California Energy Commission
March 12, 2026 Business Meeting
Backup Materials for The Regents of the University of California on behalf of the Davis 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 Davis 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-25-040 with The Regents of the University of California on behalf of the Davis campus for a $1,301,773 grant. Project will develop and test two distinct technology pathways for achieving ultra-low GWP heat pump technologies that are safe, efficient, cost-effective, and well-suited for California's residential market; 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-25-040

B. Division Information

1. Division Name: ERDD
2. Agreement Manager: Felix Villanueva
3. MS-:51
4. Phone Number: 916-776-0822

C. Recipient's Information

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

D. Title of Project

Title of project: Developing and Evaluating Two Design Approaches for Space Conditioning Heat Pumps Using Ultra-Low GWP Refrigerants

E. Term and Amount

1. Start Date: 3/31/2026
2. End Date: 6/30/2030
3. Amount: $1,301,773.00

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: Harrison Reynolds
5. Time Needed for Business Meeting: 5 minutes.
6. The email subscription topic is: EPIC

Project Description:

Proposed resolution approving agreement EPC-25-040 with The Regents of the University of California on behalf of the Davis campus for a $1,301,773 grant and adopting staff's recommendation that this action is exempt from CEQA. This project aims to develop and evaluate two innovative residential heat pump systems that utilize ultra-low global warming potential (GWP) refrigerants to support California's decarbonization goals. The first pathway utilizes an air-to-water (ATW) design with R-290 (propane) and integrated phase-change material thermal energy storage (TES) to ensure safety and grid responsiveness. The second pathway focuses on a variable-speed air-to-air (ATA) heat pump optimized for high-glide, ultra-low GWP refrigerants, such as hydrofluoroolefins like R-474B, paired with an ice-based TES system for enhanced load flexibility. By testing both secondary-loop and direct-expansion architectures, the project will provide critical insights into the technical, economic, and policy trade-offs between safety, efficiency, and equity. Ultimately, these efforts seek to accelerate the transition to climate-aligned heating and cooling technologies while maintaining high performance and cost-effectiveness for California residents.

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":

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 activities would 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.

   The above activities fall under two categorical exemptions. First, the operation, repair, maintenance, permitting, licensing, and minor alteration of existing public or private structures, facilities, and mechanical equipment, involving negligible or no expansion of use, falls under California Code of Regulations, title 14, section 15301.

Second, the project includes data collection and analysis to be conducted in residential buildings and in existing laboratories of the grant recipient team. California Code of Regulations, title 14, section 15306 exempts basic data collection, research, experimental management, and resource evaluation activities that do not result in a serious or major disturbance to an environmental resource. The proposed project's data analysis activities will have no significant effect on the environment and fall within the categorical exemption of section 15306.

This project does not involve impacts on any particularly sensitive environment; does not involve any cumulative impacts of successive projects of the same type in the same place that might be considered significant; does not involve unusual circumstances that might have a significant effect on the environment; will not result in damage to scenic resources within a highway officially designated as a state scenic highway; the project site is not included on any list compiled pursuant to Government Code section 65962.5; and the project will not cause a substantial adverse change in the significance of a historical resource. Therefore, none of the exceptions to categorical exemptions listed in CEQA Guidelines section 15300.2 apply to this project, and this project will not have a significant effect on the environment.

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

No

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

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

H. Is this project considered “Infrastructure”?

No

I. 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
TRC Engineers, Inc.	$ 90,000	**$**0

J. 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
Trane U.S., Inc.	**$**0	**$**350,000

K. 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

L. 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	$1,301,773

TOTAL Amount: $1,301,773

R&D Program Area: ICMB: Buildings

Explanation for "Other" selection Not applicable

Reimbursement Contract #: Not applicable

Federal Agreement #: Not applicable

M. Recipient's Contact Information

1. Recipient's Administrator/Officer

Name: Ryan Briard

Address: 215 Sage St Ste 100 Suite 100

City, State, Zip: Davis, CA 95616-7379

Phone: 530-752-6548

E-Mail: rbriard@ucdavis.edu

2. Recipient's Project Manager

Name: Curtis Harrington

Address: 215 Sage St Ste 100

City, State, Zip: Davis, CA 95616-7379

Phone: 530-754-7670

E-Mail: csharrington@ucdavis.edu

N. 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

O. 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: Felix Villanueva

Approval Date: 1/15/26

Branch Manager: Anthony Ng

Approval Date: 1/26/26

Director: Jonah Steinbuck delegated to the Branch Manager

Approval Date: 1/26/26

EXHIBIT A
SCOPE OF WORK
The Regents of the University of California on behalf of the Davis campus

