California Energy Commission
02-28-2023 Business Meeting
Backup Materials for Agenda Item No 03e:
Guidehouse Inc.

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

1. Proposed Resolution (attached below).
2. Grant Request Form or Grant Amendment Request Form or Contract Request Form or Loan Request Form (applicable form attached below).
3. Scope of Work (attached below).
4. CEQA documents (if applicable, attached below).
5. Other relevant documentation or link to other documentation (if applicable, attached below).

RESOLUTION NO: 23-0228-03e

STATE OF CALIFORNIA

STATE ENERGY RESOURCES
CONSERVATION AND DEVELOPMENT COMMISSION

RESOLUTION: GUIDEHOUSE INC.

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

RESOLVED, that the CEC approves Agreement 300-22-002 with Guidehouse Inc. for a $2,499,443 contract to assess the potential need for long-duration and seasonal energy storage on California's electric grid through 2045. Electrochemical, thermal, mechanical, and gaseous fuel storage technology types will be evaluated and modeled to inform electric system planning and procurement of emerging storage resources in 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 February 28, 2023.

AYE:
NAY:
ABSENT:
ABSTAIN:

Dated:

_____
Liza Lopez
Secretariat

STATE OF CALIFORNIA

CONTRACT REQUEST FORM (CRF)

CEC-94 (Revised 12/2019) CALIFORNIA ENERGY COMMISSION

A) New Agreement # 300-22-002 (to be completed by CGL office)

B) Division	Agreement Manager:	MS-	Phone
ERDD	Jeffrey Sunquist	43	916-776-0816

C) Contractor's Legal Name	Federal ID Number
Guidehouse Inc.	36-4094854

D) Title of Project
Modeling Long-Duration Energy Storage Emerging Technologies

E) Term and Amount

Start Date	End Date	Amount
3/15/2023	3/31/2026	$ 2,499,443

F) Business Meeting Information

☐ Operational agreement (see CAM Manual for list) to be approved by Executive Director

☐ ARFVTP agreements $75K and under delegated to Executive Director

Proposed Business Meeting Date 2/28/2023 ☒ Consent ☐ Discussion

Business Meeting Presenter Mike Gravely Time Needed: 5 minutes

Please select one list serve. Select

Agenda Item Subject and Description:

Guidehouse Inc.

Guidehouse Inc. Proposed resolution approving Agreement 300-22-002 with Guidehouse Inc., for a $2,499,443 contract to assess the potential need for long-duration and seasonal energy storage on California's electric grid through 2045. Electrochemical, thermal, mechanical, and gaseous fuel storage technology types will be evaluated and modeled to inform electric system planning and procurement of emerging storage resources in California, and adopting staff's determination that this action is exempt from CEQA. (LDES funding) Contact: Mike Gravely. Contact: Mike Gravely.

G) California Environmental Quality Act (CEQA) Compliance

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

   ☒ Yes (skip to question 2)
   ☐ No (complete the following (PRC 21065 and 14 CCR 15378)):

   Explain why Agreement is not considered a "Project":

2. If Agreement is considered a "Project" under CEQA:

   a) ☒ Agreement **IS** exempt.

   ☐ Statutory Exemption. List PRC and/or CCR section number:

   ☒ Categorical Exemption. List CCR section number: Cal. Code Regs., tit. 14, § 15306

   ☒ Common Sense Exemption. 14 CCR 15061 (b) (3) Explain reason why Agreement is exempt under the above section: The activity is covered by the

common sense exemption that CEQA applies only to projects, which have the potential for causing a signification effect on the environment. Where it can be seen with certainty that there is no possibility that the activity in question may have a significant effect on the environment, the activity is not subject to CEQA. Here the project involves preliminary activities such as reviewing literatures, conducting interviews, drafting reports on long duration energy storage technology and current and future financial structures for long duration energy storage. The project also includes analyzing potential locations of future storage, developing storage resource portfolios and scenarios of future electric system conditions and modeling the scenarios and portfolio combinations. The project does not involve any physical impacts since all work will be conducted on computers. The project does not commit to funding any of the recommendations flowing from the agreement. Any potential locations of future storage would require compliance with CEQA before the CEC could fund future projects.

14 CCR 15306 involves activities of basic data collection, research, and resource evaluation activities which do not result in a serious or major disturbance to an environmental resource.

This project involves activities that are information gathering, reports and modeling leading to an action which a public agency has not yet approved, adopted or funded.This project does not involve impacts on any particularly sensitive environment; 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.

