Date 7/13/2022 ☐ Consent ☒ Discussion

Business Meeting Presenter Yu Hou Time Needed: 5 minutes

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

Agenda Item Subject and Description:
Institute of Gas Technology dba Gas Technology Institute
Proposed resolution approving agreement PIR-22-001 with Institute of Gas Technology dba Gas Technology Institute for a $1,770,000 grant to fund a technical study of the impacts of utilizing hydrogen (H2) as a delivered fuel, blended with fossil fuel with greater than 50% H2 or 100% H2, used in hard-to-electrify equipment used in large commercial buildings and industrial processes in California, and adopting staff's determination that this project is exempt from CEQA. The study will assess the associated costs, safety implications, and emissions impacts of adopting H2-based fuels in these sectors. (PIER NG funding) Contact: Yu Hou.

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, § 15301 ; 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., title 14, Section 15301 provides that projects which consist of the

operation, repair, maintenance, permitting, leasing, licensing, or minor alteration of existing public and private structures, facilities, mechanical equipment, or topographical features, and which involve negligible or no expansion of use beyond that existing at the time of the lead agency's determination, are categorically exempt from the provisions of the California Environmental Quality Act.

The proposed project will primarily test and modify existing fossil-fuel burning equipment within existing laboratories, in conjunction with research and paper-based studies. The laboratory-based work will take place in existing facilities at the University of California, Irvine Combustion Laboratory. This laboratory already emits the types of air pollutants expected during testing. This work will be supported by data sets gathered from out-of-state testing at Gas Technology Institute's laboratories in Des Plaines, Illinois. For these reasons, the proposed work will not have any significant effect on the environment and is exempt under Cal. Code Regs., tit 14, Section 15301.

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 is described above. There are no sensitive environmental resources at the laboratory site. For these reasons, the proposed work will not have any significant effect on the environment and is exempt under Cal. Code Regs., tit 14, 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. (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**
Electric Power Research Institute, Inc.	$ 590,000
The Regents of the University of California, Irvine Campus	$ 790,000
	$
	$
	$
	$
	$
	$
	$
	$

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

Legal Company Name:
Air-Conditioning, Heating and Refrigeration Technology Institute

J) Budget Information

Funding Source	**Funding Year of Appropriation**	**Budget List Number**	**Amount**
NG Subaccount, PIERDD	20-21	501.001O	$1,770,000
			$
			$
			$
			$
			$

R&D Program Area: EERO: Buildings TOTAL: $ 1,770,000

Explanation for “Other” selection

Reimbursement Contract #: Federal Agreement #:

K) Recipient’s Contact Information

1. Recipient’s Administrator/Officer

Name: Kate Jauridez

Address: 1700 S Mount Prospect Rd

City, State, Zip: Des Plaines, IL 60018-1804

Phone: 847-768-0905

E-Mail: kjauridez@gti.energy

City, State, Zip: Davis, CA 95616-4112

2. **Recipient's Project Manager**

Name: Kaushik Biswas

Address: 412 F St

Phone: 530-324-6059

E-Mail: kbiswas@gti.energy

L) Selection Process Used

☒ Competitive Solicitation Solicitation #: GFO-21-503

☐ First Come First Served Solicitation Solicitation #:

☐ 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**

Exhibit A
Scope of Work
Institute of Gas Technology

I. TASK ACRONYM/TERM LISTS

A. Task List

Task #	CPR[1]	Task Name
1		General Project Tasks
2		Preliminary Techno-Economic Assessment of Hydrogen Utilization
3	X	Test Planning and Preparation
4		Experimental Assessment of Hydrogen Impacts
5	X	Extrapolative Analysis of Safety and Emissions Impacts
6		Final Techno-Economic Assessment of Hydrogen Utilization
7		Market Characterization
8		Stakeholder Outreach and Engagement
9		Evaluation of Project Benefits
10		Technology/Knowledge Transfer Activities

B. Acronym/Term List

Acronym/Term	Meaning
AHRI	Air-Conditioning, Heating, and Refrigeration Institute
CAM	Commission Agreement Manager
CAO	Commission Agreement Officer
CFD	Computational Fluid Dynamics
CEC	California Energy Commission
CPR	Critical Project Review
EPRI	Electric Power Research Institute
GHG	Greenhouse Gas
GTI	Gas Technology Institute
TAC	Technical Advisory Committee
TEA	Techno-Economic Analysis
UCI	University of California, Irvine

