California Energy Commission
January 24, 2024 Business Meeting
Backup Materials for Agenda Item No 09a:
Tour Engine, Inc.

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

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

RESOLUTION NO: 24-0124-09a

STATE OF CALIFORNIA

STATE ENERGY RESOURCES
CONSERVATION AND DEVELOPMENT COMMISSION

RESOLUTION: **Tour Engine, Inc.**

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

RESOLVED, that the CEC approves agreement PIR-23-008 with Tour Engine, Inc. for a $1,201,141 grant to develop and demonstrate the Tour Engine and the Tour ENABLE, a small engine based micro combined heat and power system using the 5-kW Tour Engine hybridized with a 15-kW battery. The Tour Engine and the Tour ENABLE system in San Diego County will run efficiently on high blends of hydrogen (exceeding 30 percent by volume) up to 100 percent in the fuel stream while mitigating greenhouse gas and oxides of nitrogen emissions; and

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

CERTIFICATION

The undersigned Secretariat to the CEC does hereby certify that the foregoing is a full, true, and correct copy of a resolution duly and regularly adopted at a meeting of the CEC held on January 24, 2024.

AYE:
NAY:
ABSENT:
ABSTAIN:

Dated:

_____
Kristine Banaag
Secretariat

STATE OF CALIFORNIA
CALIFORNIA ENERGY COMMISSION

CEC-270 (Revised 9/2022)

GRANT REQUEST FORM (GRF)

A. New Agreement Number

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

New Agreement Number: PIR-23-008

B. Division Information

1. Division Name: ERDD
2. Agreement Manager: Nadia Richards
3. MS-:None
4. Phone Number: 916-897-3804

C. Recipient's Information

1. Recipient's Legal Name: Tour Engine, Inc.
2. Federal ID Number: 20-3804442

D. Title of Project

Title of project: A Novel IC Engine Fueled by H2/CH4 Blends with High-Efficiency and Ultra-Low NOx Emissions for Prime Power Distributed Generation

E. Term and Amount

1. Start Date: 1/31/2024
2. End Date: 12/31/2027
3. Amount: $1,201,141.00

F. Business Meeting Information

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

Agenda Item Subject and Description:
Tour Engine, Inc. Proposed resolution approving agreement PIR-23-008 with Tour Engine, Inc. for a $1,201,141 grant to develop and demonstrate the Tour Engine and the Tour ENABLE, a small engine based micro combined heat and power system using the 5-kW Tour Engine hybridized with a 15-kW battery, and adopting staff's determination that this project is exempt from CEQA. The Tour Engine and the Tour ENABLE system in San Diego County will run efficiently on high blends of hydrogen (exceeding 30 percent by volume) up to 100 percent in the fuel stream while mitigating greenhouse gas and oxides of nitrogen emissions. (PIER NG funding) Contact: Nadia Richards

G. California Environmental Quality Act (CEQA) Compliance

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

   If yes, skip to question 2.

If no, complete the following (PRC 21065 and 14 CCR 15378) and explain why Agreement is not considered a "Project":

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

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

a) Agreement **IS** exempt?

Yes

Statutory Exemption?
No

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

PRC section number: None

CCR section number: None

Categorical Exemption?
Yes

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

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

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

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

The project includes the lab-scale demonstration of a 5kW split-cycle engine on an engine dynamometer and a pilot-scale demonstration using a micro combined heat and power (microCHP) system comprised of the 5-kW engine hybridized with a 15-kW battery. Both the engine and the microCHP system will have an integrated emissions mitigation system to achieve low oxides of nitrogen (NOx) emissions. The project will be developed, tested, and demonstrated at the lab scale at an existing research facility in San Diego Gas and Electric Co. service territory. The facility has been certified under the California Environmental Reporting System (CERS). This permitting covers the following: Business Activities, Business Owner/Operator Identification, Hazardous Material Inventory & Site Map, Emergency Response/Contingency Plan, as well as Employee Training Plan.

CEQA exempts certain projects from its provisions. One such exemption, found at California Code of Regulations, title 14, section 15301, provides that projects which consist of the operation, repair, maintenance, permitting, leasing, licensing, or minor alteration of existing public or private structures, facilities, mechanical equipment, or topographical features, and which involve negligible or no expansion of use are exempt. The proposed project will be located entirely within an existing facility that has the ability to operate through 2027. The proposed project will not expand the use of the facility because the project activities to design, modify, fabricate, and test the

engine and microCHP are in line with normal activities at the existing facility. Therefore, the project falls within section 15301 and will not have a significant effect on the environment.