The activity is covered by the general rule that CEQA applies only to projects which have the potential for causing a significant effect on the environment. Where it can be seen with certainty that there is no possibility that the activity in question may have a significant effect on the environment, the activity is not subject to CEQA.

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

Check all that apply

☐ Initial Study
☐ Negative Declaration
☐ Mitigated Negative Declaration
☐ Environmental Impact Report
☐ Statement of Overriding Considerations

H) List all subcontractors (major and minor) and equipment vendors: (attach additional sheets as necessary)

Legal Company Name:	Budget
	$
	$
	$
	$
	$
	$
	$
	$
	$
	$

I) List all key partners: (attach additional sheets as necessary)

Legal Company Name:

J) Budget Information

Funding Source	Funding Year of Appropriation	Budget List Number	Amount
GENERAL	22-23	303.101	$2,499,443
			$
			$
			$
			$
			$

R&D Program Area: ESRB: ETSI TOTAL: $2,499,443

Explanation for “Other” selection

Reimbursement Contract #: Federal Agreement #:

K) Contractor’s Contact Information

1. **Contractor’s Administrator/Officer**

   Name: Amul Sathe

   Address: 101 California St Ste 4100

   City, State, Zip: San Francisco, CA 94111-5886

   Phone: 415-399-2180

   E-Mail: amul.sathe@guidehouse.com

2. **Contractor’s Project Manager**

   Name: Warren Wang

   Address: 101 California St Ste 4100

   City, State, Zip: San Francisco, CA 94111-5886

Phone: 213-618-9019 E-Mail: wwang@guidehouse.com

L) Selection Process Used

☐ Solicitation Select Type Solicitation #: # of Bids: Low Bid ☐ No ☐ Yes

☐ Non Competitive Bid *(Attach DGS-GSPD-09-007 https://www.dgs.ca.gov/PD/Forms)*

☒ Exempt: The cost to the state is reasonable for the reasons provided in section R below and this non-competitive award is authorized because a competitive solicitation would frustrate the obtainment of necessary information, goods, or services in a timely manner. (PRC 25643(d)(3))

☐ Non Competitive Follow On Funding (SB 115)

M) Contractor Entity Type

☒ Private Company *(including non-profits)*

☐ CA State Agency *(including UC and CSU)*

☐ Government Entity *(i.e. city, county, federal government, air/water/school district, joint power authorities, university from another state)*

N) Is Contractor a certified Small Business (SB), Micro Business (MB) or DVBE?

If yes, check appropriate box(es): ☐ SB ☐ MB ☐ DVBE

O) Civil Service Considerations

☒ Not Applicable (Agreement is with a CA State Entity or a membership/co-sponsorship)

☐ Public Resources Code 25620, et seq., authorizes the Commission to contract for the subject work. (PIER)

☐ The Services Contracted:

- ☐ are not available within civil service
- ☐ cannot be performed satisfactorily by civil service employees
- ☐ are of such a highly specialized or technical nature that the expert knowledge, expertise, and ability are not available through the civil service system.

☐ The Services are of such an:

- ☐ urgent
- ☐ temporary, or
- ☐ occasional nature

that the delay to implement under civil service would frustrate their very purpose.

Justification:

This Contract will lead to improved understanding of the need for long-duration and seasonal energy storage in California and how to best manage and utilize emerging energy storage technologies. The modeling conducted under this project requires technical expertise and capabilities not available through the civil service system. This research and analysis are urgently needed to inform near-term investments in long-duration and seasonal storage. Agreements entered into for the purposes of Long-Duration Energy Storage Program are not required to comply with the the personal services contracting requirements of Article 4 (commencing with Section 19130) of Chapter 5 of Part 2 of Division 5 of Title 2 of the Government Code. (PRC 25644)

P) Payment Method

1. ☒ Reimbursement in arrears based on:
   ☒ Itemized Monthly ☐ Itemized Quarterly ☐ Flat Rate ☐ One-time
2. ☐ Advanced Payment
3. ☐ Other, explain:

Q) Retention

Is Agreement subject to retention? ☐ No ☒ Yes

If Yes, Will retention be released prior to Agreement termination? ☒ No ☐ Yes

R) Justification of Rates

Guidehouse's rates in this contract are similar to rates used their previous contracts with the CEC: 500-20-003 (PIER NG), 300-15-009 (EPIC), 800-20-001 (contract with EAD), 800-16-006 (contract with EAD).

