California Energy Commission
March 12, 2026 Business Meeting
Backup Materials for The Regents of the University of California on behalf of the Berkeley campus

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

CALIFORNIA ENERGY COMMISSION

PROPOSED RESOLUTION: The Regents of the University of California on behalf of the Berkeley campus

RESOLUTION NO: 26-0312-XX

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 EPC-25-045 with The Regents of the University of California on behalf of the Berkeley campus for a $2,000,000 grant. This project aims to develop a cost-effective, energy-efficient air-to-water heat pump (AWHP) integrated with low-cost thermal energy storage (TES) to provide domestic hot water and space conditioning while enabling demand flexibility for residential buildings; and

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

APPROVED AND ADOPTED this 12th day of March 2026, by the following vote:

AYE:
NAY:
ABSENT:
ABSTAIN:

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 approved and adopted by affirmative vote of the CEC at a meeting held on March 12, 2026.

Kim Todd
Secretariat

STATE OF CALIFORNIA
CALIFORNIA ENERGY COMMISSION

CEC-270 (Revised 01/2026)

GRANT REQUEST FORM (GRF)

A. New Agreement Number

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

New Agreement Number: EPC-25-045

B. Division Information

1. Division Name: ERDD
2. Agreement Manager: Jason Tancher
3. MS-:51
4. Phone Number:

C. Recipient's Information

1. Recipient's Legal Name: The Regents of the University of California on behalf of its Berkeley campus

D. Title of Project

Title of project: Advancing Multifunction Air-to-Water Ultra-Low GWP Heat Pump with Thermal Energy Storage

E. Term and Amount

1. Start Date: 3/31/2026
2. End Date: 2/28/2031
3. Amount: $2,000,000

F. Business Meeting Information

1. Are the ARFVTP agreements $75K and under delegated to Executive Director? No
2. The Proposed Business Meeting Date: 3/12/2026
3. Consent or Discussion? Discussion
4. Business Meeting Presenter Name: Karen Perrin
5. Time Needed for Business Meeting: 5 minutes.
6. The email subscription topic is: Electric Program Investment Charge (EPIC) Program

Project Description:

G. **The Regents of the University of California on behalf of its Berkeley Campus.** Proposed resolution approving agreement EPC-25-045 with The Regents of the University of California, on behalf of its Berkeley campus for a $2,000,000 grant and adopting staff's recommendation that this action is exempt from CEQA. This project aims to develop a cost-effective, energy-efficient air-to-water heat pump (AWHP) integrated with low-cost thermal energy storage (TES) to provide domestic hot water and space conditioning while enabling demand flexibility for residential buildings. (EPIC funding) Contact: Karen Perrin

H. 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":

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.

   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 beyond that existing at the time of the lead agency's determination, are categorically exempt from the provisions of the California Environmental Quality Act (CEQA). The activities include developing high efficiency ultra-low global warming potential heating, ventilation, and air conditioning (HVAC) heat pumps to be tested in an existing laboratory and installed or used in existing buildings, especially, residential buildings. The equipment and materials would include, but may not be limited to, heating, ventilation, and air conditioning units; building energy controls (e.g., heating, cooling, lighting); and evaluation, measurement, and verification equipment (e.g., power meters, flow meters, sensors, and data loggers). The physical work would include installing this equipment. The project would not involve adding residential units or substantially enlarging buildings. Therefore, since this project will result in negligible or no expansion of existing use of the facilities, this project is exempt under Section 15301.

Cal. Code Regs., tit. 14, sec. 15306 provides that projects which 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 are exempt from the provisions of CEQA. The proposed project's data analysis activities will have no significant effect on the environment and fall within the categorical exemption of section 15306.

Additionally, the project will not impact an environmental resource of hazardous or critical concern where designated, precisely mapped, and officially adopted pursuant to law by federal, state, or local agencies; does not involve any cumulative impacts of successive projects of the same type in the same place that might be considered significant; does not involve unusual circumstances that might have a significant effect on the environment; will not result in damage to scenic resources within a highway officially designated as a state scenic highway; the project site is not included on any list compiled pursuant to Government Code section 65962.5; and the project will not cause a substantial adverse change in the significance of a historical resource. Therefore, none of the exceptions to categorical exemptions listed in CEQA Guidelines section 15300.2 apply to this project, and this project will not have a significant effect on the environment.