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

A. Purpose of Agreement

The purpose of this Agreement is to fund a technical study of the impacts of utilizing 100% hydrogen (H_2) as a delivered fuel for hard to electrify equipment as a decarbonization strategy for large commercial buildings and industrial processes in California. The tiers of equipment compatibility with H_2-based fuels will be assessed and the associated costs, safety implications, and emissions impacts of adopting H_2-based fuels defined in these sectors, where the team understands that higher utilization of renewable H_2 will be prioritized. This will be accomplished

[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.

through a techno-economic assessment, informed by laboratory testing, combustion simulation, air quality modeling, and stakeholder engagement.

B. Problem/ Solution Statement

Problem

The combustion of fossil fuel remains a significant source of energy (~2.0 quads) and greenhouse gas (GHG) emissions in California. Thus, there is a strong imperative to mitigate the climate impact of this fossil fuel consumption. At opposing ends of scale solutions are accelerating, new and retrofit technologies proliferating to address GHG emissions from fossil gas use in homes (e.g., heat pumps) *and* significant investments in the electric power sector shift towards renewable energies. Such sectors represent 20% and 29% of GHG emissions from fossil gas use respectively. However, similar decarbonization efforts in commercial building and industrial facilities have remained a significant challenge, 12% and 37% of GHG emissions from fossil gas use respectively. These are comparative challenges of equipment size, operating requirements (e.g., high-grade process heat), diversity of application, and diffusion across multiple subsectors. While energy efficiency and conservation remain a significant tool in reducing the GHG emissions from fossil gas use in commercial building and industrial sectors, further decarbonization is necessary to meet aggressive climate goals, including adapting/converting combustion equipment to accommodate renewable, or otherwise low carbon, energy carriers. This is especially challeging with hard to electrify equipment such as medium to large commercial and industrial combustion equipment.

Solution

In general, hydrogen's benefits are well understood as a low-carbon energy carrier. It has the decarbonization potential as a scalable, long-term store of renewable energy. To mitigate the GHG emissions impact of fossil gas use in large commercial buildings and industrial processes, direct use of hydrogen can play a significant role when coupled with efficiency and conservation measures, partially or wholly displacing conventional fossil gas.

For the large commercial building and industrial sectors, key research questions are: a) what are the categories and applications of combustion equipment most likely to drive GHG emission reductions with hydrogen in California, b) where are the boundaries of these blending tiers, as a function of percentage volume hydrogen in fossil gas, c) what retrofit technologies and operational changes can permit greater acceptance of hydrogen in equipment, and d) with widespread use, what are the benefits and impacts of hydrogen in the large commercial/industrial sectors, quantifying regional and overall impacts while highlighting areas with disadvantaged populations? To address these questions in this comprehensive and wide-reaching study, the Recipient will identify and resolve key research and technology gaps concerning the use of hydrogen by combustion equipment in large commercial buildings and industry, through techno-economic analysis, laboratory testing and calibrated simulation of representative combustion equipment and materials, air quality modeling, and stakeholder engagement.

C. Goals and Objectives of the Agreement

Agreement Goals

The goal of this Agreement is to identify and resolve key research and technology gaps for the utilization of hydrogen by combustion equipment in large commercial buildings and industry, through techno-economic analysis, laboratory testing and calibrated simulation of representative combustion equipment and materials, air quality modeling, and stakeholder engagement.

Ratepayer Benefits: This Agreement will establish clear and technically defensible guidance concerning the techno-economic potential of decarbonizing the large commercial and industrial sectors with delivered hydrogen. This will be accomplished by establishing "tiers" of blending for each major category and application of combustion equipment and identifying safe and cost-effective pathways to increase the acceptance of hydrogen. This will be achieved in large part, by an expansive test program of commercial and industrial equipment operating with hydrogen-based fuels. This testing, coupled with extrapolative modeling of combustion phenomena and regional air quality impacts, will serve to generate the largest and most comprehensive dataset and collection of technical guidance. It will include the operational impacts of hydrogen blended fossil gas on combustion equipment in the large commercial and industrial sectors. Finally, through direct engagement with utilities, equipment manufacturers, and commercial/industrial ratepayers, this comprehensive study will also serve to educate on the challenges and opportunities of operating combustion equipment with hydrogen, blended with fossil gas or pure. It will identify the hydrogen's benefits and challenges as a decarbonization vector overall.

