



**CALIFORNIA
ENERGY COMMISSION**



**California Energy Commission
May 8, 2024 Business Meeting
Backup Materials for The Regents of the University of California as Management
and Operating Contractor for the Ernest Orlando Lawrence Berkeley National
Laboratory, hereinafter referred to as “Facility Operator”, “Lawrence Berkeley
National Laboratory or “LBNL”**

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

[PROPOSED]

RESOLUTION NO: 24-0508-15f

**STATE OF CALIFORNIA
STATE ENERGY RESOURCES
CONSERVATION AND DEVELOPMENT COMMISSION**

RESOLUTION: The Regents of the University of California as Management and Operating Contractor for the Ernest Orlando Lawrence Berkeley National Laboratory, hereinafter referred to as “Facility Operator”, “Lawrence Berkeley National Laboratory or “LBNL”

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-23-034 with Lawrence Berkeley National Laboratory for a \$5,899,990 grant to develop holistic and scalable solutions for transitioning conventional central plants to heat recovery chiller systems that use low GWP refrigerants. An early-adoption initiative will be showcased at a South San Francisco site to demonstrate energy efficiency, load flexibility, and gas consumption reduction. The goal of the solution package is to significantly reduce engineering efforts while providing a customized retrofit pathway for each site, thereby reducing upfront costs, and facilitating plant transitions throughout California; and

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

CERTIFICATION

The undersigned Secretariat to the CEC does hereby certify that the foregoing is a full, true, and correct copy of a resolution duly and regularly adopted at a meeting of the CEC held on May 8, 2024.

AYE:
NAY:
ABSENT:
ABSTAIN:

Dated:

Kristine Banaag
Secretariat



GRANT REQUEST FORM (GRF)

A. New Agreement Number

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

New Agreement Number: EPC-23-034

B. Division Information

1. Division Name: ERDD
2. Agreement Manager: Jackson Thach
3. MS-:51
4. Phone Number: 916-776-0818

C. Recipient's Information

1. Recipient's Legal Name: **The Regents of the University of California as Management and Operating Contractor for the Ernest Orlando Lawrence Berkeley National Laboratory, hereinafter referred to as "Facility Operator", "Lawrence Berkeley National Laboratory or "LBNL"**
2. Federal ID Number: 94-2951741

D. Title of Project

Title of project: Market-leading Adoption of Scalable Low GWP Refrigerant Heat Pump in a Retrofit Application

E. Term and Amount

1. Start Date: 6/3/2024
2. End Date: 3/31/2028
3. Amount: \$5,899,990.00

F. Business Meeting Information

1. Are the ARFVTP agreements \$75K and under delegated to Executive Director? No
2. The Proposed Business Meeting Date: 5/8/2024 .
3. Consent or Discussion? Discussion
4. Business Meeting Presenter Name: Bradley Meister
5. Time Needed for Business Meeting: 10 minutes.
6. The email subscription topic is: EPIC (Electric Program Investment Charge).

Agenda Item Subject and Description:

The Regents of the University of California as Management and Operating Contractor for the Ernest Orlando Lawrence Berkeley National Laboratory, hereinafter referred to as "Facility Operator," "Lawrence Berkeley National Laboratory," or "LBNL." Proposed resolution approving agreement EPC-23-034 with Lawrence Berkeley National Laboratory for a \$5,899,990 grant to develop holistic and scalable solutions for transitioning conventional central plants to heat recovery chiller systems that use low GWP refrigerants and adopting staff's determination that this action is exempt from CEQA. An early-adoption initiative will be showcased at a South San Francisco site to demonstrate energy efficiency, load flexibility, and gas consumption reduction. The goal of the solution package is to significantly reduce engineering efforts while providing a customized retrofit pathway for each site, thereby reducing upfront costs, and facilitating plant



transitions throughout California. (EPIC funding) Contact: Bradley Meister (Staff
Presentation: 10 minutes)

G. California Environmental Quality Act (CEQA) Compliance

1. Is Agreement considered a “Project” under CEQA?

Yes

If yes, skip to question 2.

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

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

2. If Agreement is considered a “Project” under CEQA answer the following questions.

a) Agreement **IS** exempt?

Yes

Statutory Exemption?

No

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

PRC section number: None

CCR section number: None

Categorical Exemption?

Yes

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

CCR section number: Cal. Code Regs., tit. 14, § 15301 ; 15302, 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.

Cal. Code Regs., tit. 14, sect. 15301 provides that projects which consist of operation, repair, maintenance, permitting or minor alterations of existing public or private structures, facilities, mechanical equipment and which involve negligible or no expansion of use beyond that existing at the time are categorically exempt from CEQA. This project involves operation and minor alterations consisting of equipment installation at a private existing facility, with no or negligible expansion of capacity. The existing central heat pump plant will be retrofitted with low-GWP equipment. This installation is at an existing, developed urban site on land that is not environmentally sensitive.

Cal. Code Regs., tit. 14, sect. 15302 exempts projects that consist of the replacement or reconstruction of existing utility systems and facilities involving negligible or no expansion of capacity. This project involves replacing and retrofitting an existing heat



pump plant. In addition, this project fits within Cal. Code Regs., tit. 14, sect. 15306 because it involves basic data collection which will not result in a serious or major disturbance to an environmental resource. All applicable health, safety, and environmental rules and regulations would be followed; activities would be conducted by appropriately trained and qualified technicians and researchers. Energy use and emissions of existing facilities would generally be lowered by project implementation.

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

H. Subcontractors

List all Subcontractors listed in the Budget (s) (major and minor). Insert additional rows if needed. If no subcontractors to report, enter “No subcontractors to report” and “0” to funds.

Delete any unused rows from the table.

Subcontractor Legal Company Name	CEC Funds	Match Funds
Genentech, Inc.	\$ 2,500,000	\$1,200,000
TRC Engineers, Inc.	\$ 682,434	\$0
University of California, Berkeley, Center for the Built Environment	\$ 473,636	\$0



Subcontractor Legal Company Name	CEC Funds	Match Funds
TBD - Community Based Outreach	\$ 30,000	\$0
YMCA of San Francisco	\$ 95,000	\$0
GCI, Inc.	\$ 2,500,000	\$737,000
TBD – Engineering Firm	\$ 0	\$263,000

I. Vendors and Sellers for Equipment and Materials/Miscellaneous

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

Vendor/Seller Legal Company Name	CEC Funds	Match Funds
No vendors to report	\$	\$

J. Key Partners

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

Key Partner Legal Company Name
Norman S Wright Mechanical Engineers
Daikin Applied
Affiliated Engineers, Inc.
Peninsula Clean Energy
United States General Services Administration
Carrier Corporation
Johnson Controls, Inc.
County of San Mateo, Office of Sustainability

K. Budget Information

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

Funding Source	Funding Year of Appropriation	Budget List Number	Amount
EPIC	22-23	301.001J	\$ 5,899,990