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

No

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

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

I. Is this project considered “Infrastructure”?

No

J. 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
Harvest Thermal, Inc.	$779,666	$0
SmithGroup, Inc.	$50,000	$0

K. 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

L. 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 Partner Legal Company to report

M. 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
EPIC	25-26	301.001M	$2,000,000

TOTAL Amount: $2,000,000

R&D Program Area: ICMB: Buildings

Explanation for "Other" selection Not applicable

Reimbursement Contract #: Not applicable

Federal Agreement #: Not applicable

N. Recipient's Contact Information

1. Recipient's Administrator/Officer

Name: Beata Najman

Address: 2195 Hearst Ave, Room 130

City, State, Zip: Berkeley, CA 94720-1108

Phone: 510-642-1400

E-Mail: cgaawards@berkeley.edu

2. Recipient's Project Manager

Name: Carlos Duarte

Address: 390 Wurster Hall #1839

City, State, Zip: Berkeley, CA 94720-1839

Phone: 208-599-4525

E-Mail: cduarte@berkeley.edu

O. Selection Process Used

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

Selection Process	Additional Information
Competitive Solicitation #	GFO-24-305
First Come First Served Solicitation #	Not Applicable
Other	Not Applicable

P. Attached Items

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

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

Approved By

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

Agreement Manager: Jason Tancher

Approval Date: 1/26/26

Branch Manager: Anthony Ng

Approval Date: 1/29/2026

Director: Jonah Steinbuck *(delegated to Manager)*

Approval Date: N/A

Exhibit A
Scope of Work
The Regents of the University of California, Berkeley

I. TASK AND ACRONYM/TERM LISTS

A. Task List

Task #	CPR[1]	Task Name
1		General Project Tasks
2	CPR1	Product Development
3	CPR2	Independent Laboratory Testing
4		Pre-Demonstration Field Testing
5	CPR3	Demonstration
6		Data Driven Analysis
7		Market Transformation
8		Evaluation of Project Benefits
9		Technology Transfer Activities

B. Acronym/Term List

Acronym/Term	Meaning
AHJ	Authority Having Jurisdiction
AWHP	Air-to-Water Heat Pump
CAM	Commission Agreement Manager
CAO	Commission Agreement Officer
CEC	California Energy Commission
CPR	Critical Project Review
DHW	Domestic Hot Water
GWP	Global Warming Potential
HVAC	Heating, ventilation, and air conditioning
TAC	Technical Advisory Committee
TES	Thermal Energy Storage

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

A. Purpose of Agreement

The purpose of this Agreement is to fund the product development of a residential multifunction air-to-water heat pump (AWHP) with thermal energy storage (TES), utilizing ultra-low global warming potential (GWP) R-290 refrigerant, and conduct laboratory testing, field demonstration, and relevant assessments to enable a safe deployment, energy efficient, and cost effective system to provide domestic hot water (DHW) and space heating and cooling in California homes.

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

B. Problem/ Solution Statement

Problem

The increased share of intermittent renewable energy sources, such as solar and wind, in the electrical grid system emphasizes the need for developing grid-interactive efficient buildings and appliances. Electricity consumers must actively participate in deploying demand-side management strategies to mitigate critical grid conditions, reduce electricity and grid system costs, and decrease both direct and indirect greenhouse gas (GHG) emissions. The challenge lies in creating a scalable solution that is cost effective, energy efficient, reliable, and safe for residential buildings.

Solution

This project will integrate a multifunction R-290 AWHP with a low-cost sensible TES system to deploy a solution that is more energy efficient and cost effective than typical and leading solutions to provide DHW and space heating and cooling in residential buildings. At minimum, the project will compare this system to common systems in existing homes (gas-fired DHW, tank or tankless with an independent gas furnace), a common electrification pathway for existing homes and all-electric new construction (heat pump water heater and independent air-to-air heat pump), and current market leading technologies (combined space heating and DHW). This proposed integrated system will enable electricity rate payers to shift equipment operation to lower electricity prices and carbon emissions. Since it is a multifunction AWHP, it can also avoid costs for electrical panel upgrades often associated with electrification projects. Furthermore, we will connect with Authorities Having Jurisdiction (AHJ) to identify California building code allowances, restrictions, voids, and ambiguities for designing, permitting, and installing systems with A3 (highly flammable), ultra-low global warming potential refrigerants in residential applications, and propose pathways for the removal of these barriers.