CEQA also exempts projects that consist of basic data collection, research, experimental management, and resource evaluation activities which do not result in a serious or major disturbance to an environmental resource. (Cal. Code Regs., tit. 14, § 15306). The proposed project will involve research to operate on high blends of hydrogen, exceeding 30 percent by volume and going up to 100 percent, to maintain or increase the efficiency while mitigating greenhouse gas and NOx emissions. The use of hydrogen to displace some of the methane gas directly results in lower carbon-based greenhouse gases and the split-cycle engine has the advantage of producing ultra-low engine-out NOx emissions. The NOx emissions will be further mitigated using a urea-free Lean NOx Trap integrated with the engine. This work will not result in a serious or major disturbance to an environmental resource because the system is expected to perform for at least 500 hours producing low greenhouse gas and NOx emissions to demonstrate compliance with California Air Resources board (CARB) emissions by project conclusion, which is small in comparison to the overall facility footprint. For these reasons, the proposed project will have no significant effect on the environment and is categorically exempt under section 15306.

CEQA's exemptions are not absolute. Once a public agency, like the CEC, believes that a project may be exempt from environmental review, it must consider whether there are any exceptions that may preclude use of the exemption. The circumstances giving rise to an exception are listed in California Code of Regulations, title 14, section 15300.2. The proposed project 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. Therefore, for the reasons stated above, this project is exemption from environmental review under CEQA.

b) Agreement **IS NOT** exempt.
IMPORTANT: consult with the legal office to determine next steps.

No

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

Additional Documents	Applies
Initial Study	No
Negative Declaration	No
Mitigated Negative Declaration	No

Environmental Impact Report	No
Statement of Overriding Considerations	No
None	Yes

H. Subcontractors

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

Subcontractor Legal Company Name	CEC Funds	Match Funds
Institute of Gas Technology dba GTI Energy	$ 40,000	**$** 10,826
Johnson Matthey, Inc.	$ 99,200	**$** 26,848
Mend Energy LLC	$ 40,722	**$** 11,022

I. Vendors and Sellers for Equipment and Materials/Miscellaneous

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

Vendor/Seller Legal Company Name	CEC Funds	Match Funds
HORIBA Instruments Incorporated	$7,083	$1,917
TBD- Lab Inspection	$7,477	$2,023
TBD- Lab Diagnostics	$2,660	$720

J. Key Partners

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

Key Partner Legal Company Name
No key partners to report

K. Budget Information

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

Funding Source	Funding Year of Appropriation	Budget List Number	Amount
NG Subaccount, PIERDD	21-22	501.001	$ 1,201,141

TOTAL Amount: $ 1,201,141

R&D Program Area: EGRB: Renewables

Explanation for "Other" selection Not applicable

Reimbursement Contract #: Not applicable

Federal Agreement #: 601 Program Continuous Appropriation

L. Recipient's Contact Information

1. Recipient's Administrator/Officer

Name: Oded Tour

Address: 9889 Hibert St Ste E

City, State, Zip: SAN DIEGO, CA 92131-1062

Phone: 619-920-1623

E-Mail: oded@tourengine.com

3. Recipient's Project Manager

Name: Oded Tour

Address: 9889 Hibert St Ste E

City, State, Zip: San Diego, CA 92131-1062

Phone: 619-920-1623

E-Mail: oded@tourengine.com

M. Selection Process Used

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

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

N. Attached Items

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

Item Number	Item Name	Attached
1	Exhibit A, Scope of Work/Schedule	Yes

Item Number	Item Name	Attached
2	Exhibit B, Budget Detail	Yes
3	CEC 105, Questionnaire for Identifying Conflicts	Yes
4	Recipient Resolution	No
5	Awardee CEQA Documentation	No

Approved By

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

Agreement Manager: Nadia Richards

Approval Date: 11/30/2023

Branch Manager: Kevin Uy

Approval Date: 12/15/2023

Director: Delegated to the Branch Manager

Approval Date: 12/15/2023

Exhibit A
Scope of Work Template
Tour Engine, Inc.