TOTAL Amount: \$ 5,899,990



R&D Program Area:TIEB

Explanation for “Other” selection Not applicable

Reimbursement Contract #: Not applicable

Federal Agreement #: Not applicable

L. Recipient’s Contact Information

1. Recipient’s Administrator/Officer

Name: Joanna Santoro

Address: 1 Cyclotron Rd

City, State, Zip: Berkeley, CA 94720-0001

Phone: 510 486-6824

E-Mail: jlsantoro@lbl.gov

3. Recipient’s Project Manager

Name: Donghun Kim

Address: 1 Cyclotron Rd MS90R3147

City, State, Zip: Berkeley, CA 94720-8028

Phone:

E-Mail: DonghunKim@lbl.gov

M. Selection Process Used

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

Selection Process	Additional Information
Competitive Solicitation #	GFO-22-308
First Come First Served Solicitation #	Not applicable
Other	Not applicable

N. Attached Items

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

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



STATE OF CALIFORNIA
CALIFORNIA ENERGY COMMISSION

Grant Request Form
CEC-270 (Revised 9/2022)

Item Number	Item Name	Attached
5	Awardee CEQA Documentation	Yes

Approved By

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

Agreement Manager: Jackson Thach

Approval Date: 3/18/2024

Branch Manager: Anthony Ng

Approval Date: 3/20/2024

Director: Anthony Ng on behalf of Cameron Peterson

Approval Date: 3/20/2024

Exhibit A
Scope of Work
Lawrence Berkeley National Laboratory

I. TASK ACRONYM/TERM LISTS

A. Task List

Task #	CPR ¹	Task Name
1		General Project Tasks
2		Market Characterization & Technology Assessment
3	X	Development of Holistic Solution Package & Application to Demo Site
4		Equipment Procurement, Installation, Integration, and Commissioning
5	X	Measurement & Verification and Equipment Performance Monitoring
6		Research on Scaling and Market Advancement Pathways
7		Stakeholder Outreach Activities
8		Disadvantaged Community Benefit Strategies & Execution
9		Technology/Knowledge Transfer Activities
10		Evaluation of Project Benefits

B. Acronym/Term List

Acronym/Term	Meaning
AB	Assembly Bill
AC	Air Conditioning
ACEEE	American Council for an Energy Efficient Economy
AHU	Air Handling Unit
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BAS	Building Automation System
BIL	Bipartisan Infrastructure Law
CA	California
CalEPA	California Environmental Protection Agency
CAM	Commission Agreement Manager
CAO	Commission Agreement Officer
CARB	California Air Resources Board
CBE	Center for the Built Environment
CBECC	California Building Energy Code Compliance
CBO	Community Based Organization
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CHPB	Center for High Performance Buildings (at Purdue University)
CO2	Carbon Dioxide
COP	Coefficient of Performance
CPP	Critical Peak Pricing (utility billing rate)
CPR	Critical Project Review
CPUC	California Public Utilities Commission
Cx	Commissioning (e.g., of a building or site)

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
Lawrence Berkeley National Laboratory

Acronym/Term	Meaning
DOE	U.S. Department of Energy
DR	Demand Response
EPA	U.S. Environmental Protection Agency
ETA	Energy Technologies Area (at Lawrence Berkeley National Laboratory)
FDD	Fault Detection and Diagnostics
GHG	Greenhouse Gas
GNE	Genentech, Inc.
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HFO	Hydrofluoroolefin
HP	Heat Pump
HVAC	Heating, Ventilation and Air Conditioning
HWST	Hot Water Supply Temperature
IPMVP	International Performance Measurement and Verification Protocol
IRA	Inflation Reduction Act
IOU	Investor Owned Utility
JCI	Johnson Controls, Inc.
kBTU	Thousand British Thermal Units
kW, kWh	Kilowatt, Kilowatt-hour
LBNL	Lawrence Berkeley National Laboratory
M&V	Measurement and Verification
MMBTU	Million British Thermal Units
mTonCO ₂ e	Metric Ton of Carbon Dioxide Equivalent
MW, MWh	Megawatt, Megawatt-hour
NPV	Net Present Value
NREL	National Renewable Energy Laboratory
PG&E	Pacific Gas & Electric Co.
PI	Principal Investigator
PM	Project Manager
RICAPS	Regional Climate Action Planning Suite (San Mateo County)
SB	Senate Bill
SFUSD	San Francisco Unified School District
SMCEW	San Mateo County Energy Watch
SMUD	Sacramento Municipal Utility District
SNAP	Significant New Alternatives Policy (under U.S. EPA)
TAC	Technical Advisory Committee
TES	Thermal Energy Storage
TMY	Typical Meteorological Year
TOU	Time of Use (utility billing rate)
TOWT	Time of Week and Temperature
TRC	TRC Consulting

Exhibit A
Scope of Work
Lawrence Berkeley National Laboratory

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

A. Purpose of Agreement

The purpose of this Agreement is to fund the development of holistic and scalable solutions for transitioning conventional central plants consisting of gas boilers and chiller systems, and the field demonstration of a significant retrofit initiative.

B. Problem/ Solution Statement

Problem

Typical central heating and cooling plants, which consist of gas boilers and chiller systems using hydrofluorocarbon (HFC) refrigerants, are responsible for over 40% of natural gas consumption for heating in California's commercial building sector. Despite the urgent need to transition these systems to align with California's climate goals and refrigerant regulations, the financial and technical barriers are too high. Typical barriers include high retrofitting costs, better economics for natural gas versus electric heating, high energy requirements of coincident heating and cooling loads, and significant engineering efforts required to correctly size and configure heat recovery chillers. Further, many central plants in the U.S. are not designed to accommodate heat recovery chillers because their hot water temperatures run too high (~180°F). Market adoption of low GWP refrigerant HP technologies faces specific additional challenges, including a scarcity of commercially available products in the U.S., uncertainties about long-term performance (due to the technology's pre-commercial stage), and flammability and toxicity concerns about low GWP refrigerants. Without clear strategies and real-world performance demonstrations, progress in transitioning existing technology to meet state goals will remain slow.

Solution

The Recipient will develop holistic and scalable solutions for transitioning conventional central plants to heat recovery chiller systems that use low GWP refrigerants. The solution package will include design tools for cost-effective integrations; screening methods for assessing eligibility of electrification retrofits; and new technologies for lowering hot water temperature. The design tools will provide a series of cost estimates (for both capital and operating costs) across various design parameters to help identify the most cost-effective hot water temperature, heat recovery chiller size and configuration, and control sequences for typical central plants. The goal of the solution package is to significantly reduce engineering efforts while providing a customized retrofit pathway for each site, thereby reducing upfront costs and facilitating plant transitions throughout California.

The Recipient will also showcase a significant retrofit initiative, integrating a large-sized (>100 ton), low GWP (<10) heat recovery chiller into an existing central plant, and demonstrating enhanced energy efficiency, cost savings, and a degree of load flexibility while reducing gas consumption. The combination of the site's exceptional readiness and our demonstration partner's strong commitment to eliminating HFCs makes this project uniquely positioned to overcome adoption and integration challenges.