C. Goals and Objectives of the Agreement

Agreement Goals

The goals of this Agreement are to:

- Develop an integrated system consisting of a multifunction R-290 AWHP that provides DHW and space heating and cooling with low-cost sensible TES enabling demand flexibility for heating and hot water in residential buildings.
- Validate the proposed integrated system using whole building energy simulation, laboratory testing, and field demonstration under design and typical climate and grid conditions and construction methods relevant to the California residential building stock.
- Identify barriers in the California and broader US regulatory landscape for DHW and HVAC equipment utilizing A3, highly flammable refrigerants that include R-290 (propane) and propose viable pathways for the removal of these barriers.

Ratepayer Benefits:[2] This Agreement will result in the ratepayer benefits of lower direct and indirect greenhouse gas emissions, reduced energy use, lower costs, and increased safety by developing a cost effective and energy efficient multifunction AWHP with TES utilizing an ultra-low GWP (≤3) refrigerant to provide DHW and space heating and cooling which is a major portion of residential ratepayers' energy bills. The proposed integrated system enables demand flexibility to mitigate periods of critical grid conditions and target lower electricity costs and lower carbon emissions periods. As the solution inherently supports load shifting for what is typically a substantial new residential electricity load, it also has significant benefits to the electricity grid, in avoiding the cost of new capacity, improving resiliency, and reducing the cost of meeting our grid de-carbonization goals.

Technological Advancement and Breakthroughs:[3] 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 validating the high performance of a multifunction AWHP with TES utilizing ultra-low GWP (≤3), R-290 refrigerant and demonstrating its safe deployment in a typical residential building by working with Authorities Having Jurisdiction and other regulatory agencies.

Agreement Objectives

The objectives of this Agreement are to:

- Design and control an integrated system consisting of a multifunction R-290 AWHP and TES to provide DHW and space heating and cooling at lower first and operational costs than typical competitive and emerging products on the market today.
- Validate the proposed integrated system in a controlled laboratory setting capable of operating at a higher coefficient of performance than typical competitive and emerging residential DHW and HVAC system designs.
- Demonstrate a safe deployment of the proposed integrated system in an actual residential home.
- Acquire data, assess life cycle costs, perform simulations, and develop resources to aid homeowners and other building stakeholders in assessing the impact of installing and operating the proposed integrated system.

[2] California Public Resources Code, Section 25711.5(a) requires projects funded by the Electric Program Investment Charge (EPIC) to result in ratepayer benefits. The California Public Utilities Commission, which established the EPIC in 2011, defines ratepayer benefits as greater reliability, lower costs, and increased safety (See CPUC "Phase 2" Decision 12-05-037 at page 19, May 24, 2012, http://docs.cpuc.ca.gov/PublishedDocs/WORD_PDF/FINAL_DECISION/167664.PDF).

[3] California Public Resources Code, Section 25711.5(a) also requires EPIC-funded projects to lead to technological advancement and breakthroughs to overcome barriers that prevent the achievement of the state's statutory and energy goals.

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, and other CEC staff relevant to the Agreement. The Recipient's Project Manager and any other individuals deemed necessary by the CAM or the Project Manager shall participate in 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., Teams, Zoom), with approval of the CAM.

  The Kick-off meeting will include discussion of the following:
  - The CAM's expectations for accomplishing tasks described in the Scope of Work;
  - An updated Project Schedule;
  - Terms and conditions of the Agreement;
  - Invoicing and auditing procedures;
  - Travel;
  - Equipment purchases;

- Administrative and Technical products (subtask 1.1);
- CPR meetings (subtask 1.3);
- Monthly Calls (subtask 1.5)
- Quarterly Progress reports (subtask 1.6)
- Final Report (subtask 1.7)
- Match funds (subtask 1.8);
- Permit documentation (subtask 1.9);
- **Obtain and Execute Subawards and Agreements with Site Hosts**
- (subtask 1.10);
- Technical Advisory Committee meetings (subtasks 1.11 and 1.12);
- Agreement changes;
- Performance Evaluations; 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 may 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 may 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. A determination of unsatisfactory progress. This may result in project delays, including a potential Stop Work Order, while the CEC determines whether the project should continue.
- 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(s)
- 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 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* organized by the tasks in the Agreement.