I. TASK ACRONYM/TERM LISTS

A. Task List

Task #	CPR[1]	Task Name
1		General Project Tasks
2		Hydrogen Blends and Emissions Equipment Procurement
3	X	Tradeoff Investigation using Various H_2 blends
4		Lean NOx Trap Development
5	X	Preliminary Durability Testing of Tour Engine and Lean NOx Trap
6	X	Tour ENABLE microCHP System Development, Pilot Demonstration, and Durability Testing
7		Techno-economic Analysis
8		Life Cycle Assessment
9		Evaluation of Project Benefits
10		Technology/Knowledge Transfer Activities

B. Acronym/Term List

Acronym/Term	Meaning
CAM	Commission Agreement Manager
CAO	Commission Agreement Officer
CARB	California Air Resources Board
CEC	California Energy Commission
CH_2O	Formaldehyde
CH_4	Methane
CHP	Combined Heat and Power
CO	Carbon Monoxide
CPR	Critical Project Review
DG	Distributed Generation
DOE	Department of Energy
GHG	Green House Gas
GREET	Greenhouse gases, Regulated Emissions, and Energy use in Technologies
GTI	Gas Technology Institute
H_2	Hydrogen
HC	Hydrocarbons
LNT	Lean NOx Trap
NOx	Oxides of Nitrogen
Recipient	Tour Engine, Inc.
TAC	Technical Advisory Committee
TRL	Technology Readiness Level

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

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

A. Purpose of Agreement

The purpose of this Agreement is to fund the development and demonstration of the 5kW split-cycle Tour Engine, and the Tour ENABLE; which is a micro combined heat and power (CHP) generation system including the Tour Engine and a battery; with emissions-mitigating technology, that can both run efficiently on high blends of hydrogen (H_2) in the fuel stream while mitigating greenhouse gas (GHG) and oxides of nitrogen (NOx) emissions. This Agreement will support using increasingly higher blends of H_2 (exceeding 30 percent by volume) up to 100 percent, without compromising generation efficiencies and performance, to support meeting California's goals for carbon neutrality and improving public health and safety.

B. Problem/ Solution Statement

Problem

In-state gas-fired generation accounts for more than half of the power generation sector's GHG emissions in California.[2] Decarbonization efforts, such as using H_2 fuel blends, can be used to support California's ambitious GHG emission reduction goals of carbon neutrality by 2045. However, as the blends of H_2 reach high amounts exceeding 30 percent, the increasing NOx emissions and other criteria pollutants become a major concern. For H_2-gas-fired generation systems to be deployable in California, they will need to reduce criteria pollutant emissions, particularly NOx, to be compliant with California's air quality standards.[3] One of the major challenges for gas-fired engines is abating NOx to ultra-low levels, where the typical approach is to use over-sized urea Selective Catalytic Reduction systems. However, urea injection for small gas-fired applications is not a preferred path as it adds complexity to an otherwise relatively simple unit.

To get additional benefits, gas-fired generation can be combined with heat production in a CHP system. Typically to be economically and environmentally viable, CHP systems are required to be more than 100 kW and do not have an economic benefit in installations without a continuous high electrical demand. The systems are large because large engines are more efficient and the systems need to be highly efficient to have a return on investment, while small engines are not highly efficient. CHP systems of all sizes often have issues with NOx emissions. In terms of performance, conventional small gas-fired engines cannot maintain their efficiency while mitigating the NOx emissions, which is typically a negative outcome of adding high blends of H_2 to the methane (CH_4) fuel stream. Thus, large engines are used in the CHP system to make the system more efficient but makes the system bulkier and expensive. Also, no small gas-fired engine based microCHP system has been California Air Resources Board (CARB) certified and widely deployed.

Solution

The Recipient will develop and demonstrate the Tour Engine to operate on high blends of H_2 to maintain or increase the efficiency while mitigating GHG and NOx emissions. The Recipient's 5

[2] California Independent System Operator. Emissions, Today's Outlook, (https://www.caiso.com/TodaysOutlook/Pages/emissions.aspx)
[3] California Air Resources Board. Air District Rules, (https://ww2.arb.ca.gov/air-district-rules)

kW split-cycle engine uses the innovative Transfer Mechanism and Combustion Chamber to demonstrate high efficiency with ultra-low engine-out NOx emissions. The split-cycle Tour Engine has three principal advantages, which are (i) over-expansion of working fluid; (ii) a superior thermal management strategy; and (iii) ultra-low engine-out NOx emissions during combustion. NOx emissions mitigation will be further addressed using a urea-free Lean NOx Trap (LNT). By using the carbon monoxide (CO) and hydrocarbons (HC) already present in the engine exhaust, NOx can effectively be reduced with a LNT to ultra-low levels, meeting and exceeding the CARB regulation limits.