The identified design tools, plus the project's real-world findings from the implementation and analysis of new low GWP equipment and the integrated system, will be shared with code officials, potential adopters, manufacturers, and other stakeholders. This effort aims to inform relevant

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refrigerant codes and utility programs and accelerate the widespread adoption of environmentally friendly technology in the large building market.

C. Goals and Objectives of the Agreement

Agreement Goals

The goals of this Agreement are to:

- Offer a holistic and scalable solution package for transitioning conventional central plants to low GWP heat recovery chillers and accelerating central plant electrification
- Showcase a significant early-adoption initiative, integrating a large-sized (>100 ton), low GWP (<10) heat recovery chiller into an existing central plant and demonstrating enhanced energy efficiency, cost savings, and a degree of load flexibility while reducing gas consumption
- Disseminate the design tools and findings for the widespread adoption of environmentally friendly technology in the large building market.

Ratepayer Benefits:² This Agreement will result in the ratepayer benefits of:

- Increased adoption of heat recovery technologies and reduced upfront costs: The holistic solution package would streamline initial decision-making, minimize engineering work, and offer tailored retrofit paths for each site, which ultimately cuts down on upfront costs for ratepayers and central plant transition time.
- More economically viable solutions for the transition: The holistic solution package will help engineers and even non-HVAC professionals to find a cost-effective way of retrofitting their plants.
- Having access to a sound benchmark for central plant transitions: In response to CA's stringent refrigerant regulations and climate goals, building owners and developers will need to move away from gas boilers and HFCs. The retrofit initiative provides a robust benchmark to support a broad, long-term transition.
- More informed relevant legislation and regulations: Sharing findings and engaging with stakeholders helps improve refrigerant codes and utility programs to encourage the use of environmentally friendly technologies, thus driving down costs and increasing financial benefits to ratepayers.
- Reduction in gas consumption and building decarbonization: The widespread adoption of heat recovery chillers in CA facilitated by the holistic solution package accelerates the cost-effective achievement of state climate and energy goals and associated ratepayer benefits.
- Long-term sustainability: Phasing out HFCs, reducing gas consumption, and enhancing energy efficiency collectively support the long-term sustainability and reliability of state energy infrastructure to benefit ratepayers.

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).

Exhibit A

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Technological Advancement and Breakthroughs: This Agreement will lead to technological advancement and breakthroughs to overcome barriers to the achievement of the State of California's statutory energy goals and refrigerant regulations. Technological advancements/innovations of this project addressing California's goals are:

- Promoting early adoption of low GWP refrigerants. The market's early adoption of low GWP refrigerant technology is a critical advancement to enable alignment with associated regulatory and legislative requirements, including U.S. EPA SNAP Rules 20 and 23 and California SB 1013 and SB 1383.
- Demonstrating the financial viability of transforming central plants through enhanced energy efficiency. The heat recovery solution conceptually doubles the overall coefficient of performance (COP), which aligns with California's Energy Efficiency Action Plan (particularly the first goal to "Double Energy Efficiency Savings by 2030").
- Developing and promulgating long-term field data for a large-sized, low GWP heat recovery chiller. The data will provide insights into the efficiency degradation, durability, and leakage of this pre-commercial technology.
- Facilitating adoption of heat recovery technologies, and thus building electrification. The proposed package could significantly reduce engineering efforts while providing a clear, customized retrofit pathway, thus reducing upfront costs and required time for the central plant transition and advancing CA's climate goals.
- Identifying control sequences and providing load flexibility. The package contains control sequences to maximize efficiency and offer a degree of load flexibility, which are key to reducing GHG emissions from buildings per CA Energy Efficiency Action Plan.
-

Agreement Objectives

The objectives of this Agreement are to:

- Procure, install, integrate, and commission at least one standalone, low GWP heat recovery chiller meeting the solicitation's criteria – i.e. heating COP>3 (evaluated at 42°F chilled water supply and 135°F hot water supply temperatures); refrigerant GWP <10; and heating capacity of at least 175 ton which meets 46% of peak heating load of the demonstration site (~ 4,500 kBtu/hr or 375 ton)
- Achieve reductions in CO2 emission and gas loads of at least 85% vs. pre-retrofit
- Demonstrate savings in annual utility costs of at least 20% vs. pre-retrofit
- Provide load shedding of 100 kW during grid contingency events and/or on-peak price periods
- Peak demand reduction of 10% when using the grid-responsive control vs. the default control
- Target 130°F year-round hot water supply temperature

III. GENERAL PROJECT TASKS

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

Exhibit A Scope of Work Lawrence Berkeley National Laboratory

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.

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○ **Software Application Development**

Use the following standard Application Architecture components in compatible versions for any software application development required by this Agreement (e.g., databases, models, modeling tools), unless the CAM approves other software applications such as open source programs:

- Microsoft ASP.NET framework (version 3.5 and up). Recommend 4.0.
- Microsoft Internet Information Services (IIS), (version 6 and up) Recommend 7.5.
- Visual Studio.NET (version 2008 and up). Recommend 2010.
- C# Programming Language with Presentation (UI), Business Object and Data Layers.
- SQL (Structured Query Language).
- Microsoft SQL Server 2008, Stored Procedures. Recommend 2008 R2.
- Microsoft SQL Reporting Services. Recommend 2008 R2.
- XML (external interfaces).

Any exceptions to the Electronic File Format requirements above must be approved in writing by the CAM. The CAM will consult with the CEC's Information Technology Services Branch to determine whether the exceptions are allowable.

MEETINGS

Subtask 1.2 Kick-off Meeting

The goal of this subtask is to establish the lines of communication and procedures for implementing this Agreement.

The Recipient shall:

- Attend a "Kick-off" meeting with the CAM, the Commission Agreement Officer (CAO), and any other CEC staff relevant to the Agreement. The Recipient will bring its Project Manager and any other individuals designated by the CAM to this meeting. The administrative and technical aspects of the Agreement will be discussed at the meeting. Prior to the meeting, the CAM will provide an agenda to all potential meeting participants. The meeting may take place in person or by electronic conferencing (e.g., WebEx), with approval of the CAM.

The administrative portion of the meeting will include discussion of the following:

- Terms and conditions of the Agreement;
- Invoicing and auditing procedures;
- Administrative products (subtask 1.1);
- CPR meetings (subtask 1.3);
- Match fund documentation (subtask 1.7);
- Permit documentation (subtask 1.8);
- Subcontracts (subtask 1.9); and
- Any other relevant topics.

The technical portion of the meeting will include discussion of the following:

- The CAM's expectations for accomplishing tasks described in the Scope of Work;
- An updated Project Schedule;
- Technical products (subtask 1.1);

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- Progress reports (subtask 1.5);
- Final Report (subtask 1.6);
- Technical Advisory Committee meetings (subtasks 1.10 and 1.11); and
- Any other relevant topics.