Products:

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

MONTHLY CALLS, REPORTS AND INVOICES

Subtask 1.5 Monthly Calls

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

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

The CAM shall:

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

The Recipient shall:

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

Product:

- Email to CAM concurring with call summary notes.

Subtask 1.6 Quarterly Progress Reports and Invoices

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

The Recipient shall:

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

Recipient Products:

- Quarterly Progress Reports
- Invoices

CAM Product:

- Invoice template

Subtask 1.7 Final Report

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

Subtask 1.7.1 Final Report Outline

The Recipient shall:

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

Recipient Products:

- Final Report Outline (draft and final)

CAM Products:

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

Subtask 1.7.2 Final Report

The Recipient shall:

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

Products:

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

CAM Product:

- Written Comments on the Draft Final Report

MATCH FUNDS, PERMITS, AND SUBAWARDS

Subtask 1.8 Match Funds

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

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

The Recipient shall:

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

  If match funds were a part of the application that led to the CEC awarding this Agreement, then provide in the letter:
  - A list of the match funds that identifies:
    - The amount of cash match funds, their source(s) (including a contact name, address, and telephone number), and the task(s) to which the match funds will be applied.
    - The amount of each in-kind contribution, a description of the contribution type (e.g., property, services), the documented market or book value, the source (including a contact name, address, and telephone number), and the task(s) to which the match funds will be applied. If the in-kind contribution is equipment or other tangible or real property, the Recipient must identify its owner and provide a contact name, address, telephone number, and the address where the property is located.
    - If different from the solicitation application, provide a letter of commitment from an authorized representative of each source of match funding that the funds or contributions have been secured.
- At the Kick-off meeting, discuss match funds and the impact on the project if they are significantly reduced or not obtained as committed. If applicable, match funds will be included as a line item in the progress reports and will be a topic at CPR meetings.
- Provide a *Supplemental Match Funds Notification Letter* to the CAM of receipt of additional match funds.
- Provide a *Match Funds Reduction Notification Letter* to the CAM if existing match funds are reduced during the course of the Agreement. Reduction of match funds may trigger a CPR meeting.

Products:

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

Subtask 1.9 Permits

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

The Recipient shall:

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

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

Products:

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

Subtask 1.10 Obtain and Execute Subawards and Agreements with Site Hosts

The goal of this task is to ensure quality products and to execute subrecipients and site host agreements, as applicable, required to carry out the tasks under this Agreement consistent with the Agreement Terms and Conditions and the Recipient's own procurement and contracting policies and procedures.

The Recipient shall:

- Execute and manage subawards and coordinate subrecipients activities in accordance with the requirements of this Agreement.
- Execute and manage site host agreements, and ensure the right to use the project site throughout the term of the Agreement, as applicable. A site host agreement is not required if the Recipient is the site host.
- Notify the CEC in writing immediately, but no later than five calendar days, if there is a reasonable likelihood the project site cannot be acquired or can no longer be used for the project.
- Incorporate this Agreement by reference into each subaward.
- Include any required Energy Commission flow-down provisions in each subaward, in addition to a statement that the terms of this Agreement will prevail if they conflict with the subaward terms.
- Submit a *Subaward and Site Letter* to the CAM describing the subawards and any site host agreement needed or stating that no subawards or site host agreements are required.
- If requested by the CAM, submit a draft of each *Subaward* and any *Site Host Agreement* required to conduct the work under this Agreement.
- If requested by the CAM, submit a final copy of each executed *Subaward* and any *Site Host Agreement*.
- Notify and receive written approval from the CAM prior to adding any new subrecipient (see the terms regarding subrecipient additions in the terms and conditions).