The Recipient will also develop and demonstrate the Tour ENABLE, which is designed to be the first small engine based microCHP system using the 5-kW Tour Engine hybridized with a 15-kW battery. The Tour ENABLE addresses typical CHP system issues by being micro-scale while maintaining high efficiency through hybridization and low emissions. The ENABLE system only operates the engine in the most efficient performance regions and uses the battery for load following and for providing the high peak demand, when needed. The Tour ENABLE will demonstrate CARB emissions compliance and will be an economically and environmentally viable system. The Tour ENABLE system cost per kW (~$5,000 per kW) will be more than a prime move and generator system alone as it combines energy storage (electrical and thermal) and grid connection (with built in solar integration). The Tour ENABLE will target the distributed generation (DG) prime and backup power for commercial and residential markets.

C. Goals and Objectives of the Agreement

Agreement Goals

The goals of this Agreement are to:

- Develop and demonstrate the Tour Engine that can operate on high blends of H_2, optimizes cost-efficiency, and minimizes carbon footprint.
- Demonstrate emissions mitigation for GHG and NOx during combustion, using the Tour Engine, and after combustion, using an LNT.
- Achieve CARB DG emissions compliant operation for the Tour ENABLE with a 5-kW prime power microCHP application.
- Demonstrate the durability and advance the maturity of the Tour Engine using the blended fuel.
- Develop and implement a safety plan to address safe operating thresholds, reduce leak reductions, and standard operating procedures to reduce safety risks.

Ratepayer Benefits: This Agreement will result in the ratepayer benefits of economic and environmental gains. Economic benefits are principally greater power availability, reduced electricity price, reduced grid operating costs, and resilience by using the DG system which lowers the grid congestion, reducing the peak prices and reducing load on transmission and distribution. Environmental benefits include decreased impacts from global climate change, reduced health risks related to poor outdoor air quality, and diminished environmental impact from energy generation and use by using high blends of H_2 and the LNT system.

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 having a highly efficient CHP system built from off the shelf components and that can run on available fuels ensuring lower system and electric cost. This will

motivate the end user to adapt to more DG systems that can use high blends of H_2. Distributed generation also adds total generation capacity to California, resulting in less need to import high CO_2 electricity from other areas.

Agreement Objectives

The objectives of this Agreement are to:

- Use steady blends of H_2, exceeding 30% by volume, along with a developed LNT for GHG and NOx emissions mitigation.
- Achieve CO emissions reductions of at least 60 percent from baseline taken at zero percent H_2 blend.
- Achieve NOx emissions parity or better with baseline taken at zero percent H_2 blend.
- Demonstrate a fully developed Tour ENABLE microCHP system that complies with CARB DG emission standards.
- Validate the electric generation efficiency to be at parity or better with baseline taken at zero percent H_2 blend.
- Demonstrate the durability for 500 cumulative hours of testing using blended fuel, including 300 continuous hours of operation (as part of the 500 cumulative hours), and assess the performance degradation and fuel impact on the capacity factor.
- Achieve an increase in maturity from Technology Readiness Level (TRL) 4 to TRL 6 by integration of the Tour Engine and the LNT into the Tour ENABLE microCHP system.
- Complete a detailed safety plan to identify at least 3 leading and lagging indicators to assess safety outcomes both proactively and retrospectively.
- Conduct a techno-economic analysis and a carbon intensity analysis that uses key factors in the cost of H_2 based on the U.S. Department of Energy (DOE)'s Hydrogen Shot goal for the procurement and generation costs.[4]

[4] U.S. Department of Energy. Hydrogen Shot. USDOE. (https://www.energy.gov/eere/fuelcells/hydrogen-shot)

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

MONTHLY CALLS, REPORTS AND INVOICES

Subtask 1.5 Monthly Calls
The goal of this task is to have calls at least monthly between the CAM and Recipient to verify that satisfactory and continued progress is made towards achieving the objectives of this Agreement on time and within budget.

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

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

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

Product:
- Email to CAM concurring with call summary notes.

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

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

Recipient Products:
- Quarterly Progress Reports
- Invoices

CAM Product:
- Invoice template
-

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

Subtask 1.7.1 Final Report Outline

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

Recipient Products:
- Final Report Outline (draft and final)

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

Subtask 1.7.2 Final Report

The Recipient shall:
- Prepare a *Final Report* for this Agreement in accordance with the approved Final Report

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

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

CAM Product:
- Written Comments on the Draft Final Report

MATCH FUNDS, PERMITS, AND SUBCONTRACTS

Subtask 1.8 Match Funds

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

While the costs to obtain and document match funds are not reimbursable under this Agreement, the Recipient may spend match funds for this task. 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 1.9 Permits

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

The Recipient shall:

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

  The list of permits and the schedule for obtaining them will be discussed at the Kick-off meeting (subtask 1.2), and a timetable for submitting the updated list, schedule, and copies of the permits will be developed. The impact on the project if the permits are not obtained in a timely fashion or are denied will also be discussed. If applicable, permits will be included as a line item in progress reports and will be a topic at CPR meetings.
- If during the course of the Agreement additional permits become necessary, then provide the CAM with an *Updated List of Permits* (including the appropriate information on each permit) and an *Updated Schedule for Acquiring Permits*.
- Send the CAM a *Copy of Each Approved Permit*.
- If during the course of the Agreement permits are not obtained on time or are denied, notify the CAM within 5 days. Either of these events may trigger a CPR meeting.

Products:

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

Subtask 1.10 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 1.11 Technical Advisory Committee (TAC)

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

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

The TAC may be composed of qualified professionals spanning the following types of disciplines:

- Researchers knowledgeable about the project subject matter;
- Members of trades that will apply the results of the project (e.g., designers, engineers, architects, contractors, and trade representatives);
- Public interest market transformation implementers;
- Product developers relevant to the project;
- U.S. Department of Energy research managers, or experts from other federal or state agencies relevant to the project;
- Public interest environmental groups;
- Utility representatives;
- Air district staff; and
- Members of relevant technical society committees.

The Recipient shall:

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

discussed at the Kick-off meeting, and a schedule for recruiting members and holding the first TAC meeting will be developed.
- Recruit TAC members. Ensure that each individual understands member obligations and the TAC meeting schedule developed in subtask 1.11.
- 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 1.12 TAC Meetings
The goal of this subtask is for the TAC to provide strategic guidance for the project by participating in regular meetings, which may be held via teleconference.

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

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

Products:
- TAC Meeting Schedule (draft and final)

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

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

The Recipient shall:

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

Products:

- TAC Performance Metrics Summary
- Project Performance Metrics Results

IV. TECHNICAL TASKS

TASK 2: HYDROGEN BLENDS AND EMISSIONS EQUIPMENT PROCUREMENT

The goal of this task is to source and procure the H_2 blends to be used in the Agreement and procure the emissions measurement system.

The Recipient shall:

- Prepare and provide a *Fuel Procurement Plan* that shows the use of Match Funds or other non-CEC funds for procuring the H_2 + CH_4 blends from a gas supplier that will have H_2 percentages greater than 30 percent volume. The Fuel Procurement Plan shall include but is not limited to the following:
    - Description of the approach for sourcing and procuring the H_2 to be used in the project.
    - Explanation of the process used to produce the H_2, and/or of the carbon intensity of the H_2 used in the fuel blend.
    - Explanation of how H_2 volumetric blend percentages will be measured and verified to remain accurate at the target blend percentage.
- Procure and install a NOx emissions analyzer capable of measuring lower than 5 ppm, as required for CARB certification.
- Procure and install a Fourier Transform Infrared Spectroscopy system to monitor Volatile Organic Compound, in particular formaldehyde (CH_2O) levels.
- Prepare and provide an *Equipment Measurement Report* that provides information on the different measurement systems. The Equipment Measurement Report includes but is not limited to the following:
    - A description of the facilities, equipment, and instrumentation required to conduct the tests.
    - A description of the calibration procedures to be used, and recommended calibration interval.
    - A description of parameters to be measured.

Products:

- Fuel Procurement Plan
- Equipment Measurement Report

TASK 2.1 MEASUREMENT AND VERIFICATION PLAN

The goal of this task is to describe how actual project benefits will be measured and quantified.

The Recipient Shall:

- Prepare and provide a *Measurement and Verification Plan* to summarize the metrics that will be evaluated and used in determining benefits that includes but is not limited to:
    - Equipment and methodologies that will be used to gather performance data.
    - Environmental and equity benefits from reducing GHG emissions and mitigating increases in NOx emissions.
    - Technology potential benefits for the adoption of new technology, strategy, and research results through innovative component redesigns and parts materials.

  - Increased market connection benefits across a range of sectors that use fossil gas onsite (commercial, industrial, and electric power) for the potential adoption of H_2 blends.
  - Safety benefits through development and demonstration of standard procedures when handling and operating generation systems using H_2 fuel blends.
  - Electric generation efficiency improvement benefits (electrical output compared to fuel energy input) when using the H_2 fuel blend.
- Consult with TAC on draft *Measurement and Verification Plan* to verify technical feasibility in accordance with subtask 1.10 (Technical Advisory Committee). Incorporate TAC feedback into the final *Measurement and Verification Plan* as appropriate.