- Provide *Kick-off Meeting Presentation* to include but not limited to:
 - Project overview (i.e. project description, goals and objectives, technical tasks, expected benefits, etc.)
 - Project schedule that identifies milestones
 - List of potential risk factors and hurdles, and mitigation strategy

- Provide an *Updated Project Schedule*, *Match Funds Status Letter*, and *Permit Status Letter*, as needed to reflect any changes in the documents.

The CAM shall:

- Designate the date and location of the meeting.
- Send the Recipient a *Kick-off Meeting Agenda*.

Recipient Products:

- Kick-off Meeting Presentation
- Updated Project Schedule (*if applicable*)
- Match Funds Status Letter (subtask 1.7) (*if applicable*)
- Permit Status Letter (subtask 1.8) (*if applicable*)

CAM Product:

- Kick-off Meeting Agenda

Subtask 1.3 Critical Project Review (CPR) Meetings

The goal of this subtask is to determine if the project should continue to receive CEC funding, and if so whether any modifications must be made to the tasks, products, schedule, or budget. CPR meetings provide the opportunity for frank discussions between the CEC and the Recipient. As determined by the CAM, discussions may include project status, challenges, successes, advisory group findings and recommendations, final report preparation, and progress on technical transfer and production readiness activities (if applicable). Participants will include the CAM and the Recipient and may include the CAO and any other individuals selected by the CAM to provide support to the CEC.

CPR meetings generally take place at key, predetermined points in the Agreement, as determined by the CAM and as shown in the Task List on page 1 of this Exhibit. However, the CAM may schedule additional CPR meetings as necessary. The budget will be reallocated to cover the additional costs borne by the Recipient, but the overall Agreement amount will not increase. CPR meetings generally take place at the CEC, but they may take place at another location, or may be conducted via electronic conferencing (e.g., WebEx) as determined by the CAM.

The Recipient shall:

- Prepare and submit a *CPR Report* for each CPR meeting that: (1) discusses the progress of the Agreement toward achieving its goals and objectives; and (2) includes recommendations and conclusions regarding continued work on the project.

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- Attend the CPR meeting.
- Present the CPR Report and any other required information at each CPR meeting.

The CAM shall:

- Determine the location, date, and time of each CPR meeting with the Recipient's input.
- Send the Recipient a *CPR Agenda* with a list of expected CPR participants in advance of the CPR meeting. If applicable, the agenda will include a discussion of match funding and permits.
- Conduct and make a record of each CPR meeting. Provide the Recipient with a schedule for providing a Progress Determination on continuation of the project.
- Determine whether to continue the project, and if so whether modifications are needed to the tasks, schedule, products, or budget for the remainder of the Agreement. If the CAM concludes that satisfactory progress is not being made, this conclusion will be referred to the Deputy Director of the Energy Research and Development Division.
- Provide the Recipient with a *Progress Determination* on continuation of the project, in accordance with the schedule. The Progress Determination may include a requirement that the Recipient revise one or more products.

Recipient Products:

- CPR Report(s)

CAM Products:

- CPR Agenda(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 and the CAO of the following Agreement closeout items:
 - Disposition of any procured equipment.
 - The CEC's request for specific "generated" data (not already provided in Agreement products).
 - Need to document the Recipient's disclosure of "subject inventions" developed under the Agreement.
 - "Surviving" Agreement provisions such as repayment provisions and confidential products.
 - Final invoicing and release of retention.

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- Prepare a *Final Meeting Agreement Summary* that documents any agreement made between the Recipient and Commission staff during the meeting.
- Prepare a *Schedule for Completing Agreement Closeout Activities*.
- Provide copies of *All Final Products* on a USB memory stick, organized by the tasks in the Agreement.

Products:

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

REPORTS AND INVOICES

Subtask 1.5 Progress Reports and Invoices

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

The Recipient shall:

- Submit a monthly *Progress Report* to the CAM. Each progress report must:
 - Summarize progress made on all Agreement activities as specified in the scope of work for the preceding month, including accomplishments, problems, milestones, products, schedule, fiscal status, and an assessment of the ability to complete the Agreement within the current budget and any anticipated cost overruns. See the Progress Report Format Attachment for the recommended specifications.
- Submit a monthly or quarterly *Invoice* that follows the instructions in the “Payment of Funds” section of the terms and conditions, including a financial report on Match Funds and in-state expenditures.

Products:

- Progress Reports
- Invoices

Subtask 1.6 Final Report

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

Subtask 1.6.1 Final Report Outline

The Recipient shall:

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

Recipient Products:

- Final Report Outline (draft and final)

CAM Product:

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

Subtask 1.6.2 Final Report

The Recipient shall:

- Prepare a *Final Report* for this Agreement in accordance with the approved Final Report Outline, Energy Commission Style Manual, and Final Report Template provided by the CAM with the following considerations:
 - Ensure that the report includes the following items, in the following order:
 - Cover page (**required**)
 - Credits page on the reverse side of cover with legal disclaimer (**required**)
 - Acknowledgements page (optional)
 - Preface (**required**)
 - Abstract, keywords, and citation page (**required**)
 - Table of Contents (**required**, followed by List of Figures and List of Tables, if needed)
 - Executive summary (**required**)
 - Body of the report (**required**)
 - References (if applicable)
 - Glossary/Acronyms (If more than 10 acronyms or abbreviations are used, it is required.)
 - Bibliography (if applicable)
 - Appendices (if applicable) (Create a separate volume if very large.)
 - Attachments (if applicable)
- Submit a draft of the Executive Summary to the TAC for review and comment.
- Develop and submit a *Summary of TAC Comments 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*

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MATCH FUNDS, PERMITS, AND SUBCONTRACTS

Subtask 1.7 Match Funds

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

While the costs to obtain and document match funds are not reimbursable under this Agreement, the Recipient may spend match funds for this task. The Recipient may only spend match funds during the Agreement term, either concurrently or prior to the use of CEC funds. Match funds must be identified in writing, and the Recipient must obtain any associated commitments before incurring any costs for which the Recipient will request reimbursement.

The Recipient shall:

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

If match funds were a part of the proposal that led to the CEC awarding this Agreement, then provide in the letter:

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

Products:

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

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Subtask 1.8 Permits

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

The Recipient shall:

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

The list of permits and the schedule for obtaining them will be discussed at the Kick-off meeting (subtask 1.2), and a timetable for submitting the updated list, schedule, and copies of the permits will be developed. The impact on the project if the permits are not obtained in a timely fashion or are denied will also be discussed. If applicable, permits will be included as a line item in progress reports and will be a topic at CPR meetings.

- If during the course of the Agreement additional permits become necessary, then provide the CAM with an *Updated List of Permits* (including the appropriate information on each permit) and an *Updated Schedule for Acquiring Permits*.
- Send the CAM a *Copy of Each Approved Permit*.
- If during the course of the Agreement permits are not obtained on time or are denied, notify the CAM within 5 days. Either of these events may trigger a CPR meeting.

