

WORK STATEMENT

TECHNICAL TASK LIST

Task #	CPR	Task Name
1	N/A	Administration
2	X	Obtain APC In-Row Cooler and Prepare Site for Installation
3		Install, Commission, and Operate System
4		Monitor Performance
5		Technology Transfer Activities
6		Production Readiness Plan

KEY NAME LIST

Task #	Key Personnel	Key Subcontractor(s)	Key Partner(s)
1	William Tschudi	APC	LBNL IT dept.
2	William Tschudi	APC	LBNL IT dept.
3	William Tschudi	APC	LBNL IT dept.
4	William Tschudi	APC	LBNL IT dept.
5	William Tschudi	APC	LBNL IT dept.
6	William Tschudi	APC	LBNL IT dept.

GLOSSARY

Specific terms and acronyms used throughout this scope of work are defined as follows:

Term/ Acronym	Definition
APC	American Power Conversion
BTU	British Thermal Unit
CPR	Critical Project Review
Energy Commission	California Energy Commission
EPA	United States Environmental Protection Agency
HVAC	Heating Ventilating and Air Conditioning
IT	Information Technology
kW	Kilowatts
LBNL	Lawrence Berkeley National Laboratory
M&V	Measurement & Verification
PAC	Project Advisory Committee
PG&E	Pacific Gas & Electric Company
PIER	Public Interest Energy Research
RD&D	Research, Development and Demonstration

Term/ Acronym	Definition
Ton	Measure of cooling

Problem Statement:

Conventional data centers are cooled with chilled water or refrigerant based systems. The United States Environmental Protection Agency (EPA) report to Congress in 2006¹ estimated that data centers accounted for 1.5% of the nation's energy use and that data centers could be approaching 3% of the total energy use by 2011. The percentage is likely higher in California, which is thought to have a larger than average percentage of data centers. The energy for cooling represents 30-50% of total data center energy use.

In much of California, cooling could be provided for most, if not all, of the year using cooling towers alone if the Heating Ventilating and Air Conditioning (HVAC) equipment were designed to remove the heat generated by Information Technology (IT) equipment using higher temperature water. Traditional computer room air handlers, for example, contain coils that are designed to operate using lower temperature chilled water, so chillers must operate continuously to provide the cold water that the coils were designed for. This Agreement will demonstrate the use of a dual coil developed by American Power Conversion which can operate on higher temperature water when it can be produced without operating a chiller or on traditional chilled water if conditions require mechanical cooling. Typical data center cooling in practice today has efficiencies in the 1 to 1.4 kilowatt (kW)/ton range. With this technology, cooling could be provided with efficiency in the range of 0.3 to 0.6 kW/Ton (one ton of refrigeration can remove 12,000 BTUs of heat in one hour).

Goals of the Agreement:

The goal of this Agreement is to demonstrate the energy savings that can be obtained using cooling tower water to cool IT equipment using higher temperature water than traditional chilled water systems. This demonstration at Lawrence Berkeley National Laboratory (LBNL) will quantify energy savings from a technology that is readily able to be deployed.

Objectives of the Agreement:

The objectives of this Agreement are to measure cooling system performance in order to quantify energy savings using this technology while providing reliable and controlled cooling for the IT equipment keeping within its specifications. An objective will be to show how tower water cooling can eliminate many hours per year of chiller operation in order to speed adoption of this energy efficiency strategy. The pilot demonstration of the in-row cooling system contains dual cooling coils which can operate on normal chilled water if the outside environment is too hot or higher temperature water when the necessary cooling can be supplied through the use of cooling towers. This product is not currently available to the market but has been tested by the manufacturer. This pilot

¹http://www.energystar.gov/ia/partners/prod_development/downloads/EPA_Datacenter_Report_Congress_Final1.pdf

demonstration will provide reinforcement to the manufacturer that this technology will be desired by the market while also potentially stimulating other manufacturers to develop products that operate with higher temperature cooling. The demonstration will also help to create demand for this technology.

Product Guidelines:

For complete product guidelines, refer to Section 5 in the Terms and Conditions.

TASK 1 ADMINISTRATION

Task 1.1 Attend Kick-off Meeting

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

The Recipient shall:

- Attend a “Kick-Off” meeting with the Commission Project Manager, the Grants Officer, and a representative of the Accounting Office. The Recipient shall bring its Project Manager, Agreement Administrator, Accounting Officer, and others designated by the Commission Project Manager to this meeting. The administrative and technical aspects of this Agreement will be discussed at the meeting. Prior to the kick-off meeting, the Commission Project Manager will provide an agenda to all potential meeting participants.