Technological Advancement and Breakthroughs: This Agreement will develop a robust techno-economic assessment of hydrogen's decarbonization potential in California's large commercial and industrial sectors. Hydrogen can potentially be sourced from renewable energy in the near future to provide a near zero emissions energy source for these hard to electrify sectors. The team will establish a methodology to select large commercial and industrial combustion equipment categories, based both on the magnitude of the GHG emissions associated with the category and the potential for abatement via hydrogen use. The team will create a database of the populations of combustion equipment in California and model the decarbonization potential of using hydrogen-based blends to fuel these equipment categories paired with other measures (e.g., energy efficiency) to 2035 and 2050. These scenarios will be compared to business-as-usual and with alternative pathways (e.g., electrification). Recipient will select a representative sample of combustion equipment of most interest for experimental assessment and design testing protocols, procure equipment, and to fabricate custom experimental hardware. The focus will be on hard to electrify equipment used in large commercial buildings and industrial processes. Five or more unique test rigs will be designed and constructed in the team's laboratories. The focus will be on measuring combustion performance as a function of incrementally increased hydrogen blends up to the anticipated upper limit. The establishment of the upper hydrogen limits on equipment categories will be through extrapolation via simulation and modeling. For this effort, the team will leverage recent advancements and techniques in techno-economic modeling of energy systems, combustion testing and simulation, material testing, and regional air quality modeling, in addition to extensive stakeholder engagement and outreach.

Agreement Objectives

The objectives of this Agreement are to:

- Develop a Preliminary Techno-Economic Analysis (TEA), including a California-specific Combustion Equipment Database to establish a foundation for the selection of hard to electrify applications in large commercial and industrial combustion equipment categories. This will be based on the magnitude of the GHG emissions emitted and the potential for abatement via hydrogen utilization.
- Perform a Technical Survey for each equipment category/application identified in the TEA to define key H_2 blending tiers performance/operability, safety, and emissions standpoint, including a review of specific modifications to increase H_2 utilization.
- Develop two test plans to resolve key research gaps on selected categories/applications experimentally via short-term equipment testing and long-term material testing and solicit

industry/peer-review of the plans. Execute this plan at team laboratory facilities to establish key tiers of H_2 blending tolerance (high/mid/low) and evaluating equipment modifications.

- Extrapolate from experimental findings, via a) combustion simulation to establish upper H_2 acceptance limits on equipment categories with and without retrofit solutions, up to 100% H_2 and b) estimate the regional air quality impact of hydrogen utilization in specified equipment categories/applications.
- Finalize the TEA, updating boundary conditions from surveys, tests, and simulation results, and adding multiple hydrogen blended fuel scenarios. These scenarios will be defined during this grant agreement in Task 3.
- For each equipment category/application, estimate lifecycle costs and benefits of using hydrogen to replace fossil gas, such as avoided GHG emissions, costs, and GHG intensity of retrofit/upgrades.
- Perform a Market Characterization, informed by results of the research, which will outline the following for large commercial buildings and industry in California:
    - Define future challenges and outstanding research gaps regarding the TEA and performance of using hydrogen. This includes a summary of market barriers and drivers to the manufacture and installation of equipment to tolerate greater tiers of hydrogen blending.
    - Summarize and quantify the costs of delivered fuels, equipment (retrofit and new) to both manufacturer and end user, and other operating and maintenance concerns.
    - Estimate the market penetration from manufacturer and end user perspectives of equipment conversions and retrofits to accommodate increasing tiers of hydrogen/fossil gas blended fuels, up to an industry-wide conversion, and estimate a timeline to achieve this market potential.
- Engage manufacturers throughout technical execution, both through the Technical Advisory Committee (TAC) and other, informal channels.
- Transfer knowledge and findings to a wide group of stakeholders, including policymakers, researchers, utilities, manufacturers, etc. to inform decision-making.

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:

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.