I. TASK AND ACRONYM/TERM LISTS

A. Task List

Task #	CPR[1]	Task Name
1		General Project Tasks
2		Development of Enhanced Secondary Loop Design For R-290 ATW Heat Pumps
3		Laboratory Test of ATW Heat Pump with Integrated Thermal Storage
4	X	Development of ATA Heat Pump for High-Glide Ultra-Low GWP Refrigerants and Ice Thermal Storage
5		Laboratory Test ATA Heat Pump with High-Glide Refrigerant and Ice Thermal Storage
6	X	Model Performance of Both Systems In California Climate Zones
7		Technology Selection Implications Analysis
8		Evaluation of Project Benefits
9		Technology Transfer Activities

B. Acronym/Term List

Acronym/Term	Meaning
A2L	ASHRAE classification of (A) low toxicity, (2) mildly flammable, and (L) low burning velocity refrigerant
ATA	Air-to-Air
ATW	Air-to-Water
CAM	Commission Agreement Manager
CAO	Commission Agreement Officer
CEC	California Energy Commission
COP	Coefficient of Performance
CPR	Critical Project Review
DEER	California Database for Energy Efficiency Resources
GWP	Global Warming Potential
MPHX	Microchannel Polymer Heat Exchanger
PCM	Phase Change Material
TAC	Technical Advisory Committee
TES	Thermal Energy Storage

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

A. Purpose of Agreement

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

EXHIBIT A
SCOPE OF WORK
The Regents of the University of California on behalf of the Davis campus

The purpose of this Agreement is to fund the development of heat pump technologies that use ultra-low global warming potential (GWP) refrigerants for residential applications, which have the potential to reduce greenhouse gas emissions from heat pump systems. This project will develop two system design pathways for achieving this goal and compare the long-term implications of each system type relative to carbon emissions, energy use, and energy costs.

B. Problem/ Solution Statement

Problem

Refrigerants used in residential heat pump systems today have a relatively high GWP. The California Air Resource Board and the U.S. Environmental Protection Agency have recently imposed restrictions on the GWP of refrigerants used in heat pumps to below 750 and 700, respectively. However, it is understood that further reductions in refrigerant GWP are necessary to meet California's ambitious carbon goals. This will require new developments in heat pump technologies utilizing ultra-low GWP (a rating of less than GWP 10) refrigerants that are safe, efficient, and equitable.

Solution

The recipient will develop and test two pathways for achieving ultra-low GWP heat pump technologies that are safe, efficient, and cost-effective. These two pathways will consider different system architecture that each have a unique set of advantages and disadvantages. The first path will develop an improved secondary-loop design for air-to-water (ATW) heat pumps using R-290 (GWP 4) refrigerant. The secondary-loop innovations will include an advanced microchannel polymer heat exchanger (MPHX) to improve heat pump efficiency, and a phase-change material (PCM) integrated thermal storage system for achieving load flexibility. This path potentially enables the safe use of highly flammable hydrocarbon refrigerant outside in a chiller platform while trading off efficiency and complexity of the equipment while providing grid flexibility.

The second path will develop a variable-speed air-to-air (ATA) direct-expansion heat pump for use with high-glide refrigerants (such as R-474B GWP <10) and thermal storage for grid flexibility. This path enables continued use of existing heat pump platforms which preserves the safety of using low toxicity (A), mildly flammable(2), low burning velocity refrigerants (L) (A2Ls) indoors, while enabling continued higher efficiency platforms and potentially having less impact on complexity and cost to consumers. This technology path will integrate an ice thermal storage system for achieving reduced condenser pressure at high ambients thus significantly increasing the efficiency of the heat pump and providing load flexibility.

Energy modeling across several Title 24 prototype buildings will evaluate the energy and operating cost implications of both system types for California ratepayers. This modeling will allow a comprehensive analysis of the implication of each path relative to safety, cost, carbon emissions, and electric infrastructure capacity requirements.