Products:

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

Subtask 1.9 Subcontracts

The goals of this subtask are to: (1) procure subcontracts required to carry out the tasks under this Agreement; and (2) ensure that the subcontracts are consistent with the terms and conditions of this Agreement.

The Recipient shall:

- Manage and coordinate subcontractor activities in accordance with the requirements of this Agreement.
- Incorporate this Agreement by reference into each subcontract.
- Include any required Energy Commission flow-down provisions in each subcontract, in addition to a statement that the terms of this Agreement will prevail if they conflict with the subcontract terms.
- If required by the CAM, submit a draft of each *Subcontract* required to conduct the work under this Agreement.

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- Submit a final copy of each executed subcontract.
- Notify and receive written approval from the CAM prior to adding any new subcontractors (see the discussion of subcontractor additions in the terms and conditions).

Products:

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

TECHNICAL ADVISORY COMMITTEE

Subtask 1.10 Technical Advisory Committee (TAC)

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

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

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

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

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- Utility representatives;
- Air district staff; and
- Members of relevant technical society committees.

The Recipient shall:

- Prepare a *List of Potential TAC Members* that includes the names, companies, physical and electronic addresses, and phone numbers of potential members. The list will be discussed at the Kick-off meeting, and a schedule for recruiting members and holding the first TAC meeting will be developed.
- Recruit TAC members. Ensure that each individual understands member obligations and the TAC meeting schedule developed in subtask 1.11.
- Prepare a *List of TAC Members* once all TAC members have committed to serving on the TAC.
- Submit *Documentation of TAC Member Commitment* (such as Letters of Acceptance) from each TAC member.

Products:

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

Subtask 1.11 TAC Meetings

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

The Recipient shall:

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

The TAC shall:

- Help set the project team's goals and contribute to the development and evaluation of its statement of proposed objectives as the project evolves.
- Provide a credible and objective sounding board on the wide range of technical and financial barriers and opportunities.
- Help identify key areas where the project has a competitive advantage, value proposition, or strength upon which to build.
- Advocate on behalf of the project in its effort to build partnerships, governmental support and relationships with a national spectrum of influential leaders.

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- Ask probing questions that insure a long-term perspective on decision-making and progress toward the project's strategic goals.
- Review and provide comments to proposed project performance metrics.
- Review and provide comments to proposed project Draft Technology Transfer Plan.

Products:

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

Subtask 1.12 Project Performance Metrics

The goal of this subtask is to 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

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TASK 2 MARKET CHARACTERIZATION & TECHNOLOGY ASSESSMENT

Subtask 2.1. Market Analysis on Heat Pump Technologies

The goal of this subtask is to characterize the market landscape of current and near-future low GWP HP products suitable for central plant applications and assess market and policy drivers and barriers to electrification in large commercial buildings.

The Recipient shall:

- Perform a market analysis to identify current and future low GWP heat recovery chillers and other heat pump products (e.g, air-to-water heat pump). The analysis will encompass aspects such as product availability, refrigerant, cost, operational features (including capacity, temperature range and efficiency, and standard configurations), infrastructure needs, and market and policy trends. For heat recovery chillers, additional technical detail information will be collected for other Tasks in this project, which includes performance data over various operating conditions for heat recovery chillers, and embedded-sensors and fault detection & diagnostics in the equipment. The site host will hire a design firm to help identify standard candidate configuration and control options.
- Prepare the *Technical Memorandum on Specifications of Investigated Low GWP Refrigerant HPs*. This memo will document the specifications of the candidate low-GWP HP products identified through a series of meetings with large HVAC OEMs (including, but not limited to, Daikin, Carrier, and JCI). The memo will describe refrigerant, cost, performance specifications, embedded sensors, other main functions like FDD, as well as product availability for each HP product.
- Conduct interviews with policy makers, owners, designers, manufacturers, and installers to understand drivers and barriers to electrifying hot water systems in large commercial buildings.
- Ensure that the investigated low GWP refrigerant heat pumps comply with local building codes, energy efficiency standards, and environmental regulations at the site.
- Prepare the *Market Analysis Technical Memorandum*, which will summarize the findings from stakeholder interviews and analyze technical challenges, market, and policy factors that hinder electrifying heating plants in large commercial buildings in CA.
-

Products:

- Technical Memorandum on Specifications of Investigated Low GWP Refrigerant HPs
- Market Analysis Technical Memorandum

Subtask 2.2. Heat Recovery Chiller Technology Assessment in CA

The goals of this subtask are to evaluate technical feasibility, applicability, and market size of the proposed heat recovery chiller solutions using market surveys, and to identify key design considerations that drive design decision making.

The Recipient shall:

- Perform at least 5-7 surveys on previous case studies retrofitting central plants with heat recovery chillers, and document common design practices including design configurations, technical challenges and solutions, sizing approach and equipment

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selection considerations, whole system design strategies such as the use of thermal storage and heat recovery, and control and operation approaches.

- Develop a series of design cases that are representative of California's large commercial building segments from the survey and evaluate the technical feasibility and market fit of current low-GWP technologies and their potential market size.
- Prepare the *Heat Recovery Chiller in CA - Technical Memorandum*, which will describe heat recovery chiller (HRC) retrofit and control approaches from existing HRC retrofit cases. Additionally, it will estimate a series of design cases of Low-GWP HRC that could be representative of CA's large commercial building and potential market size.

Products:

- Heat Recovery Chiller in CA - Technical Memorandum

TASK 3 DEVELOPMENT OF HOLISTIC SOLUTION PACKAGE & APPLICATION TO DEMO SITE

The goal of this task is to develop the design tools that provide a series of estimated costs (both capital and operating costs) over various design parameters, and help identify the most cost-effective hot water temperature, heat recovery chiller size and configuration, and control sequences for typical central plants. Once the software is developed, it will be applied to the demonstration site.

Subtask 3.1. Exploring Technologies Lowering Hot Water Temperature

Goal: This subtask is to explore, develop and test analytical and technical solutions to lowering hot water temperature.

The Recipient shall:

- Analyze an existing database of heating hot water system data from 300 buildings (collected as part of CEC PIER project 19-013) to quantify existing practice for technologies for cost-effectively reducing HWST.
- Test the identified technologies using the EnergyPlus model for a building on the host site's campus.
- Develop a step-by-step procedure for properly implementing each technology for reducing HWST.
- Develop building characteristics and BAS trend data analysis algorithms that are usable by engineers or consultants to screen for HWST reduction technologies in existing buildings.
- Develop a screening method to identify candidate buildings for reducing HWST and subsequent electrification retrofit.
- Develop the *Technical Memorandum on Technologies Lowering Hot Water Temperature Requirement (focusing on site application)*, that will describe identified technologies for lowering hot water supply temperature of heating plants, the corresponding step-by-step procedure, focusing on this project's site.
- Develop the *Technical Memorandum on Technologies Lowering Hot Water Temperature Requirement (general applications)*, that will document more general technical

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approaches for further applications beyond this project's site and the corresponding screening method.