Exhibit A
Scope of Work
Institute of Gas Technology

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:

- Project Performance Metrics Questionnaire (draft and final)
- TAC Performance Metrics Summary
- Project Performance Metrics Results

IV. TECHNICAL TASKS

TASK 2: PRELIMINARY TECHNO-ECONOMIC ASSESSMENT OF HYDROGEN UTILIZATION

The primary goal of this task is to establish a foundation for the selection of large commercial and industrial combustion equipment categories, based on the magnitude of the GHG emissions associated with the category, the potential for abatement via hydrogen utilization, and on how technically and economically challenging the equipment is to electrify with current available technology. The latter will be driven by an estimate of lifecycle cost capital and operating cost and GHG emission reductions for each sub-sector and application (e.g., fire-tube boilers utilized in industrial food production) relative to alternative pathways.

The Recipient shall:

- Establish a *Combustion Equipment Database,* delivered as a database or spreadsheet file, as directed by the CAM, of hard to electrify combustion equipment at large commercial and industrial facilities in California, describing equipment by:
  - Sector and Sub-Sector, e.g., large commercial hospitality
  - Equipment Type and Sub-type, e.g., gas-fired rotary drum dryer
  - Equipment Characteristics, including input, capacity, age, key features (modulating, premixed combustion, etc.)
  - Installation factors, including infrastructure requirements, siting, regional location
- Quantify statewide and regional (by California climate zone, investor-owned utility territory) fuel consumption and GHG emissions for each equipment category/application. For each equipment category/application, establish the following:
  - A population-weighted efficiency baseline and a maximum achievable energy efficiency potential, both equipment and process (e.g., condensing boiler and demand-controlled recirculation pumps).
  - A preliminary estimate of the range of delivered costs of low carbon fuels, including renewable gas and hydrogen, and retrofit/replacement costs to accept these fuels.
  - Estimate of retrofit and operating costs of full and partial electrification, the latter representing a hybrid approach.
  - A preliminary estimate of the GHG reduction with each option and required capital and operating cost: 1) maximize energy efficiency, 2) use of low carbon fuels, and 3) full or partial electrification
- Complete a *Preliminary Techno-Economic Assessment of Hydrogen Utilization Report* and, for each sector and sub-sector (e.g., large commercial – health care). This assessment will include, but not be limited to:
  - Quantify and rank the direct and indirect GHG emissions from each combustion equipment category, by sector/sub-sector/application, and
  - Provide a preliminary assessment of decarbonization pathways for each, by estimating the lifecycle cost of each GHG emission reduction alternative for multiple scenarios versus business-as-usual, including:
    - Maximum achievable energy efficiency (MAEE) with fossil gas
    - Operating with fossil gas/low carbon fuel blends
    - MAEE + operating with fossil gas/low carbon fuel blends
    - MAEE + operating with 100% low carbon fuels
    - Partial electrification (“hybrid” pathway)
    - Full electrification
  - As part of this assessment, recommend to the broader project team and TAC those equipment categories/applications with the greatest GHG reduction potential from hydrogen utilization based on life cycle cost and benefits.

Products:

- Combustion Equipment Database
- Preliminary Techno-Economic Assessment of Hydrogen Utilization Report (draft and final)
- Preliminary List of Priority Equipment Categories for Testing (draft and final)

TASK 3: TEST PLANNING AND PREPARATION

The goals of this task are to identify key research and technology gaps for the utilization of hydrogen by combustion equipment in large commercial buildings and industry, select a

representative sample of combustion equipment for experimental assessment, and prepare for the testing.

The Recipient shall:

- Prepare a *Technical Survey of Performance, Safety, and Emissions Impacts of Hydrogen Utilization* for the equipment categories/applications from the Task 2 Combustion Equipment Database. The survey will consider available literature and industry data, including the following:
  - A review of efficiency, operability, emissions, and safety impacts of combustion equipment operating with hydrogen blended fossil gas and, if suitable, 100% hydrogen.
  - A survey of equipment/operational modifications to tolerate higher blends of hydrogen.
  - Identifying research and technology gaps, concerning hydrogen utilization in key equipment categories/applications.
- From this survey, establish tiers of hydrogen blending on a volumetric mixture basis, varying as appropriate for each equipment category/application.
- In consultation with the TAC, the CEC CAM, and informed by Task 2 outcomes, select and recommend priority equipment categories/applications for hydrogen utilization and, from this, a representative sample of combustion equipment for testing.
  - Key equipment categories that cannot be easily electrified are anticipated to be as follows:
    - Large space heating equipment, including commercial warm-air furnaces, roof top units, and unit heaters
    - Large commercial water heating equipment, storage and tankless-type
    - Boilers
    - Industrial furnaces
    - Process ovens and dryers
    - Other miscellaneous equipment (e.g., commercial cooking equipment)
- For equipment categories specified, survey key California end users in target large commercial and industrial sectors, to establish a representative set of experimental boundary conditions. This includes but is not limited to process temperature requirements, nature of steady versus transient loading, installation factors (e.g., stack back pressure), and other factors to inform the experimental test plan. On an as-needed basis, this survey effort may include on-site visits for further data collection.
- With the equipment specified in the prior step, develop an *Experimental Assessment of Hydrogen Impacts Test Plan* for execution in Task 3, including:
  - Identifying the make/model of equipment to be tested and/or the combustion system tested under a simulated load (e.g., industrial ribbon burner)
  - Method of establishing and/or verifying the tiered cutoffs for “Low”, “Mid”, and “High” for hydrogen blends into fossil gas up to 100% hydrogen if possible, using short-term tests and simulated loads.
  - Potential to evaluate operational and/or retrofit modifications to permit acceptance of higher or pure hydrogen blends.
  - Instrumentation and data collection procedure, informing this and subsequent tasks regarding calibration of extrapolative simulations.
- For specified priority equipment categories/applications, perform a literature survey and define key research gaps concerning longer term impacts of hydrogen utilization on materials of construction. To resolve research gaps in a subsequent testing task, develop

a *Long-Term Material Impacts Test Plan,* to simulate accelerated exposure of key components to hydrogen blended atmospheres.
- Prepare the *CPR Report #1* per Subtask 1.3.
- Attend the CPR meeting.

Products:
- Technical Survey of Performance, Safety, and Emissions Impacts of Hydrogen Utilization (draft and final)
- Experimental Assessment of Hydrogen Impacts - Test Plan (draft and final)
  - Including Final List of Priority Equipment Categories for Testing
- Long-Term Material Impacts – Test Plan (draft and final)
- CPR Report #1

TASK 4: EXPERIMENTAL ASSESSMENT OF HYDROGEN IMPACTS

The goal of this task is to execute the Experimental Assessment of Hydrogen Impacts Test Plan and to execute the final Long Term Material Impacts Test Plan Task 3.

The Recipient shall:
- Design and fabricate experimental test rigs per the *Experimental Assessment of Hydrogen Impacts Test Report* from Task 3, including provisions for gathering calibration data for subsequent extrapolative simulation.
  - Design and construct five or more unique test rigs across the team's laboratories.
  - Procure, install, and commission subject equipment and/or combustion components for testing, as per the Test Plan.
  - Quantify the cost and schedule impacts of executing test plan with renewable hydrogen versus hydrogen generated from hydrocarbon sources.
- Execute the test plan for each specified equipment category/application, focusing on the following outcomes as a function of incrementally increased hydrogen blends up to the anticipated upper limit:
  - Steady-state data collected regarding heat transferred, process efficiency, surface/material temperatures, criteria pollutant emissions (NOx, CO, UHC), and other factors (e.g., operating noise)
  - Transient data collected regarding system startup and ignition, flame stability and positioning, cycling impacts, and the impact of fluctuating gas quality.
- Where included in the Test Plan and influenced by the observed upper limit of hydrogen blending tolerance, implement and quantify the effectiveness of operational and retrofit solutions to accommodate higher hydrogen blends and/or mitigate adverse impacts (e.g., reduce impact on NO_x)
- Secure the material and/or component samples for *Long Term Materials Impacts Test Report* testing. Initiate accelerated exposure of samples in simulated hydrogen atmospheres. Examine exposed samples versus baseline, adjusting the Test Plan as necessary before completing the full battery of tests.
- Document and summarize the outcomes from each test plan execution in Experimental Assessment of Hydrogen Impacts Test Report and Long Term Material Impacts Test Report for review by the project team/TAC and CAM prior to finalization.