Products:

- Subaward and Site Letter
- Draft Subawards *(if requested by the CAM)*
- Draft Site Host Agreement *(if requested by the CAM)*
- Final Subawards *(if requested by the CAM)*
- Final Site Host Agreement *(if requested by the CAM)*

TECHNICAL ADVISORY COMMITTEE

Subtask 1.11 Technical Advisory Committee (TAC)

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

- Provide guidance in project direction. The guidance may include scope and methodologies, timing, and coordination with other projects. The guidance may be based on:
  - Technical area expertise;
  - Knowledge of market applications; or
  - Linkages between the Agreement work and other past, present, or future projects (both public and private sectors) that TAC members are aware of in a particular area.
- Review products and provide recommendations for needed product adjustments, refinements, or enhancements.
- Evaluate the tangible benefits of the project to the state of California, and provide recommendations as needed to enhance the benefits.
- Provide recommendations regarding information dissemination, market pathways, or commercialization strategies relevant to the project products.

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

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

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

The Recipient shall:

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

Products:

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

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

The Recipient shall:

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

*Products that require a draft version are indicated by marking **"(draft and final)"** after the product name in the "Products" section of the task/subtask. If "(draft and final)" does not appear after the product name, only a final version of the product is required. **Subtask 1.1 (Products)** describes the procedure for submitting products to the CAM.*

TASK 2: PRODUCT DEVELOPMENT

The goal of this task is to develop an integrated system consisting of a multifunction AWHP utilizing ultra-low GWP, R-290 refrigerant that provides DHW and space heating and cooling with TES to enable space and water heating demand flexibility in residential buildings.

The Recipient shall:

- Adapt multifunction R-290 AWHP electrical power supply for use with US electricity standards.
- Test and characterize multifunction R-290 AWHP at application-relevant operating points.
- Design and develop heat exchanger and controls to integrate TES system with a multifunction R-290 AWHP.
- Adapt existing load shifting and whole system performance optimization algorithm to a multifunction R-290 AWHP.
- Build and control functionally complete prototypes for climate chamber laboratory testing and field demonstration.
- Prepare *Integration of Multifunction R-290 Air to Water Heat Pump with Thermal Energy Storage Report* which includes, but is not limited to discussing:
    - Process and results of the product development phase in the project
    - Testing of the product
    - Technical issues
    - Lessons learned for this phase in the project

- Submit the draft *Integration of Multifunction R-290 Air to Water Heat Pump with Thermal Energy Storage Report* to the CAM for feedback and incorporate changes as requested in the final report.
- Prepare a *CPR Report #1* and participate in a CPR meeting in accordance with subtask 1.3 (CPR Meetings).

Products:
- Integration of Multifunction R-290 Air to Water Heat Pump with Thermal Energy Storage Report (draft and final)
- CPR Report #1

TASK 3: INDEPENDENT LABORATORY TESTING
The goal of this task is to validate the high performance and load shifting capabilities of the integrated multifunction R-290 AWHP and TES through laboratory testing under various California design and typical climate and grid conditions. A laboratory testing plan will be developed to ensure replicability and an accurate assessment of a multifunction AWHP with a TES system.

The Recipient shall:
- Establish laboratory testing methods to demonstrate under various California climates and grid conditions the:
  - Coefficient of performance for the proposed integrated system
  - Load shifting capabilities of the proposed integrated system
- Create a *Laboratory Testing Plan* that includes but is not limited to an outline of:
  - Measurement tools and sensors required for verification
  - The tests being conducted
  - Critical metrics being validated
- Validate and calibrate system sensors
- Conduct laboratory testing according to the laboratory testing plan.
  - Prepare a draft *Laboratory Testing Report* which includes, but is not limited to discussing:
    - Process and results of the laboratory testing
    - Testing of the product
    - Technical issues and lessons learned
- Submit the draft *Laboratory Testing Report* to the CAM for feedback and incorporate changes as requested in the final *Laboratory Testing Report*
- Prepare a *CPR Report #2* and participate in a CPR meeting in accordance with subtask 1.3 (CPR Meetings).