S) Disabled Veteran Business Enterprise Program (DVBE)

1. ☐ Exempt (Interagency/Other Government Entity)
2. ☐ Meets DVBE Requirements DVBE Amount:$ DVBE %:
   a. ☐ Contractor is Certified DVBE
   b. ☐ Contractor is Subcontracting with a DVBE:
3. ☐ Contractor selected through CMAS or MSA with no DVBE participation
4. ☒ Requesting DVBE Exemption (attach CEC 95)

T) Miscellaneous Agreement Information

1. Will there be Work Authorizations? ☒ No ☐ Yes
2. Is the Contractor providing confidential information? ☒ No ☐ Yes
3. Is the contractor going to purchase equipment? ☒ No ☐ Yes
4. Check frequency of progress reports
   ☒ Monthly ☐ Quarterly ☐ Other
5. Will a final report be required? ☐ No ☒ Yes
6. Is the Agreement, with amendments, longer than three years? If yes, why?
   ☐ No ☒ Yes

   The Department of General Services has agreed to give the Commission blanket authority to execute multi-year contracts to support the Commission's RD&D Programs.

U) The following items should be attached to this CRF (as applicable)

1.	Exhibit A, Scope of Work	☐ N/A	☒ Attached
2.	Exhibit B, Budget Detail	☐ N/A	☒ Attached
3.	DGS-GSPD-09-007, NCB Request	☒ N/A	☐ Attached
4.	CEC 95, DVBE Exemption Request	☐ N/A	☒ Attached
5.	CEQA Documentation	☐ N/A	☒ Attached
6.	Resumes	☒ N/A	☐ Attached
7.	CEC 105, Questionnaire for Identifying Conflicts		☒ Attached

Agreement Manager **Date**

_____ _____

Office Manager **Date**

_____ _____

Deputy Director **Date**

EXHIBIT A
SCOPE OF WORK
Guidehouse Inc.

I. TASK ACRONYM/TERM LISTS

TASK LIST

Task #	CPR[1]	Task Name
1		Agreement Management
2		Determine Technology Options and Trends for Long Duration and Seasonal Energy Storage
3		Assess Existing Market and Contracting Structures
4		Conceptualize Revenue Structures for Long Duration and Seasonal Storage
5	X	Identify Potential Locations and Requirements for Seasonal Energy Storage
6		Identify Portfolio Evaluation Criteria and Benchmark/Validate Production Cost and Capacity Expansion Models
7		Develop Portfolios and Scenarios
8	X	Run Production Cost Model for Scenario and Portfolio Combinations
9		Knowledge Transfer

ACRONYMS/GLOSSARY

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

Acronym	Definition
CAISO	California Independent System Operator
CAM	Commission Agreement Manager
CAO	Commission Agreement Officer
CEC	State Energy Resources Conservation and Development Commission or as commonly called, the California Energy Commission
CPR	Critical Project Review
CPUC	California Public Utilities Commission
DOE	United States Department of Energy
EE	Energy Efficiency
GHG	Greenhouse Gas
LDES	Long Duration Energy Storage
NYSERDA	New York State Energy Research and Development Authority
O&M	Operations and Maintenance
PSH	Pumped Storage Hydropower
State	State of California
TAC	Technical Advisory Committee

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

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

A. Purpose of Agreement

The purpose of this Contract is to assess the potential need for long duration and seasonal storage on California's electric grid through 2045 and evaluate the economic implications of different cost recovery options and system reliability based on multiple scenarios of future electric system conditions. The Contract will develop several resource portfolios composed of different types, amounts, and durations of long duration and seasonal storage technologies that meet identified needs. The Contract will use production cost modeling to compare the portfolios of storage technologies based on criteria such as total system cost, system reliability, projected commercial viability, worldwide acceptance, and greenhouse gas emissions. The results will identify tradeoffs between different portfolios and help inform electric system planning and procurement of storage resources in California.

B. Problem/Solution Statement

Problem

SB 1020 requires that renewable and zero-carbon energy resources supply 90 percent of all retail sales of electricity to California end-use customers by December 31, 2035, increasing to 100 percent by December 31, 2045. Energy storage already contributes to electric grid reliability and resilience in California and is expected to play an increasingly critical role in achieving policy targets for grid decarbonization. To date almost all energy storage deployments are lithium-ion batteries used for short duration (principally 4 hours or less) applications that are ill suited for extended outages such as those prompted by prolonged extreme weather or Public Safety Power Shutoff events. However, compared to lithium-ion batteries, long duration energy storage (LDES) technologies (defined as 8 hours or more of duration and based on non-lithium-ion technologies) have less deployment history or manufacturing capacity and face greater challenges securing financing. There is significant uncertainty regarding the scale up and deployment of long duration and seasonal storage technologies (defined as seven days or more of energy storage durations for this analysis) and how to treat these resources in long term electric system planning and storage procurement processes (e.g., CPUC procurement targets of 15,000 MWs by 2030, 30,000 MW by 2035 and 45,000 MWs by 2045).