Products:

- Measurement and Verification Plan (draft and final)

TASK 3: TRADEOFF INVESTIGATION USING VARIOUS H_2 BLENDS

The goal of this task is to select the optimal H_2/CH_4 blended fuel and the optimal Tour Engine hardware configuration by investigating the impact of H_2 fraction of various H_2/CH_4 blended fuels, up to 100% H_2.

The Recipient shall:

- Prepare and provide a *Parameter Test Plan* that shows the parameters to be tested and the range of test conditions to be evaluated. The Parameter Test Plan shall include but is not limited to:
  - Test objectives and technical approach.
  - A description of the test procedures.
  - The rationale for selecting those test procedures.
  - A test matrix showing the number of test conditions and replicated runs.
  - A description of the data analysis procedures.
  - Predicted performance based on calculations, modeling, or other analyses.
  - A description of quality assurance procedures; and
  - Contingency measures to be considered if the test objectives are not met.
  - A description of safety standard operating procedures for handling and operating the Tour Engine when using the H_2 fuel blends.
- Implement the *Parameter Test Plan* using the test system.
- If needed, optimize hardware configuration to the selected optimal H_2/CH_4 blended fuel.
- Prepare and provide a *Data Review Report* that includes but is not limited to:
  - Methods used during testing.
  - Description of any modifications that were made to the Tour Engine components to accommodate the increasing blends of H_2.
  - Evaluation of the Tour Engine performance and emission characteristics with various H_2/CH_4 blended fuels up to 100% H_2.
  - Selection of the optimal H_2/CH_4 blended fuel which can comply to the CARB DG NO_x emissions regulations while maintaining the highest possible engine efficiency.

  - Optimization of the Tour Engine hardware configurations, such as compression ratio, crank-offset, shuttle timing, etc., to maximize the benefits of H_2/CH_4 blended fuels.
  - Conclusion about how the results will impact and inform the next project phase.
- Prepare a CPR Report and participate in CPR meeting per subtask 1.3.

Products:

- Parameter Test Plan (draft and final)
- Data Review Report (draft and final)
- CPR Report #1

TASK 4: LEAN NO_X TRAP DEVELOPMENT
The goal of this task is to develop a fully formulated novel LNT to achieve ultra-low NOx emissions using the results of Task 3.

The Recipient shall:

- Prepare and provide a *Design Basis Summary* that presents the design criteria for the LNT that must be met to achieve a successful and cost-effective design. The *Design Basis Summary* will include but is not limited to:
  - The expectations for the incoming flow to the LNT.
  - Material design criteria (e.g., using standard components sizes and material grades).
  - Identifications of engineering designs standards that will be applicable.
  - Discussion about designing for emission compliance.
- Develop and simulate a LNT model to understand the H_2 impact on LNT behaviors.
- Design and build a LNT that optimizes the performance by adjusting the formulations, size, canning, etc. by using the information provided from Task 3.
- Procure, assemble, and conduct evaluation testing of the LNT on the Tour Engine.
- Develop a fully functional LNT which can meet the CARB DG Certification standards.
- Prepare and Provide a *Lean NOx Trap Report* that presents a summary of the LNT model, design, and testing outcomes. The Lean NOx Trap Report includes but is not limited to:
  - The assumptions used to develop the LNT model and the model results.
  - The results of the LNT testing and performance and comparison to the model.
  - A description of the challenge identified with the original design.
  - A discussion on any adjustments that were needed to obtain the final design.
  - A description of lessons learned.
  - The results showing compliance with the CARB DG certification standards.

Products:

- Design Basis Summary (draft and final)
- Lean NOx Trap Report (draft and final)

TASK 5: PRELIMINARY DURABILITY TESTING OF TOUR ENGINE AND LEAN NOx TRAP ON ENGINE DYNAMOMETER

The goal of this task is to perform engine dynamometer durability testing for initial evaluation of Tour Engine and LNT.