Products:
- Laboratory Testing Plan (draft and final)
- Laboratory Testing Report (draft and final)
- CPR Report #2

TASK 4: PRE-DEMONSTRATION FIELD TESTING

The goal of this task is to prepare for and inform the safe field deployment of the integrated multifunction R-290 AWHP and TES by deploying the system in a semi-controlled, yet realistic, building reasonably representative of a single-family home. We will work closely with the AHJ at the demonstration site to permit, install, and operate the system under simulated residential conditions, enabling iterative testing of control strategies for longer durations than possible in a highly controlled laboratory setting. Insights gained from this evaluation will directly inform the subsequent field demonstration (Task 5) in an occupied residential property. The demonstration site is located in a Disadvantaged and Low-Income community according to the California Climate Investments Priority Populations Map (4.0).

The Recipient shall:

- Perform investigation to evaluate various retrofit adaptations of the existing residential DHW and HVAC system to AWHP system to:
  - Assess cost-effectiveness, benefits, and disadvantages of single and multi-zone system designs, such as single hydronic coil for central air distribution and multizone hydronic distribution designs for new and existing residential construction.
  - Develop guidelines to cost-effectively retrofit existing DHW and HVAC systems to multifunction AWHP systems for California homes.
- Create a *Pre-Demonstration Site Testing Plan* that includes but is not limited to an outline of:
  - Measurement tools and sensors required for verification
  - The procedures to be used for measurements and verification
  - Critical metrics being validated
  - The timeline for the installation and associated acquisition of data
- Submit the draft *Pre-Demonstration Site Testing Plan* to the CAM for feedback and incorporate changes as requested in the final plan.
- Design the equipment layout, hydronic distribution, and zone terminal locations for the pre-demonstration at the site.
- Obtain permit in accordance with subtask 1.9 (Permits) from the relevant AHJ for the installation of the multifunction R-290 AWHP with TES for the pre-demonstration at the site, including developing and submitting Alternative Means and Methods Requests as required by the AHJ.
- Install and commission the proposed integrated system at the demonstration site.
- Prepare a draft *Factory-Sealed, Ultra-Low Global Warming Potential R-290 Multifunction Air to Water Heat Pump with Thermal Energy Storage Testing Report* which includes but not limited to discussing:
  - Process, results, and impacts of the demonstration projects
  - Weather normalized results of measured performance data
  - Electricity consumption and coefficient of performance for the combined DHW and HVAC equipment
  - Emissions associated with electricity consumption using grid marginal carbon emissions or other dynamic signal sources such as MIDAS, WattTime, and dynamic utility prices that are proposed to be available to the public in the near future.
  - Load shifting capabilities under different dynamic and/or time-of use rates.
  - Testing of the product
  - Technical issues and lessons learned

Products:

- Pre-Demonstration Site Testing Plan (draft and final)
- Factory-Sealed, Ultra-Low Global Warming Potential R-290 Multifunction Air to Water Heat Pump with Thermal Energy Storage Testing Report (draft and final)

TASK 5: DEMONSTRATION

The goal of this task is to demonstrate the safe and efficient deployment of the integrated multifunction R-290 AWHP and TES in typical residential settings. This will be accomplished by working with the AHJ to find permitting pathways to deploy a representative home. The demonstration site is located in a Low-Income community according to the California Climate Investments Priority Populations Map (4.0). The building is owned by the nonprofit Resources for Community Development, and replacing their aging existing equipment at no cost will directly benefit that organization and the low-income community members it serves.

The Recipient shall:

- Create a *Demonstration Site Measurement & Verification Plan* that includes but is not limited to an outline of:
  - Measurement tools and sensors required for verification
  - The procedures to be used for measurements and verification
  - Critical metrics being validated
  - The timeline for the installation and associated acquisition of data
- Submit the draft *Demonstration Site Measurement & Verification Plan* to the CAM for feedback and incorporate changes as requested in the final plan.
- Install new submetering equipment as required to measure natural gas and electricity consumption of DHW and HVAC systems for demonstration site.
- Develop installation documentation and training for contractors.
- Submit an *Installation Documentation and Training Memo* that includes digital photographs of the installation and examples of training materials.
- Design the equipment layout, hydronic distribution, and zone terminal locations for the demonstration site.
- Obtain permit in accordance with subtask 1.9 (Permits) from the relevant AHJ for the installation of multifunction R-290 AWHP with TES at the demonstration site, including developing and submitting Alternative Means and Methods Requests as required by the AHJ.
- Install and commission the proposed integrated system at the demonstration site.
- Develop a questionnaire for building occupant interviews to assess user experience.
- Conduct building occupant interviews to assess the user experience of the proposed integrated system.
- Prepare a draft *Factory-Sealed, Ultra-Low Global Warming Potential R-290 Multifunction Air to Water Heat Pump with Thermal Energy Storage Regent Demonstration Report* which includes but not limited to discussing:
  - Process, results, and impacts of the demonstration project
  - Weather normalized results of pre- and post- measurement data
  - Change in energy consumption and cost of natural gas and electricity for DHW and HVAC equipment
  - Change in carbon emissions from natural gas and associated emissions from electricity using grid marginal carbon emissions or other dynamic signal sources such as MIDAS,

WattTime, and dynamic utility prices that are proposed to be available to the public in the near future.
    - Testing of the product
    - Technical issues and lessons learned
- Submit the draft *Factory-Sealed, Ultra-Low Global Warming Potential R-290 Multifunction Air to Water Heat Pump with Thermal Energy Storage Demonstration Report* to the CAM for feedback and incorporate changes as requested in the final report.
- Prepare a *CPR Report* #3 and participate in a CPR meeting in accordance with subtask 1.3 (CPR Meetings).

Products:
- Demonstration Site Measurement & Verification Plan (draft and final)
- Installation Documentation and Training Memo
- Factory-Sealed, Ultra-Low Global Warming Potential R-290 Multifunction Air to Water Heat Pump with Thermal Energy Storage Demonstration Report (draft and final)
- CPR Report #3

TASK 6: DATA DRIVEN ANALYSIS
The goal of this task is to support the transition of California's residential building stock to ultra-low GWP refrigerants, sustainable, cost effective, and energy efficient DHW and HVAC systems by evaluating hot water and space conditioning load patterns and assessing the technical, economic, and environmental impacts of adopting AWHP systems.

The Recipient shall:
- Coalesce existing DHW consumption data to characterize usage patterns to inform proposed integrated system design, performance modeling, and webtool.
- Identify housing types common in disadvantaged and low-income communities and neighborhoods, especially older homes with limited panel capacity, inefficient gas or resistance-based systems, and low-performance envelopes.
- Develop model-based design workflow to analyze the operational performance of the proposed integrated system in California climate zones and grid conditions.
- Conduct whole building energy simulations performed with EnergyPlus and related tools to compare the operational performance of the proposed ultra-low GWP multifunction R-290 AWHP with TES to other typical competitive and emerging product alternatives. Report in *Initial Simulation Results Memo.*
- Evaluate the impact on first costs of switching from typical DHW and HVAC systems to AWHP based systems.
- Evaluate the impact on embodied carbon and greenhouse gas emissions of switching from typical DHW and HVAC systems to AWHP based systems.
- Prepare *Performance, Cost, and Environmental Assessment of Factory-Sealed, Ultra-Low Global Warming Potential R-290 Multifunction Air to Water Heat Pump with Thermal Energy Storage for California Homes Report* including but not limited to:
    - Process, results, and impacts of collected data and simulation results
    - Change in energy consumption and cost of natural gas and electricity for DHW and HVAC equipment
    - Change in carbon emissions from natural gas and associated emissions from electricity using grid marginal carbon emissions or other dynamic signals from MIDAS, WattTime, or similar.

  - Technical issues and lessons learned
- Submit the draft *Performance, Cost, and Environmental Assessment of Factory-Sealed, Ultra-Low Global Warming Potential R-290 Multifunction Air to Water Heat Pump with Thermal Energy Storage for California Homes Report* to the CAM for feedback and incorporate changes as requested in the final report.

Products:
- Initial Simulation Results Memo
- Performance, Cost, and Environmental Assessment of Factory-Sealed, Ultra-Low Global Warming Potential R-290 Multifunction Air to Water Heat Pump with Thermal Energy Storage for California Homes Report (draft and final)

TASK 7: MARKET TRANSFORMATION
The goal of this task is to develop public resources, training materials, tools, and hold interviews with AHJ that drive the adoption of AWHP based DHW and HVAC systems with ultra-low GWP refrigerants in residential buildings.