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Products:

- Technical Memorandum on Technologies Lowering Hot Water Temperature Requirement (focusing on site application)
- Technical Memorandum on Technologies Lowering Hot Water Temperature Requirement (general applications)

Subtask 3.2. Development of Design Tools

The goal of this subtask is to develop design software to perform initial HP sizing; to provide a heat recovery chiller model library, a simulation model template for candidate design configurations, and control sequences for each configuration; and to perform a series of life cycle cost analyses over a range of design parameters.

The Recipient shall:

- Develop a high-level sizing tool, which will provide an initial heat recovery size and/or a suitable size range, given historical data of chiller and boiler loads for a central plant.
- Develop a model library of investigated low GWP heat recovery chillers, utilizing performance data obtained from the equipment survey conducted in Task 2.
- Develop a simulation model template. The template will encompass a range of candidate system configurations, both with and without TES, and typical heat source options (including exhaust air heat recovery and the use of a cooling tower). The configurations will be based on the Market Analysis results from Subtask 2.1 along with a comprehensive review of relevant literature.
- Develop a control design tool using OpenModelica. Control sequences will be designed for each configuration (with/without TES) to efficiently switch between HPs, gas boilers, chillers and other heat sources (e.g., exhaust air heat recovery and TES) in response to load changes.
- Develop a system design tool using EnergyPlus, Python and Microsoft Excel. This tool, with building-specific inputs, executes a series of life cycle cost analyses over a range of hot water temperatures, HP models and sizes, and configurations.
- Design *Tool Deployment Memorandum (focusing on site application)*, that will document the design tools, candidate low GWP HRC retrofit configurations, and anticipated costs specifically for project site applications.
- Develop the *Software and User Manual Technical Memorandum* (general applications), which will document and deliver the design tools (software) that would report candidate low GWP HRC retrofit configurations and anticipated costs for general applications. It will document the step-by-step guidelines and the distribution of the open-source design tools described above, free of charge in an open-source forum such as GitHub

Products:

- Design Tool Deployment Memorandum (focusing on site application).
- Software and User Manual Technical Memorandum (general applications) .

Subtask 3.3. Application to Demo Site

The goal of this subtask, by applying the design tools to the demo site, is to determine the most promising heat recovery chiller size, model, configuration including additional heat sources (e.g.,

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exhaust air heat recovery system) and control sequences, and perform a sensitivity study to consider several climate change scenarios. It will also develop another control sequence to provide demand response and demand charge regulation capabilities.

- Simulate an EnergyPlus model for the demo site to consider on-going retro-commissioning efforts and perform sensitivity analysis:
 - Perform quality control on the previously developed EnergyPlus model to ensure the accuracy and reliability of the baseline model
 - Update the building envelope and AHU parts of the baseline EnergyPlus model according to the retro-commissioning.
- Generate building load data using the updated EnergyPlus model (building envelope + AHUs).
- Apply the design tools to optimally design the system with the building load data generated from the EnergyPlus model, using energy, carbon, and operation cost as key metrics.
- Perform a sensitivity study of the proposed design to consider several climate change scenarios.
- Develop control sequences to provide demand response and demand charge reduction capabilities.
- Review the integrated system and control design and update as needed:
 - Hold regular meetings between the research team and project site host to discuss and address concerns and questions
 - Review and update the integrated system design as needed.
- Perform Title 24 compliance analysis
 - Develop a baseline building model with the existing HVAC system representing the test site in CBECC-COM
 - Implement the selected low-GWP HP system configuration in CBECC-COM and perform a compliance analysis
 - Prepare a *Title 24 Compliance Report* that assesses how the designed system meets or exceeds the energy efficiency requirements set forth by California's Title 24 standards. The report will include recommendations for any necessary modifications to achieve compliance.
- Conduct a final design review with our project team, which was not originally involved in the design process, and the design firm enlisted during Task 2.
- Prepare the *Technical Report on Final Design for Project Site and Cost Analysis Results*, which will include specifications of the selected low GWP HP and the final integrated system, results of life cycle cost and parametric study, and control sequences. Title 24 compliance analysis will also be included
- Prepare *CPR Report #1* and participate in a CRP Meeting per subtask 1.3.

Products:

- Technical Report on Final Design for Project Site and Cost Analysis Results
- CPR Report #1

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TASK 4 EQUIPMENT PROCUREMENT, INSTALLATION, INTEGRATION, AND COMMISSIONING

Subtask 4.1 Planning Retrofit

The goal of this subtask is to plan for retrofitting the central plant. It will include scheduling and identifying safety measures, with a special emphasis on the selected low GWP refrigerant. It will also involve the creation of detailed mechanical/electrical drawings according to the system and control design from Task 3, and of a set of construction documents, and the obtainment of any necessary permits and approvals from local authorities, through subcontracts to project site host using their customary source selection processes and vendors.

The Recipient shall:

- Subcontract to an engineering design firm to create design documents, including mechanical/electrical drawings, required for initiating the construction phase (including procurement)
- Schedule the procurement, installation and commissioning process
- Identify safety measures with a special emphasis on the selected low GWP refrigerant
- Complete a *Design and Engineering Technical Memorandum* that describes the design choices, the plan for procurement, installation, and commissioning processes, and safety measures for the selected low GWP refrigerant.

Products:

- Design and Engineering Technical Memorandum

Subtask 4.2. Procure, Install and Commission the Central Plant Retrofit

The goal of this task is to retrofit the central heating and cooling plants at the demonstration site according to the system and control design (Task 3). The procurement, installation, and management of the architectural, structural, electrical and mechanical modifications, and commissioning of the central plant retrofit will be performed through subcontracts to the project site host, using their customary source selection processes and vendors. In addition to the typical retrofit project, the following activities will address potential concerns about new low GWP HP technologies: (1) The project team will secure a service agreement and warranty from the selected manufacturer of the low GWP heat recovery chiller for additional support throughout the design, construction, commissioning, servicing, and maintenance phases, even after the grant is completed; (2) Building operators and maintenance staff will be trained on the new low GWP refrigerant system's operation and maintenance.