Solution

The Contractor will assess non-lithium-ion long duration and seasonal energy storage technologies as well as the market and financial contracting structures necessary to accelerate their deployment and use in order to support grid reliability and achievement of SB100 goals as they are integrated into a mixture of lithium-ion and non-lithium-ion technology systems installed on the California grid. The Contractor will first identify cost and performance metrics for different LDES technologies and then develop multiple scenarios with various environmental and market conditions with corresponding portfolios of different LDES technologies as inputs for production cost modeling. At least one of these portfolios will feature both 4- and 8-hour duration storage, as well as seasonal storage of 7 days or more. In addition, at least one of these portfolios will add 100-hour duration storage to the resource mix, specifically to assess whether and how the presence of emerging technologies that can provide low-cost 100-hour duration storage when assessing the overall need for all durations of energy storage in 2035 and 2045 systems can impact the usage of short duration, other long duration and seasonal storage. The resulting

analyses will characterize potential needs and economic implications for short duration, long duration and seasonal storage in California and provide detailed pathways for deployment of different storage portfolios that will meet identified needs through 2035, 2045 and beyond.

A. Goals and Objectives of the Agreement

Agreement Goals

The goal of this agreement is to assess the need for energy storage of different durations (4-hour, 8-hour, 100-hour, and 7 days or more) on California's electric system through 2035 and 2045. Using various exogenously driven scenarios, this Contract will explore what system conditions lead to different requirements for long duration and seasonal energy storage deployment and how they are dispatched and integrated in to the existing and planned fleet of short duration energy storage systems. By comparing different portfolios of storage technologies and durations, this Contract will identify development and deployment opportunities and determine what market/business models are required to ensure these energy storage systems receive sufficient payments to recover their investment and achieve economic competitiveness for their entire useful life while maintaining system reliability.

This agreement will identify market and regulatory barriers to different durations of long duration and seasonal storage, and the results will inform electric system planning, including future IEPR and CEC SB100 report updates, as well as CPUC procurement proceedings. One of the key outputs of this agreement will be recommendations for applied research and technology development and demonstration activities, which will inform investments made through the Long Duration Energy Storage Program, the Electric Program Investment Charge (EPIC) Program, Department of Energy investments, and other complementary federal and state energy storage procurement programs.

Identifying Opportunities that Provide Significant Benefits to the Electrical Grid: This Agreement will result in the significant benefits and savings of greater electricity reliability and resiliency at a competitive and sustainable costs consistent with SB100 by addressing key barriers to scaling up long duration and seasonal storage options available to Californians to better capturing energy generated by renewable energy and other low carbon sources of electricity while reducing the reliance on power plants fueled by fossil fuels and expanding the use of renewable energy generation systems, thereby reducing greenhouse gas (GHG) emissions.

Technological Advancement and Breakthroughs: This Agreement will lead to technological advancement and breakthroughs to overcome barriers in the achievement of the State of California's statutory energy goals by identifying and evaluating short duration, long duration and seasonal energy storage technologies, and determining market/business models, key performance metrics, and supportive conditions for commercializing and scaling those technologies. Additionally, this project will differ from similar studies of long duration and seasonal storage in several ways. This study will simulate the full nodal Western Electricity Coordinating Council (WECC) footprint, as well as simulating every hour of the year for each year studied. This will provide a level of granularity in both space and time that has not been examined, but that is crucial to understanding how energy storage systems operate on the bulk electric grid. This study will also focus effort on the market and contracting structures that both exist now and may be necessary in the future to incentivize the right types of storage technologies and ensure that they perform the way that California needs to meet reliability and environmental goals while at the same time, operate in a commercially viable and cost competitive environment.