The Recipient shall:
- Develop AHJ interview questions and framework to compile data on constraints, barriers, and knowledge gaps that prevent permitting of DHW and HVAC equipment with A3 refrigerants such as R-290 in residential homes. Report in *Interview Questions and Framework Memo.*
- Recruit and conduct AHJ interviews
- Develop a web-based *Simplified Design Tool* to aid homeowners and other residential building stakeholders in exploring the performance and impact of switching to ultra-low GWP multifunction AWHP systems with thermal storage. The web tool features will include but limited to:
  - Include preloaded ‘example’ DHW and HVAC load profiles and capability for hourly annual data
  - Allow users to select location (weather and electricity grid carbon emissions data) and add utility costs and escalation rates.
  - Allow selection of different design options (equipment sizing, tank sizes, etc)
  - Quantify energy and carbon emission impacts of design options
- Develop *Residential Building Decarbonization Policy Recommendation Report* including but not limited to:
  - Results of the AHJ interviews
  - Recommendation for changes in incentive programs, training programs, certification programs, and codes and standards to drive adoption of ultra-low GWP AWHP systems
- Submit the draft *Residential Building Decarbonization Policy Recommendation Report* to the CAM for feedback and incorporate changes as requested in the final report.
- Develop *Installation Documentation and Training Materials for Multifunction R-290 Air to Water Heat Pumps in Residential Buildings* targeted towards residential contractors to facilitate the installation of R-290 AWHP systems.
- Submit the draft *Installation Documentation and Training Materials for Multifunction R-290 Air to Water Heat Pumps in Residential Buildings* to the CAM for feedback and incorporate changes as requested in the final report.

Products:

- Interview Questions and Framework Memo
- Residential Building Decarbonization Policy Recommendation Report (draft and final)
- Simplified Design Tool
- Installation Documentation and Training Materials for R-290 Air to Water Heat Pumps in Residential Buildings (draft and final)

TASK 8: EVALUATION OF PROJECT BENEFITS

The goal of this task is to report the benefits resulting from this project.

The Recipient shall:

- Complete *the Initial Project Benefits Questionnaire*. The Initial Project Benefits Questionnaire shall be initially completed by the Recipient with 'Kick-off' selected for the 'Relevant data collection period' and submitted to the CAM for review and approval.
- Complete the *Annual Survey* by January 31st of each year. The Annual Survey includes but is not limited to the following information:
    - Technology commercialization progress
    - New media and publications
    - Company growth
    - Follow-on funding and awards received
- Complete the *Final Project Benefits Questionnaire*. The Final Project Benefits Questionnaire shall be completed by the Recipient with 'Final' selected for the 'Relevant data collection period' and submitted to the CAM for review and approval.
- Respond to CAM questions regarding the questionnaire drafts.
- Complete and update the project profile on the CEC's public online project and recipient directory on the Energize Innovation website (www.energizeinnovation.fund), and provide *Documentation of Project Profile on EnergizeInnovation.fund*, including the profile link.
- If the Prime Recipient is an Innovation Partner on the project, complete and update the organizational profile on the CEC's public online project and recipient directory on the Energize Innovation website (www.energizeinnovation.fund), and provide *Documentation of Organization Profile on EnergizeInnovation.fund*, including the profile link.

Products:

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

TASK 9: TECHNOLOGY 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.
- When directed by the CAM, participate in annual EPIC symposium(s) sponsored by the CEC.
- 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.
- Publish at least three *Peer-Reviewed Papers* in relevant academic and industry venues, leveraging the work in the above tasks.
- Host extensive industry outreach through at least six presentations at different conference venues including but not limited to relevant academic and industry conferences such as ASHRAE, ACEEE, and IBPSA, the CBE industry conference.
- Host a free-to-public continuing education class (e.g. in collaboration with PG&E)
- Create a *Decarbonization of Residential Buildings Video* summarizing impact of the demonstration project(s) and public resources created by the research team.

Products:

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

- Decarbonization of Residential Buildings Video

V. PROJECT SCHEDULE

Please see the attached Excel spreadsheet.