The Recipient shall:

- Perform construction administration services during including review of subcontractor(s).
- Procure all the systems and material necessary for the project as specified in the Design and Engineering Memo (Subtask 4.1). These components include, but are not limited to the following:
 - Selected low GWP heat recovery chiller(s)
 - Selected additional heat sources such as exhaust air heat recovery system
 - Pump(s), pipe(s), and control valve(s) for mechanical modifications
 - Electrical material
 - M&V instrumentation
 - Sensors for equipment-level performance monitoring including leak detectors

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- Install all procured material. Project site host will coordinate all work for proper installations and access to the facility, and perform punch walks to review to contractor installation and integration process
- Perform commissioning (Cx) to include site acceptance testing of the following:
 - Heat recovery chiller system
 - Meters required for M&V
 - Sensors required for M&V and equipment monitoring
 - Thermal storage (when applicable)
 - Two supervisory level controls: energy-efficient control (default control) and grid-responsive control
- Secure a service agreement and warranty from the selected manufacturer of the low GWP heat recovery chiller
- Train building operators and maintenance staff on the new low GWP refrigerant system's operation and maintenance
- Develop the *Procurement and Installation Technical Memorandum*, that describes the equipment that will be procured, product specification(s), along with model and vendors' name(s), and the completed system information including control updates
- Develop the *Commissioning Reports*, that documents the HRC equipment procured, equipment specifications, control updates for the retrofitted system, and commissioning results.
- If required by the CAM, host a tour of the project site for CEC leadership and staff to view the newly installed system

Products:

- Procurement and Installation Technical Memorandum (draft and final)
- Commissioning Reports

TASK 5 MEASUREMENT & VERIFICATION and EQUIPMENT PERFORMANCE MONITORING

Goal: The goal of this task is to comprehensively assess the actual operational efficiency, energy savings, performance of control strategies, environmental impacts, and stakeholder satisfaction of the implemented retrofits, in order to identify best practices and opportunities for replication in similar facilities in the future. In addition, a comprehensive equipment-level monitoring process will be performed using information to reveal potential degradation over the demonstration period. Leakage detection sensors will also be monitored and results stored and shared with stakeholders to address flammability and toxicity concerns.

Subtask 5.1. M&V Planning and Baseline Data Collection **The Recipient shall:**

- Develop *Baseline Measurement Plan* that documents the plan to evaluate the performance of the baseline without any retrofit implemented, and conduct baseline metering including collecting at least 12 months of pre-retrofit data, reviewing HVAC data (such as cooling and heating load profiles, and supply and return water temperatures) to characterize existing and retrofit system operational efficiency. The

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team will review historical data collected for the baseline system and validate and calibrate existing instrumentation to ensure high quality data.

- Develop the *Baseline Analysis Report* that analyzes the performance of the baseline using the collected data of baseline operation.
- Develop two detailed measurement and verification plans to evaluate the demonstration at the host site:
 - *Energy-efficient Control Measurement and Verification Plan* for evaluating the retrofitted plant with the energy-efficient control
 - *Grid-responsive Control Measurement and Verification Plan* for evaluating the retrofitted plant with grid-responsive control.

The two plans will include methodology for estimating the impact on energy use, impact on peak demand, impact on greenhouse gas emissions, implementation first cost, maintenance costs, and customer satisfaction.

Products:

- Baseline Measurement Plan
- Baseline Analysis Report
- Energy-efficient Control Measurement and Verification Plan
- Grid-responsive Control Measurement and Verification Plan

Subtask 5.2. Evaluation of Retrofitted System With Energy-efficient Control

The goal of this subtask is to evaluate the performance of the retrofitted system with the default, energy-efficient control.

The Recipient shall:

- Collect at least 12 months of post-retrofit data
- Perform energy and utility cost savings analysis using monitored data
 - TRC's evaluation team will estimate the impact on energy use using IPMVP Option B (retrofit isolation) and, for comparison, Option C (whole facility). Savings analysis will be based on interval HVAC submeter data using methods compliant with both IPMVP and ASHRAE Guideline 14-2023.
 - We will characterize the annual savings in terms of normalized energy use at each demonstration site. We will also develop regression models using the Time-of-Week and Temperature (TOWT) approach to determine typical annual energy use profiles for both the baseline and the demonstrated technology for an annual typical meteorological year (TMY3) weather file.
- Evaluate the performance of implemented default control strategy, greenhouse gas emission, energy resiliency, and proportion of boiler load.
- Collect information from building owners, contractors, and facility managers to evaluate satisfaction with equipment deployment, commissioning, maintenance, and servicing.
- Collect information from the project engineering and commissioning team to gather lessons learned and evaluate barriers and opportunities for replication in similar facilities.
- Document costs of the proposed partial electrification solutions, including equipment and labor, commissioning, control, maintenance, and servicing costs.
- Prepare the *Energy-efficient Control Measurement and Verification Analysis Report* for evaluating the performance of the retrofitted system with the default (energy-efficiency focused) control compared to the pre-retrofit system

Exhibit A

Scope of Work

Lawrence Berkeley National Laboratory

Products:

- Energy-efficient Control Measurement and Verification Analysis Report

Subtask 5.3. Evaluation of Retrofitted System with Grid-responsive Control

The goal of this subtask is to actively control the retrofitted system to evaluate the performance of the grid responsive control developed in Task 3. We will alternate between the default control (i.e., energy-efficient control) and grid-responsive control on a regular basis (e.g., a week). This strategy allows us to assess the system's success in meeting objectives related to peak demand reduction and load shedding. The field test for each peak reduction and load flexibility case will be performed during three months.

The Recipient shall:

- Collect at least 3 months of post-retrofit data under the grid-responsive control strategy
- Evaluate the performance of implemented control strategy, greenhouse gas emission, energy resiliency, and proportion of boiler load.
 - We will evaluate load flexibility of the control strategy for both load shed and peak demand (kW) between the default control and improved control periods. We will analyze the performance of grid-responsive control by isolating the peak periods and calculate the energy and demand savings between the default and improved controls during the peak periods. We will also estimate the impact on greenhouse gas (GHG) emissions under both controls.
- Prepare the *Grid-responsive Control Measurement and Verification Analysis Report* for evaluating the performance of the retrofitted system with the grid-responsive control compared to the retrofitted system with the pre-retrofit system
- Prepare *CPR Report #2* and participate in a CRP Meeting per subtask 1.3.
-

Products:

- Grid-responsive Control Measurement and Verification Analysis Report
- CPR Report #2

Subtask 5.4. Equipment Performance Monitoring

The Recipient shall:

- Monitor comprehensive equipment-level monitoring process using information to reveal potential degradation over the demonstration period. The essential data points to be monitored for equipment performance are compressor power, compressor speed, temperatures at suction, discharge, liquid-line and evaporator inlet locations, condensing and evaporating pressures, and leakage detector(s).
- Monitor and store results of leakage detection sensors.
- Develop the *Equipment Performance Degradation and Leakage Data Analysis Report*, that analyzes the monitored data over the demonstration period and identify potential performance degradation and leakage

Products:

- Equipment Performance Degradation and Leakage Data Analysis Report

TASK 6 RESEARCH ON SCALING AND MARKET ADVANCEMENT PATHWAYS

Exhibit A

Scope of Work

Lawrence Berkeley National Laboratory

Goal: This task is to develop materials to facilitate the market adoption of the proposed solution transitioning central plants with low GWP heat recovery chillers, identify and evaluate the critical technical considerations to scale the design configuration solutions (Task 3), describe market readiness level for retrofitting existing central plants to adopt the proposed solutions, and identify market resources and business cases to scale the adoption.