C. Goals and Objectives of the Agreement

Agreement Goals

The goals of this Agreement are to:

- Evaluate the broad implications of both system types on California ratepayers in terms of safety, efficiency, environment, and equity

- Provide the policy makers with a thorough analysis of the benefits of each system design to help inform policy on how to meet California's carbon goals and understand the implications of ultra-low GWP heat pumps on California Investor-Owned Utilities ratepayers and the electric grid broadly

Ratepayer Benefits:[2] This Agreement will result in the ratepayer benefits of greater electricity reliability, lower costs, and increased safety when transitioning to ultra-low GWP refrigerants for residential heat pumps. The project will explore multiple system types for use with ultra-low GWP refrigerants to maximize efficiency and provide data on the capacity needed for the California electrical grid when transitioning to ultra-low GWP refrigerants. By evaluating these two pathways, this project will be able to provide the CEC and California ratepayers with directional understanding of the impact of future refrigerant regulations and energy policy, while balancing the direct refrigerant emissions when balancing safety, efficiency, environment and equity.

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 developing two different system types for incorporating ultra-low GWP (<10) refrigerants in residential heat pumps.

One system allows the safe use of highly flammable R-290 refrigerant by designing around an air-to-water heat pump platform that maintains all the refrigerant outdoors and incorporates a novel thermal storage system for achieving load flexibility. Advanced polymer heat exchangers will be developed to improve the efficiency of the air-to-water system. The second system will optimize a heat pump for use with newly developed mildly flammable refrigerants that are allowed for use indoors but have challenges related to their thermodynamic properties that must be managed. An ice thermal storage system will also be explored for the second heat pump system that integrates directly into the refrigerant loop for load flexibility.

Agreement Objectives

The objectives of this Agreement are to:

- Design, develop, and test an ATW heat pump system for use with R-290 refrigerant that achieves a system coefficient of performance (COP) of 3.0 at the 95°F test condition.
- Design, develop, and test a PCM-based TES (Thermal Energy Storage) system that provides one ton-hour (ton-hr) of thermal storage per 15 gallons of PCM material.
- Develop an optimized MPHX heat exchanger that achieves an effectiveness of 0.78 with a 90 Pascal (Pa) air-side pressure drop.
- Design, develop, and test an air-to-air heat pump system for use with ultra-low GWP high-glide refrigerant that achieves a system COP of 3.5 at the 95F° test condition.

[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.

- Design, develop, and test an ice-based TES that can improve ATA heat pump efficiency by 40% compared to rejecting to ambient air at 95°F

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 DEVELOPMENT OF ENHANCED SECONDARY LOOP DESIGN FOR R-290 ATW HEAT PUMPS

The goal of this task is to develop and test an enhanced secondary-loop design for use with R-290 air-to-water (ATW) heat pumps that improve efficiency and load flexibility of these systems. The key features of the secondary loop design are an optimized injection-molded microchannel polymer heat exchanger (MPHX) and phase change material (PCM) thermal storage system to allow for shifting electric load. The optimized injection molded MPHX will be developed and tested in this task. A small-scale PCM thermal storage will be developed and used to validate model predictions of the system, as well as test the durability of the PCM material through cyclic testing of the melting-freezing process.

The Recipient shall:

- Model optimized MPHX based on injection-molding manufacturing methods
- Build an injection-molded MPHX
- Prepare *MPHX Development Memo* that describes:
  - The design architecture of the MPHX
  - The modeled performance relative to competing coil designs
  - The injection molding and assembly process
- Characterize the mechanical integrity of the injection-molded MPHX
- Prepare *MPHX Performance Testing Results* discussing the results from mechanical and thermal testing of the optimized MPHX
- Model PCM thermal storage system for both heating and cooling load shifting
- Build small-scale PCM thermal storage system designed for ATW heat pump load shifting
- Test the small-scale PCM thermal storage system and compare to model predictions
- Cyclic testing of the PCM material to evaluate any hysteresis or degradation
- Prepare *PCM Thermal Storage Design and Testing* describing:
  - The thermal storage design concepts
  - The modeled performance of the thermal storage system compared to sensible-only (water or water-glycol) storage design
  - The results of testing quantifying the relationship between volume and thermal storage capacity
  - A comparison of laboratory testing to model predictions
  - PCM material hysteresis or degradation from cyclic testing

Products:

- MPHX Development Memo
- PCM Thermal Storage Design and Testing
- MPHX Performance Testing Results

TASK 3 LABORATORY TEST OF ATW HEAT PUMP WITH INTEGRATED THERMAL STORAGE

The goal of this task is to test the integrated ATW heat pump system with optimized MPHX and PCM-enhanced thermal storage. Testing will be conducted at UC Davis laboratory facilities to develop performance curves of the system for energy modeling. A full-scale PCM thermal storage system will be built based on optimized design determined in Task 2. The testing will include charging and discharging modes of the PCM thermal storage.