Product:

- Experimental Assessment of Hydrogen Impacts - Test Report (draft and final)
- Long Term Material Impacts – Test Report (draft and final)

TASK 5: EXTRAPOLATIVE ANALYSIS OF SAFETY AND EMISSIONS IMPACTS

Using the aggregate population data collected in Task 3 and the experimental data collected in Task 4, extrapolate these findings via simulation and modeling to a) establish an upper limit on equipment categories with and without retrofit solutions, up to 100% hydrogen and b) estimate the regional air quality impact of hydrogen utilization in specified equipment categories/applications. .

The Recipient shall:

- Prepare *Review of Operational and Equipment Retrofits to Extend Hydrogen Tolerance* to include summary of the following:
    - For each equipment category/application tested in Task 4, identify operational and/or equipment retrofits suitable to extend hydrogen tolerance up to 100%, beyond what were experimentally assessed.
    - Develop and finalize a simulation plan to evaluate the efficacy of these operational and/or equipment retrofits, regarding the operational safety, performance, and emissions impact.
    - After calibrating representative computational fluid dynamics (CFD) models of each specified equipment category/application with data from Task 3 survey and Task 4 testing, assess the effectiveness of each strategy to extend beyond the assigned upper limit of hydrogen tolerance.
    - Catalogue the nature and effectiveness of these strategies for each equipment category/application, as explored via CFD simulation.
- Prepare *Modeling Report on Hydrogen Utilization Impacts on Regional Air Quality* to include a discussion of the following:
    - Using estimates of criteria pollutant emissions from each equipment category/application per data collected in prior tasks, employ regional air quality modeling to estimate the geographic benefits and impacts of hydrogen utilization in the large commercial/industrial sectors, quantifying regional and overall impacts while highlighting areas with disadvantaged populations.
    - Regional air quality modeling will be performed on the major California Air Basins, South Coast, Bay Area Regional, and the San Joaquin Valley. CARB defines these regions here - https://ww2.arb.ca.gov/applications/emissions-air-basin
- Prepare the *CPR Report #2* per Subtask 1.3.
- Attend the CPR meeting.

Product:

- Review of Operational and Equipment Retrofits to Extend Hydrogen Tolerance (draft and final)
- Hydrogen Utilization Impacts on Regional Air Quality – Modeling Report (draft and final)
- CPR Report #2

TASK 6: FINAL TECHNO-ECONOMIC ASSESSMENT OF HYDROGEN UTILIZATION

Using the data collected and outcomes from Tasks 3-5, the preliminary TEA performed in Task 2 will be finalized.

The Recipient shall:

- Prepare *Final Techno-Economic Assessment of Hydrogen Utilization* by including the following at a minimum:
  - Using data and information collected in Tasks 3, 4, and 5, revise the assumptions feeding into the TEA modeling, including three additional scenarios where identified equipment categories/applications are assumed to operate at the upper end of their respective "low", "mid", and "high" hydrogen blending ratios.
  - Catalogue and incorporate specific retrofit and operating costs/benefits associated with modifications to equipment for higher hydrogen tolerance.
  - Adjust assumptions to equipment fuel/electricity consumption, emissions, and assumed operational life based on prior task outcomes.
  - Discuss the potential for GHG emission reductions in the large commercial and industrial sectors using hydrogen in combustion equipment.

Products:

- Final Techno-Economic Assessment of Hydrogen Utilization (draft and final)

TASK 7: MARKET CHARACTERIZATION

Using information collected and analyzed in prior tasks, this task will identify research and knowledge gaps that will be needed to drive adoption of hydrogen-fossil gas blends and quantify the full breadth of costs associated with expanded use of hydrogen in the future (up to and including an industry-wide conversion). The carbon intensity of covered equipment categories/applications will be estimated as well. Finally, this analysis will include recommendations on resolving pending research and technology gaps to improve the techno-economics of hydrogen utilization in the sectors considered.