The administrative portion of the meeting shall include, but not be limited to, the following:

- Discussion of the terms and conditions of the Agreement
- Discussion of Critical Project Review (Task 1.2)
- Match fund documentation (Task 1.6)
- Permit documentation (Task 1.7)

The technical portion of the meeting shall include, but not be limited to, the following:

- The Commission Project Manager’s expectations for accomplishing tasks described in the Scope of Work
- An updated Schedule of Products
- Discussion of Progress Reports (Task 1.4)
- Discussion of Technical Products (Product Guidelines located in Section 5 of the Terms and Conditions)
- Discussion of the Final Report (Task 1.5)

The Commission Project Manager shall:

- Designate the date and location of this meeting.

Recipient Products:

- Updated Schedule of Products (no draft)
- Updated List of Match Funds (no draft)
- Updated List of Permits (no draft)

Commission Project Manager Product:

- Kick-Off Meeting Agenda (no draft)

Task 1.2 Critical Project Review (CPR) Meetings

The goal of this task is to determine if the project should continue to receive Energy Commission funding to complete this Agreement and to identify any needed modifications to the tasks, products, schedule or budget.

CPRs provide the opportunity for frank discussions between the Energy Commission and the Recipient. CPRs generally take place at key, predetermined points in the Agreement, as determined by the Commission Project Manager and as shown in the Technical Task List above. However, the Commission Project Manager may schedule additional CPRs as necessary, and any additional costs will be borne by the Recipient.

Participants include the Commission Project Manager and the Recipient and may include the Commission Grants Officer, the Public Interest Energy Research (PIER) Program Team Lead, other Energy Commission staff and Management as well as other individuals selected by the Commission Project Manager to provide support to the Energy Commission.

The Commission Project Manager shall:

- Determine the location, date, and time of each CPR meeting with the Recipient. These meetings generally take place at the Energy Commission, but they may take place at another location.
- Send the Recipient the agenda and a list of expected participants in advance of each CPR. If applicable, the agenda shall include a discussion on both match funding and permits.
- Conduct and make a record of each CPR meeting. One of the outcomes of this meeting will be a schedule for providing the written determination described below.
- Determine whether to continue the project, and if continuing, whether or not modifications are needed to the tasks, schedule, products, and/or budget for the remainder of the Agreement. Modifications to the Agreement may require a formal amendment (please see the Terms and Conditions). If the Commission Project Manager concludes that satisfactory progress is not being made, this conclusion will be referred to

the Energy Commission's Research, Development and Demonstration (RD&D) Policy Committee for its concurrence.

- Provide the Recipient with a written determination in accordance with the schedule. The written response may include a requirement for the Recipient to revise one or more product(s) that were included in the CPR.

The Recipient shall:

- Prepare a CPR Report for each CPR that discusses the progress of the Agreement toward achieving its goals and objectives. This report shall include recommendations and conclusions regarding continued work of the projects. This report shall be submitted along with any other products identified in this scope of work. The Recipient shall submit these documents to the Commission Project Manager and any other designated reviewers at least 15 working days in advance of each CPR meeting.
- Present the required information at each CPR meeting and participate in a discussion about the Agreement.

Commission Project Manager Products:

- Agenda and a list of expected participants (no draft)
- Schedule for written determination (no draft)
- Written determination (no draft)

Recipient Products:

- CPR Report(s) (no draft)

Task 1.3 Final Meeting

The goal of this task is to closeout this Agreement.

The Recipient shall:

- Meet with Energy Commission staff to present the findings, conclusions, and recommendations. The final meeting must be completed during the closeout of this Agreement.

This meeting will be attended by, at a minimum, the Recipient, the Commission Grants Office Officer, and the Commission Project Manager. The technical and administrative aspects of Agreement closeout will be discussed at the meeting, which may be two separate meetings at the discretion of the Commission Project Manager.

The technical portion of the meeting shall present an assessment of the degree to which project and task goals and objectives were achieved, findings, conclusions, recommended next steps (if any) for the Agreement, and recommendations for improvements. The Commission Project Manager will determine the appropriate meeting participants.

The administrative portion of the meeting shall be a discussion with the Commission Project Manager and the Grants Officer about the following Agreement closeout items:

- What to do with any equipment purchased with Energy Commission funds (Options)
- Energy Commission's request for specific "generated" data (not already provided in Agreement products)
- Need to document 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 schedule for completing the closeout activities for this Agreement

Products:

- Written documentation of meeting agreements (no draft)
- Schedule for completing closeout activities (no draft)

Task 1.4 Monthly Progress Reports

The goal of this task is to periodically verify that satisfactory and continued progress is made towards achieving the research objectives of this Agreement on time and within budget.

The objectives of this task are to 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, and to form the basis for determining whether invoices are consistent with work performed.

The Recipient shall:

- Prepare a Monthly Progress Report which summarizes all Agreement activities conducted by the Recipient for the reporting period, including an assessment of the ability to complete the Agreement within the current budget and any anticipated cost overruns. Each progress report is due to the Commission Project Manager within 10 working days of the end of the reporting period. The recommended specifications for each progress report are contained in Exhibit A, Attachment A-2.