The Recipient shall:

- Gather information to evaluate market adoption readiness level, by organizing interviews and focus groups, as well as market research.
 - Assess the policy and regulatory environment that supports or hinders the adoption of low-GWP heat pump at scale, including research on refrigerant regulations, safety codes and permitting.
 - Assess the ability of a new project to adopt and operationalize the retrofit technology and identify technical and market resources needed to address market barriers.
 - Leverage the design tools from Task 3 to comprehensively evaluate the feasibility and product/market fit of multiple products. We will engage with manufacturers to assess cost competitiveness, future product development, manufacturing and supply chain, as well as design/installation/service support.
- Develop business cases for partial electrification and suggest incentive program connections including addressing partial electrification measure type barriers and impact of Total System Benefit metrics."
- Develop a systematic HVAC decarbonization technical assessment protocol that helps utilities, building owners in evaluating design approaches and technology solutions for their applications. The assessment protocol will include key decision-making parameters such as heat source availability, load profile, utility rates, climate, and financial needs
 - We will establish a set of evaluation criteria, such as product-market fit, financial feasibility (payback period threshold), resource maturity (e.g., manufacturing, supply chain and support during installation and services), market acceptance and risk, potential value stream (energy as well as non-energy benefits), for assessment of product and design options.
 - We will analyze market readiness financial and technical criteria for decision making through conducting surveys.
- Identify building types and market segments where the proposed design solution can be easily replicated.
- Develop the *Market Barriers and Advancement Pathway Report*, that documents and shares the technical and market resources, costs, and processes needed for low GWP HRC retrofit from this demonstration project, and identifies potential streamlined pathways to facilitate market adoption of low GWP HRC. Interview results for understanding market adoption readiness level and market barriers identified from market research will also be included.

Products:

- Market Barriers and Advancement Pathway Report (draft and final)

Exhibit A
Scope of Work
Lawrence Berkeley National Laboratory

TASK 7 STAKEHOLDER OUTREACH ACTIVITIES

The goal of this task is to share the findings from this research and demonstration project widely to a broad range of relevant industry stakeholders.

The Recipient shall:

- Host at least two conferences in which we present the results of our analysis, the control strategy, and the overall project outcome.
- Share project outcomes with the Center for High Performance Buildings at Purdue University who partners with major manufacturers and utility companies and solicit feedback.
- Disseminate the findings and lessons learned to the industry via presentations at the CBE bi-annual industry meeting and at relevant industry conferences such as ASHRAE and/or ACEEE, and present research findings as publications at these venues.
- Share the project results in a free, public seminar held in collaboration with PG&E.
- Convene a utility program stakeholder meeting to gather input on barriers and opportunities to promote ultra low GWP heat pumps in CA utility programs.
- Present findings to the California Technical Forum and gather input on developing utility program measures for ultra low GWP heat pumps
- Produce a short video summary of project findings
- Prepare *Outreach Materials*, that are the materials used for each outreach channel above and their appropriate format (which may be, but are not limited to, slides, conference papers, videos)
- Prepare the *Stakeholder Outreach Report* that summarizes audiences and their feedback

Products:

- Outreach Materials
- Stakeholder Outreach Report

TASK 8 DISADVANTAGED COMMUNITY BENEFIT STRATEGIES & EXECUTION

The goal of this task is to identify needs of local communities through community outreach, develop plans and strategies to benefit disadvantaged communities leveraging the research activities of this project, and launch the initial implementation to demonstrate benefits.

Subtask 8.1. Develop Local Workforce for the Green Building Industry to Increase Competitiveness

The Recipient shall:

- Conduct community outreach through YMCA South San Francisco's local network to identify and recruit residents of local disadvantaged communities that are interested in developing professional skills in the green building industry.
- Provide professional training to local residents identified above through free learning resources like the BayRen training program and the Sustainability Academy run by the San Mateo County Office of Sustainability. Certified training programs by third parties will also be explored and provided to selected eligible candidates.

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- Summarize the practical experience and outcomes of this demonstration project into teaching materials and add to the existing curriculums of the above training programs.
- Provide scholarships for eligible residents to reduce tuition fee burden.
- Prepare the *Outcomes of Workplace Development Memos*, that will document the outcomes of the workforce development and training programs through YMCA South San Francisco and San Mateo County Office of Sustainability

Products:

- Outcomes of Workforce Development Memos

Subtask 8.2. Transfer the Knowledge and Experience Learned from the Demonstration Project to Large Building Candidates Serving the Local Disadvantaged Communities

The Recipient shall:

- Conduct community outreach through the EnergyWatch and RICAPS program to identify potential large building candidates serving the local disadvantaged communities, such as local government public buildings (e.g., community centers) and buildings of local school districts. These buildings are candidates of early adopters of the low-GWP heat pump technology and may benefit the most from the practical experience through this demonstration project.
- Regularly share progress, successes, failures, and practical experience from the project during the quarterly hosted Facilities Working Group through the EnergyWatch program and the monthly working group's meetings with city sustainability staff through the RICAPS program. Participate in active discussion with the working group and get their feedback.
- Develop the *Outcomes of Community Outreach Activities Memo*, that documents the outcomes of the community outreach activities

Products:

- Outcomes of Community Outreach Activities Memo

Subtask 8.3. Enrich Educational Programs of Local School Districts

The Recipient shall:

- Organize tours of the demonstration site at project site for local K-12 students, which provides hands-on learning experience about building decarbonization.
- Leverage the existing Youth Exploring Climate Science Program at the San Mateo County Office of Sustainability, transfer and customize knowledge and lessons learned from this project into applicable teaching material and feed into its curriculum.
- Develop the *Teaching Materials*, that summarizes the practical experience and outcomes of this demonstration project into teaching materials.

Products:

- Teaching Material

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TASK 9 TECHNOLOGY/KNOWLEDGE TRANSFER ACTIVITIES

The goal of this subtask is to ensure the technological learning that resulted from the demonstration(s) is captured and disseminated to the range of professions that will be responsible for future deployments of this technology or similar technologies.

The Recipient Shall:

- Develop and submit a *Project Case Study Plan* that outlines how the Recipient will document the planning, construction, commissioning, and operation of the technology or system being demonstrated. The Project Case Study Plan should include:
 - An outline of the objectives, goals, and activities of the case study.
 - The organization that will be conducting the case study and the plan for conducting it.
 - A list of professions and practitioners involved in the technology's deployment.
 - Specific activities the recipient will take to ensure the learning that results from the project is disseminated to those professions and practitioners.
 - Presentations/webinars/training events to disseminate the results of the case study.
- Present the draft *Project Case Study Plan* to the TAC for review and comment.
- Develop and submit a *Summary of TAC Comments* that summarizes comments received from the TAC members on the draft *Project Case Study 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 *Project Case Study Plan* to the CAM for approval.
- Execute the final Project Case Study Plan and develop and submit a Project Case Study.
- When directed by the CAM, develop presentation materials for a CEC sponsored conference/workshop(s) on the project.
- When directed by the CAM, participate in annual EPIC symposium(s) sponsored by the California 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:

- Project Case Study Plan (draft and final)
- Summary of TAC Comments
- Project Case Study (draft and final)
- High Quality Digital Photographs

TASK 10 EVALUATION OF PROJECT BENEFITS

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

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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