The Recipient shall:

- Develop the *Durability Test Plan* that shows the methods for the engine and NOx mitigation operation. This plan includes but is not limited to:
    - A description of how the LNT will be integrated into the Tour Engine. This description will include items such as:
        - Process flow diagrams.
        - Energy and mass balances for the engine and LNT system.
    - A detailed methodology for the test set points and operating conditions.
    - A description of the parameters that will be monitored and measured.
    - A detailed description of safety procedures to be used for handling and operating the Tour Engine and LNT when using the H_2 fuel blend.
- Optimize and modify the experimental system for the durability test.
- Conduct the durability test of Tour Engine and LNT for a minimum of 25 cumulative hours of testing using the blended fuel.
- Evaluate the Tour Engine performance.
- Evaluate the LNT performance.
- Prepare and provide the *Durability Test Report* that includes but is not limited to:
    - Background information about the experimental design.
    - Materials and methods used during testing.
    - Results and analysis of the testing of the Tour Engine, LNT, and the combined engine and LNT system.
    - Analyze the fuel impact on the capacity factor.
- Prepare a CPR Report and participate in CPR meeting per subtask 1.3.

Products:

- Durability Test Plan #1 (draft and final)
- Durability Test Report #1 (draft and final)
- CPR Report #2

TASK 6: TOUR ENABLE MICROCHP SYSTEM DEVELOPMENT, PILOT DEMONSTRATION, AND DURABILITY TESTING

The goal of this task is to integrate the Tour Engine and the LNT into the Tour ENABLE microCHP system, demonstrate the system with the optimal H_2/CH_4 blended fuel found from Task 3 with a goal to comply with the CARB DG certification requirements, and perform the durability testing.

TASK 6.1 SYSTEM INTEGRATION

The goal of this task is to integrate the Tour Engine and the LNT into the Tour ENABLE microCHP system.

The Recipient shall:

- Prepare and provide a *System Integration Plan* that will include but not be limited to:
  - A description of the battery specifications used in the Tour ENABLE that includes aspects such as the chemistry, capacity, cycle life, cell voltage, and selection process.
  - A description of how the Tour Engine and the LNT will be integrated into the Tour ENABLE system. This description will include items such as:
    - Process flow diagrams.
    - Energy and mass balances for the overall system.
- Integrate the Tour Engine and the LNT into the Tour ENABLE microCHP system.
- Prepare and provide a *CHP System Test Plan* to demonstrate the Tour ENABLE microCHP system that includes but is not limited to:
  - A detailed methodology for the test set points and operating conditions.
  - A description of the parameters that will be monitored and measured.
  - A description of the CARB DG certification requirements that will be monitored during testing.
  - A detailed description of safety procedures to be used for handling and operating the Tour ENABLE microCHP system when using the H_2 fuel blend.

Products:

- System Integration Plan (draft and final)
- CHP System Test Plan (draft and final)

TASK 6.2 PILOT DEMONSTRATION
The goal of this task is to secure a commitment from the host site and conduct the pilot demonstration.

The Recipient shall:

- Confirm a Pilot Demonstration Site.
- Provide an updated *Host Site Commitment Letter* signed by an authorized representative of the host site that includes but is not limited to:
  - Identifying the location of the site.
  - An explanation of the suitability for testing Tour ENABLE at the site.
  - A commitment to providing the site for testing Tour ENABLE.
- Test Tour ENABLE microCHP system with the optimal H_2/CH_4 blended fuel at the pilot demonstration site.
- Prepare and provide the *CHP System Test Report* that includes but is not limited to:
  - Background information about the experimental design.
  - Materials and methods used during testing.
  - Results and analysis of the testing of the integrated Tour ENABLE system that shows compliance with the CARB DG certification requirements. At the minimum the emissions will show:
    - CO emissions reductions of at least 60 percent from the baseline taken at zero percent H_2 blend.
    - NOx emissions parity or better with baseline taken at zero percent H_2 blend.
  - System durability for 500 cumulative hours.

- Electric generation efficiency parity or better with baseline taken at zero percent H_2 blend.
- Justification for advancing technology maturity from TRL 4 to TRL 6.
- Discussion on safety indicators to assess safely testing using high blends of H_2.

Products:

- Host Site Commitment Letter
- CHP System Test Report (draft and final)

TASK 6.3 DURABILITY TESTING
The goal of this task is to perform durability testing of Tour ENABLE microCHP system.

The Recipient shall:

- Develop the *Durability Test Plan* that shows the methods for the Tour ENABLE microCHP system and NOx mitigation operation. This plan includes but is not limited to:
  - A description of how the Tour Engine and the LNT will be integrated into the Tour ENABLE microCHP system. This description will include items such as:
    - Process flow diagrams.
    - Energy and mass balances for the Tour ENABLE microCHP system.
  - A detailed methodology for the test set points and operating conditions.
  - A description of the parameters that will be monitored and measured.
  - A detailed description of safety procedures to be used for handling and operating the Tour ENABLE microCHP system when using the H_2 fuel blend.
- Optimize and modify the experimental system for the durability test.
- Conduct the durability test of Tour ENABLE microCHP system for a minimum of 500 cumulative hours of testing using the blended fuel. The hours start accruing after the unit has reached stable operation. The 500 cumulative hours will include at least 300 continuous hours of operation.
- Evaluate the Tour ENABLE microCHP system performance.
- Prepare and provide the *Durability Test Report* that includes but is not limited to:
  - Background information about the experimental design.
  - Materials and methods used during testing.
  - Results and analysis of the testing of the Tour ENABLE microCHP system.
  - Analyze the fuel impact on the capacity factor.
- Prepare a CPR Report and participate in CPR meeting per subtask 1.3.