Products:

- Monthly Progress Reports (no draft)

Task 1.5 Final Report

The goal of the Final Report is to assess the project's success in achieving its goals and objectives, advancing science and technology, and providing energy-related and other benefits to California.

The objectives of the Final Report are to clearly and completely describe the project's purpose, approach, activities performed, results, and advancements in science and technology; to present a public assessment of the success of the project as measured by the degree to which goals and objectives were achieved; to make insightful observations based on results obtained; to draw conclusions; and to make recommendations for further RD&D projects and improvements to the PIER project management processes.

The Final Report shall be a public document. If the Recipient has obtained confidential status from the Energy Commission and will be preparing a confidential version of the Final Report as well, the Recipient shall perform the following activities for both the public and confidential versions of the Final Report.

The Recipient shall:

- Prepare an Outline of the Final Report.
- Prepare a Final Report following the approved outline and the latest version of the PIER Final Report guidelines published on the Energy Commission's website at <http://www.energy.ca.gov/contracts/pier/contractors/index.html> at the time the Recipient begins performing this task, unless otherwise instructed in writing by the Commission Project Manager. Instead of the timeframe listed in the Product Guidelines located in Section 5 of the Terms and Conditions, the Commission Project Manager shall provide written comments on the Draft Final Report within fifteen (15) working days of receipt. The Final Report must be completed on or before the end of the Agreement Term.
- Submit one bound copy of the Final Report with the final invoice.

Products:

- Draft Outline of the Final Report
- Final Outline of the Final Report
- Draft Final Report
- Final Report

Task 1.6 Identify and Obtain Matching Funds

The goal of this task is to ensure that the match funds planned for this Agreement are obtained for and applied to this Agreement during the term of this Agreement.

The costs to obtain and document match fund commitments are not reimbursable through this Agreement. Although the PIER budget for this task will be zero dollars, the Recipient may utilize match funds for this task. Match funds shall be spent concurrently or in advance of PIER funds for each task during the term of this Agreement. Match funds must be identified in writing and the associated commitments obtained before the Recipient can incur any costs for which the Recipient will request reimbursement.

The Recipient shall:

- Prepare a letter documenting the match funding committed to this Agreement and submit it to the Commission Project Manager at least 2 working days prior to the kick-off meeting. If no match funds were part of the proposal that led to the Energy Commission awarding this Agreement and none have been identified at the time this Agreement starts, then state such in the letter. If match funds were a part of the proposal that led to the Energy Commission awarding this Agreement, then provide in the letter a list of the match funds that identifies the:
 - Amount of each cash match fund, its source, including a contact name, address and telephone number and the task(s) to which the match funds will be applied
 - Amount of each in-kind contribution, a description, documented market or book value, and its 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 shall identify its owner and provide a contact name, address and telephone number, and the address where the property is located
- Provide a copy of the letter of commitment from an authorized representative of each source of cash match funding or in-kind contributions that these funds or contributions have been secured.
- Discuss match funds and the implications to the Agreement if they are reduced or not obtained as committed, at the kick-off meeting. If applicable, match funds will be included as a line item in the progress reports and will be a topic at CPR meetings.
- Provide the appropriate information to the Commission Project Manager if during the course of the Agreement additional match funds are received.
- Notify the Commission Project Manager within 10 working days if during the course of the Agreement existing match funds are reduced. Reduction in match funds must be approved through a formal amendment to the Agreement and may trigger an additional CPR.

Products:

- A letter regarding match funds or stating that no match funds are provided (no draft)
- Copy(ies) of each match fund commitment letter(s) (if applicable)

- (no draft)
- Letter(s) for new match funds (if applicable) (no draft)
- Letter that match funds were reduced (if applicable) (no draft)

Task 1.7 Identify and Obtain Required Permits

The goal of this task 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. Although the PIER budget for this task will be zero dollars, the Recipient shall budget match funds for any expected expenditures associated with obtaining permits. Permits must be identified in writing and obtained before the Recipient can make any expenditures for which a permit is required.

The Recipient shall:

- Prepare a letter documenting the permits required to conduct this Agreement and submit it to the Commission Project Manager at least 2 working days prior to the kick-off meeting. If there are no permits required at the start of this Agreement, then state such in the letter. If it is known at the beginning of the Agreement that permits will be required during the course of the Agreement, provide in the letter:
 - A list of the permits that identifies the:
 - Type of permit
 - Name, address and telephone number of the permitting jurisdictions or lead agencies
- The schedule the Recipient will follow in applying for and obtaining these permits.
- Discuss the list of permits and the schedule for obtaining them at the kick-off meeting and develop a timetable for submitting the updated list, schedule and the copies of the permits. The implications to the Agreement 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 the Progress Reports and will be a topic at CPR meetings.
- If during the course of the Agreement additional permits become necessary, provide the appropriate information on each permit and an updated schedule to the Commission Project Manager.
- As permits are obtained, send a copy of each approved permit to the Commission Project Manager.
- If during the course of the Agreement permits are not obtained on time or are denied, notify the Commission Project Manager within 10 days. Either of these events may trigger an additional CPR.