The Recipient shall:

- Set up ATW heat pump with enhanced secondary loop in climate chambers or representative environment
- Prepare *ATW Heat Pump System Lab Test Plan* to include:
  - Detailed measurement and instrumentation plan
  - List of test conditions and modes of operation for the testing
  - Analysis methods
- Perform testing under a range of conditions and operating modes
- Analyze test data and develop performance curves for use in energy modeling software
- Perform modeling to adjust performance for R-290 ATW heat pump if a surrogate refrigerant is used in laboratory testing
- Prepare *ATW Heat Pump System Lab Report* documenting the results of the lab testing including the performance maps developed.

Products:

- ATW Heat Pump System Lab Test Plan
- ATW Heat Pump System Lab Report

TASK 4 DEVELOPMENT OF ATA HEAT PUMP FOR HIGH-GLIDE ULTRA-LOW GWP REFRIGERANTS AND ICE THERMAL STORAGE

This task will leverage the expertise of Trane Technologies to design an optimized air-to-air (ATA) heat pump for use with high-glide refrigerants. The heat pump will be developed for use with design-compatible refrigerants, R-474B and R-454C. Depending on the status of R-474B refrigerant on the market, the heat pump will be optimized and tested with R-474B refrigerant otherwise R-454C will be used as a surrogate for the development of the R-474B system. An integrated ice storage system will also be developed for providing load flexibility to the ATA heat pump technology and could be applied to other heat pump technologies on the market.

The Recipient shall:

- Develop an ATA heat pump for use with high-glide refrigerants, R-474B and R-454C
- Optimize performance through compressor and heat exchanger innovations to increase efficiency of the system
- Prepare *ATA Heat Pump for High-Glide Refrigerants Interim Development Memo* to outline the status of development and expected timeline for completing the development.
- Deliver prototype ATA heat pump unit to UC Davis for testing
- Prepare *ATA Heat Pump for High-Glide Refrigerants Development Report* describing heat pump development, strategies for handling high-glide refrigerants, and market potential based on cost and expected efficiency relative to available heat pump technology

- Develop ice thermal storage system for integration into direct expansion (DX) high-glide ATA heat pump
- Deliver prototype ice thermal storage unit to UC Davis for testing
- Prepare *Dispatchable Ice Storage System Development Report* describing the design of the storage system, the modes of operation including charging and discharging modes, and integration into DX refrigerant circuit
- Prepare a *CPR Report* in accordance with subtask 1.3 (CPR Meetings)
- Participate in a CPR meeting

Products:

- ATA Heat Pump for High-Glide Refrigerants Interim Development Memo
- ATA Heat Pump for High-Glide Refrigerants Development Report
- Dispatchable Ice Storage System Development Report
- CPR Report

TASK 5 LABORATORY TEST ATA HEAT PUMP WITH HIGH-GLIDE REFRIGERANT AND ICE THERMAL STORAGE

The goal of this task is to test the ATA heat pump technology developed by Trane in UC Davis laboratory facilities. These tests will characterize the performance of the ATA system including capacity and energy use under a range of representative outdoor and indoor air conditions. The performance of the integrated ice storage system for providing load flexibility will also be tested in this task to understand the load shifting capacity and round-trip efficiency.

The Recipient shall:

- Setup ATA heat pump prototype supplied by Trane in UC Davis test facility
- Prepare *ATA Heat Pump Lab Test Plan* to include:
  - Detailed measurement and instrumentation plan
  - List of test conditions and modes of operation for the testing
  - Analysis methods
- Perform testing of ATA heat pump under a range of conditions and operating modes
- Analyze ATA heat pump test data and develop performance curves for use in energy modeling software
- Prepare *ATA Heat Pump System Lab Report* documenting the results of the lab testing including the performance maps developed.
- Setup ice thermal storage prototype supplied by Trane in UC Davis test facility
- Prepare *Dispatchable Ice Storage System Lab Test Plan* to include:
  - Detailed measurement and instrumentation plan
  - List of test conditions and modes of operation for the testing
  - Analysis methods
- Perform testing of ice thermal storage system under a range of conditions and operating modes
- Analyze ice thermal storage system test data and develop modeling strategies to incorporate the storage into energy modeling result
- Prepare *Dispatchable Ice Storage System Lab Report* documenting the results of the lab testing and modeling strategy developed

Products:

- ATA Heat Pump Lab Test Plan
- ATA Heat Pump System Lab Report
- Dispatchable Ice Storage System Lab Test Plan
- Dispatchable Ice Storage System Lab Report

TASK 6 MODEL PERFORMANCE OF BOTH SYSTEMS IN CALIFORNIA CLIMATE ZONES
This task will evaluate the implications of transitioning to ATA and ATW heat pumps with ultra-low GWP refrigerants in California by modeling the total environmental warming impact of the different refrigerants and system types including both direct and indirect emissions.