Products:

- Durability Test Plan #2 (draft and final)
- Durability Test Report #2 (draft and final)
- CPR Report #3

TASK 6.4 MEASUREMENT AND VERIFICATION REPORT
The goal of this task is to report on the actual project benefits that were realized for the Tour ENABLE microCHP system using high blends of H_2 for power generation with GHG and NOx mitigation.

The Recipient Shall:

- Prepare and provide a *Measurement and Verification Report* to that evaluates the outcomes of implementing the *Measurement and Verification Plan*. The report includes but it not limited to:
    - Review of Measurement and Verification protocol employed.
    - Measurements and calculations from testing period.
    - Analysis of Measurement and Verification results and use in determining the project benefits.

Products:

- Measurement and Verification Report (draft and final)

TASK 7: TECHNO-ECONOMIC ANALYSIS
The goal of this task is to determine the economic value of the Tour ENABLE microCHP system to end users, including the evaluation of the fuels and efficiency of the Tour ENABLE microCHP system.

The Recipient shall:

- Provide an independently prepared *Techno-economic Analysis Report* of the Tour ENABLE microCHP system that is based on the actual cost impacts associated with the H_2 procured for the project. The report includes, but is not limited to:
    - A description of the technical performance of the system when using the H_2 blended fuel that includes the electric generation efficiency, Nox emissions, and CO emissions.
    - An evaluation of the costs of H_2 for blending with Gas Utilities when projected out to full commercial deployment scale.
    - An evaluation of the generation cost, emissions control technology costs, full integrated system costs, and fuel costs compared to zero emission alternatives.
    - A cradle-to-cradle perspective for operating the Tour ENABLE microCHP system.
    - A description of the approach used for a break-even analysis, sensitivity analysis, assessment on the return on investment, payback period, and replicability of the project.
- Consult with TAC on draft *Techno-Economic Analysis Report* to verify technical feasibility in accordance with subtask 1.10 (Technical Advisory Committee). Incorporate TAC feedback into the final *Techno-Economic Analysis Report* as appropriate.

Products:

- Techno-economic Analysis Report (draft and final)

TASK 8: LIFE CYCLE ASSESSMENT
The goal of this task is to provide an assessment of the carbon reduction achieved by the Tour ENABLE microCHP system compared to the traditional gas-fired reciprocating engine microCHP system.

The Recipient shall:

- Provide an independently prepared *Life Cycle Assessment Report* of the Tour ENABLE microCHP system using GREET (Greenhouse gases, Regulated Emissions, and Energy use in Technologies) model, or other relevant software for carbon intensity analysis, that includes but is not limited to:
    - A description of the approach and methodology for assessing the lifecycle emissions of operating the system on the tested H_2 fuel blends.
    - The actual environmental impacts associated with the H_2 procured for the project will be used to evaluate the carbon intensity and compared with other low carbon H_2 pathways.
    - An evaluation of the carbon intensity of H_2 generation and blending technologies with Gas Utilities when projected out to full commercial deployment scale.
    - An evaluation of the carbon intensity of complete Tour ENABLE microCHP system production compared with zero emission alternatives.
    - Assumptions and system boundaries for the assessment.

Products:

- Life Cycle Assessment Report (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 conduct activities that will accelerate the commercial adoption of the technology being supported under this agreement. Eligible activities include, but are not limited to, the following:

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

The Recipient Shall:

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

summaries of the activities, results, and lessons learned of tasks performed relating to implementing the *Final Technology Transfer Plan*. This report should not include any proprietary information.

- When directed by the CAM, develop presentation materials for an CEC- sponsored conference/workshop(s) on the project.
- Provide at least (6) six *High Quality Digital Photographs* (minimum resolution of 1300x500 pixels in landscape ratio) of pre and post technology installation at the project sites or related project photographs.

Products:

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

V. PROJECT SCHEDULE

Please see the attached Excel spreadsheet.