Products:

- Letter documenting the permits or stating that no permits are required (no draft)
- A copy of each approved permit (if applicable) (no draft)
- Updated list of permits as they change during the term of the Agreement (if applicable) (no draft)
- Updated schedule for acquiring permits as changes occur during the term of the Agreement (if applicable) (no draft)

TECHNICAL TASKS**TASK 2 OBTAIN APC PROTOTYPE IN-ROW COOLER AND PREPARE SITE FOR INSTALLATION**

The goal of this task is to obtain the APC prototype in-row cooler and prepare the data center for its installation. This will involve contracting with APC and location planning and commitments for the IT equipment to be installed in the system with LBNL IT staff.

The Recipient shall:

- Execute a sub-contract agreement with APC for the purchase of the prototype in-row cooler
- Locate a suitable location for installation
- Determine IT equipment to populate the system
- Coordinate with APC on design and installation requirements
- Participate in a CPR as per Task 1.2
- Prepare a summary of results of the work performed under this task (to be included in the Monthly Progress Report)
- Prepare a complete write-up of the work performed under this task (to be included in the Final Report)

Products:

- Summary of work performed in Task 2 (no draft)
- Complete write-up of work performed in Task 2

TASK 3 INSTALL, COMMISSION, AND OPERATE SYSTEM

The goal of this task is to install the in-row cooling system and commission the system to ensure adequate cooling is provided. System operation will be verified through manual and wireless temperature monitoring.

The Recipient shall:

- Install the in-row cooler. LBNL staff in concert with an APC technical advisor will install and commission the APC prototype.
- Observe thermal performance of the APC unit and troubleshoot any anomalies.
- Prepare a summary of results of the work performed under this task and photograph(s) of installed equipment (to be included in the Monthly Progress Report)
- Prepare a complete write-up of the work performed under this task (to be included in the Final Report)

Products:

- Summary of work performed in Task 3 to include photograph(s) of installed equipment (no draft)
- Complete write-up of work performed in Task 3

TASK 4 MONITOR PERFORMANCE

The goal of this task is to monitor the performance of the in-row cooling system and document the potential energy savings compared to traditional chilled water cooling under various scenarios. The recipient will develop a monitoring plan will be developed in conjunction with APC which will include temperature and flow monitoring. The monitoring plan will be reviewed with Pacific Gas and Electric Company's (PG&E) data center efficiency staff in order for it to be similar to a Utility Measurement & Verification (M&V) plan. A further goal will be to estimate a range of yearly energy savings that could accrue using this system at the location tested.

The Recipient shall:

- Install the in-row cooler. LBNL resources in concert with APC technical advisor will install and commission the APC prototype.
- Prepare a Monitoring Plan to include but not be limited to:
 - Temperature
 - Airflow
 - Power consumption
 - Range of yearly energy savings
 - Consistency with PG&E Utility M&V practices
- Collect and analyze the monitored data
- Prepare a summary of results of the work performed under this task (to be included in the Monthly Progress Report)
- Prepare a complete write-up of the work performed under this task (to be included in the Final Report)

Products:

- Monitoring Plan (no draft)

- Summary of results performed in Task 4 to include a written analysis of monitored data (no draft)
- Complete write-up of work performed in Task 4

TASK 5 TECHNOLOGY TRANSFER ACTIVITIES

The goal of this task is to develop a plan to make the knowledge gained, experimental results and lessons learned available to key decision-makers.

The Recipient shall:

- Using established technology transfer channels (effective in prior PIER data center projects), disseminate results from the study to a broad group of data center professionals to include but not be limited to:
 - 7x24 Exchange
 - Uptime Institute
 - Green Grid
 - Data Center Pulse
 - Critical Facilities Roundtable
 - Silicon Valley Leadership Group
- Prepare one or more trade magazine articles summarizing the performance of the in-row cooling equipment
- Prepare and conduct a power point presentation for open house briefing(s) to allow the public to view the installation and hear about the technology application
- (APC) Prepare a white paper for posting on LBNL and APC websites

Products:

- One or more trade magazine articles
- Copy of power point presentation (no draft)
- APC white paper

TASK 6 PRODUCTION READINESS PLAN

The goal of this task is to develop a plan to make the technology demonstrated ready for production.

The Recipient shall:

- Develop a plan for producing the technology for the marketplace.

Products:

- Draft Production Readiness Plan
- Final Production Readiness Plan