The Recipient shall:

- Run annual simulations of different heat pump scenarios using the EnergyPlus simulation engine using performance maps gathered through laboratory testing and modeling.
- Implement the heat pump scenarios in a parametric modeling framework that allows automated simulation of a variety of building types, climate zones and vintages (e.g. the DEER (California Database for Energy Efficiency Resources) modeling framework which includes multifamily, single family and manufactured home prototypes pre-calibrated to the California building stock).
- Process results, using hourly simulation outputs to calculate the operating utility cost across modeling parameters (e.g. climate zones, building types, vintages).
- Prepare *ATW and ATA Performance Modeling Results* which include but will not be limited to:
    - Description of the building prototypes
    - Modeling approach and performance curves
    - Modeling results, including annual site energy consumption, peak demand and utility cost
    - Direct and indirect emissions for the different system types
- Prepare a *CPR Report* in accordance with subtask 1.3 (CPR Meetings)
- Participate in a CPR meeting

Products:

- ATW and ATA Performance Modeling Results
- CPR Report

TASK 7 TECHNOLOGY SELECTION IMPLICATIONS ANALYSIS
The goal of this task is to analyze the technical and non-technical implications of California transitioning to space conditioning heat pumps with ATW with propane (R-290) or ATA with a synthetic ultra-low GWP refrigerant (R-474B), relative to the current code-compliant space conditioning heat pump technologies and refrigerants.

The Recipient shall:

- Describe the technical implications of moving to ATW with R-290 or ATA with R-474B, including
    - Describe the implications of any differences in refrigerant used across the two system designs, in terms of flammability/safety, environmental impacts, commercial availability, and cost.

  - Describe the technical differences in the equipment components and system design (e.g., compressor, air distribution) and the implications these will have on installation time, cost, and complexity.
  - Describe the characteristics of homes suitable for retrofit.
- Describe the policy landscape relevant to ATW with R-290 and ATA with R-474B based on a literature review on electrification, emissions, efficiency, incentive program, and other relevant policies.
- Describe the cost implications of ATW with R-290 and ATA with R-474B, relative to each other and an appropriate baseline technology
  - Gather qualitative and (to the extent possible, quantitative) data on initial and operating costs from existing market studies, public databases, and manufacturers.
  - Gather data on existing local, state and federal incentives for which both system types would likely qualify
  - Conduct a qualitative (and to the extent possible, quantitative) cost comparison of the upfront and operating costs associated with moving to ATW with R-290 or ATA with R-474B.
- Describe the implications for customer experience in moving to ATW with R-290 or ATA with R-474B.
  - Gather data from market studies and industry experts on the potential impacts on factors such as comfort, convenience, acceptability, and affordability.
  - Synthesize the data on customer considerations
- Describe workforce considerations in moving to ATW with R-290 or ATA with R-474B.
  - Gather data from market studies, public resources, and industry experts on the workforce implications of moving to ATW with R-290 or ATA with R-474B.
  - Synthesize findings on the workforce implications, in terms of workforce size, skills, training, and outlooks on the two system types.
- Describe system-wide implications of transitioning to ATW with R-290 versus ATA with R-474B
  - Estimate grid impacts of transitioning to ATW with R-290 versus ATA with R-474B at scale, considering the energy efficiency demonstrated in Task 6 and projected grid conditions.
  - Estimate total system benefit of transitioning to ATW with R-290 versus ATA with R-474B using avoided cost calculator, addressing energy, carbon emissions, refrigerant, and grid impacts.
- Draft *Technology Implications Report* synthesizing the technical and non-technical implications of transitioning to ATW with R-290 versus ATA with R-474B.

Products:

- Technology Implications Report (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 technologies being supported under this agreement. Eligible activities include, but are not limited to, the following:
- Technology verification testing, or application to a test bed 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.

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.