The Recipient shall:

- Develop a *Market Characterization Report*, which includes, but is not limited to, the following:
  - Identify which commercial and industrial markets have the highest potential for adoption and use of H2 blended or pure H2 delivered fuels.
  - Identify future challenges and outstanding research gaps regarding the TEA and performance of using blended hydrogen/fossil gas fuels in hard to electrify equipment used in large commercial buildings and industrial processes. Include a summary of market barriers and drivers to the manufacture and installation of equipment to tolerate greater tiers of hydrogen blending.
  - Summarize and quantify the following for both the manufacturer and end user:
    - operational (OPEX) costs, such as delivered fuels, and operation and maintenance
    - capital (CAPEX) costs, such as equipment for retrofit and new
  - Estimate the market penetration from manufacturers and end user perspectives, of equipment conversions and retrofits to accommodate increasing tiers of hydrogen/fossil gas blended fuels, up to an industry-wide conversion, and estimate a timeline to achieve this market potential and what energy policies and government actions will be needed.

Products:

- Market Characterization Report (draft and final)

TASK 8: STAKEHOLDER OUTREACH AND ENGAGEMENT

The goal of this task is to solicit input from key stakeholders and CEC staff during the agreement and to provide timely updates.

The Recipient shall:

- Lead two or more public outreach meetings to review the outcomes of Task 2 and prepare *Materials from Task 2 Stakeholder Webinar* to include copies of outreach materials, summary of each event and the feedback received.
    -
- Conduct a series of outreach events at the conclusion of Task 6, and prepare *Materials from Manufacturer Outreach* and *Materials from Large Commercial and Industrial Ratepayer Outreach* to include copies of outreach materials and summary of each event, feedback received and outcome/actions taken. The recipient will proceed with the following events, or others, at the direction of the CAM:
    - Manufacturer Outreach, participating or leading at least two events to leverage project team partnerships and industries
    - Large Commercial and Industrial Ratepayer Outreach via utility partnerships
- Prepare publications to include, but not be limited to, and provide copies of the final documents as *Prepared Publication #1 and Prepared Publication #2*:
    - At least two prepared industry papers, journal articles, and/or conference proceedings
    - A Project Synopsis summarizing results and findings to be posted online and made available to interested stakeholders. Provide weblink for the posting.

Products:

- Materials from Task 2 Stakeholder Webinar
- Materials from Manufacturer Outreach
- Materials from Large Commercial and Industrial Ratepayer Outreach
- Prepared Publication #2 (draft and final)
- Prepared Publication #1 (draft and final)

TASK 9: 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 10: TECHNOLOGY/KNOWLEDGE TRANSFER ACTIVITIES

The goal of this task is to ensure the scientific and techno-economic analysis and tools developed under this agreement are utilized in the energy policy, and/or planning decisions at the state and/or local levels, academic community and/or commercial sector.

The Recipient Shall:

- Develop and submit a *Knowledge Transfer Plan (draft and final)* that identifies the proposed activities the recipient will conduct to meet the goal of the task. The *Knowledge Transfer Plan* should include at a minimum:
  - Specific policy and planning efforts this project is expected to inform.
  - Specific stakeholder groups and energy policy and planning practitioners who will utilize the results of this project.
  - Proposed activities the recipient will conduct to ensure the tools and results from this project be utilized and adopted by the groups identified above.
- Present the *Draft Knowledge 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 Knowledge Transfer Plan*. This document will identify:
  - TAC comments the recipient proposes to incorporate into the *Final Knowledge Transfer Plan*.
  - TAC comments the recipient does not propose to incorporate with and explanation why.

- Submit the *Final Knowledge Transfer Plan* to the CAM for approval.
- Implement the activities as described in the *Final Knowledge Transfer Plan.*
- Develop a *Knowledge Transfer Summary Report (draft and 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:

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

V. PROJECT SCHEDULE

Please see the attached Excel spreadsheet.

RESOLUTION NO: 22-0713-10

STATE OF CALIFORNIA

STATE ENERGY RESOURCES
CONSERVATION AND DEVELOPMENT COMMISSION

RESOLUTION: Institute of Gas Technology dba Gas Technology Institute

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-22-001 with Institute of Gas Technology dba Gas Technology Institute for a $1,770,000 grant for a technical study of the impacts of using 100% hydrogen (H2) or fossil fuel blended with greater than 50% H2 in hard-to-electrify equipment in large commercial buildings and industrial processes. The study will assess the associated costs, safety implications, and emissions impacts of adopting H2-based fuels in these sectors; 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 July 13, 2022.

AYE:

NAY:

ABSENT:

ABSTAIN:

_____
Liza Lopez
Secretariat