Agreement Objectives

The objectives of this Agreement are to:

- Determine Technology Options for Long Duration and Seasonal Energy Storage
  - Conduct literature reviews and expert interviews regarding electrochemical, thermal, mechanical, hydrogen and other viable technologies for long duration and seasonal storage.
  - Develop cost estimates and key performance attributes as achieved today and trends into the future to include lessons being learned in the CEC EPIC and LDES programs
  - Characterize expected technology and commercialization readiness for large-scale deployment of different energy storage durations and technologies in the 2025, 2030, 2035, 2040, and 2045 timeframes.
- Assess the Market and Contracting Structures Needed for Seasonal Storage to Operate as Intended
  - Develop performance characteristics that define what it means for storage to act "seasonally". These would be used as inputs to the production cost modeling.
  - Ensure that these performance characteristics meet California's specific need for seasonal storage that will be developed here in this work that represent both operational and costs viable options to meeting these seasonal energy storage needs for the California Grid.
  - Interview stakeholders from the storage finance community on the needs and challenges of financing long duration and seasonal energy storage and develop recommended future research and operation actions needed to allow these long duration and seasonal storage assets to compete in future procurements.
  - Characterize the financial (e.g., revenue and bankability) challenges for seasonal and long duration energy storage technologies using existing structures and any new financial structures developed as part of this research activity.
  - Identify potential new financial structures that may be more supportive for long duration and seasonal energy storage so these new structures can co-exist with the structures being used and planned for short duration energy storage systems.
- Identify Potential Locations for Seasonal Energy Storage
  - Identify specific locations in California and the Western Interconnection where seasonal storage installations would be feasible and financially viable, making use of all available studies and literature on the subject.
  - Consider a variety of factors including access to transmission lines and technology-specific infrastructure needed for effective operation such access to underground storage or other long term storage capacities, access to needed supply chain items, and other requirements identified as unique needs of seasonal energy storage systems.
- Identify Portfolio Evaluation Criteria and Prepare Production Cost and Capacity Expansion Model
  - Select the most appropriate and relevant portfolio evaluation criteria.
  - Determine key parameters and inputs and outputs of the production cost model.
- Develop Portfolios (combinations of different grid-scale resources) and Scenarios (alternative future conditions) for Modeling
  - Develop five different portfolios, or resource strategies, to model.
  - Develop five different exogenously driven scenarios to model.
- Run Production Cost Model for Scenario and Portfolio Combinations
  - Run production cost model that is comprised of up to 6 portfolios and 6 scenarios (6 X 6), resulting in 36 model run results.

  - Production cost model results will characterize which configurations of seasonal storage carry the most benefit for the State of California.
  - Present the results of the model runs (production cost, dispatch, emissions, etc.).
- Incorporate Feedback, Transfer Knowledge and Develop Final Report and Presentation
  - Engage the Technical Advisory Committee (TAC) at key checkpoints and obtain feedback on relevant draft deliverables.
  - Plan and execute knowledge transfer to key stakeholders such as the CAISO and CPUC as well as internally within the CEC and nationally through CEC contacts at DOE and NYSERDA through regular meetings and coordination.
  - Develop final report and interim and summary presentations.

III. TASK 1 GENERAL PROJECT TASKS

DELIVERABLES

Subtask 1.1 Deliverables
The goal of this subtask is to establish the requirements for submitting project deliverables (e.g., reports, summaries, plans, and presentation materials). Unless otherwise specified by the Commission Agreement Manager (CAM), the Contractor must provide deliverables as required below by the dates listed in the **Schedule of Deliverables (Part V).** Deliverables that require a draft version are indicated by marking **"(draft and final)"** after the deliverable name in the "Deliverables" section of the task/subtask. If "(draft and final)" does not appear after the deliverable name, only a final version of the deliverable is required. With respect to due dates within this Scope of Work, **"days"** means working days.

The Contractor shall:
For deliverables that require a draft version, including the Final Report Outline and Final Report
- Submit all draft deliverables to the CAM for review and comment in accordance with the Schedule of Deliverables (Part V). The CAM will provide written comments to the Contractor on the draft deliverable within 15 days of receipt, unless otherwise specified in the task/subtask for which the deliverable 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 deliverable.
- Submit the revised deliverable with responses and 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 deliverables that require a final version only
- Submit the deliverable to the CAM for acceptance. The CAM may request minor revisions or explanations prior to acceptance.

For all deliverables
- Submit all data and documents required as deliverables in accordance with the following:

  Instructions for Submitting Electronic Files and Developing Software:
  - **Electronic File Format**

Submit all data and documents required as deliverables under this Agreement in an electronic file format that is fully editable and compatible with the Energy Commission's 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 or CD-ROM.

The following describes the accepted formats for electronic data and documents provided to the Energy Commission as deliverables under this Agreement, and establishes the software versions that will be required to review and approve all software deliverables:

- 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.
- Documents intended for public distribution will be in PDF file format.
- The Contractor must also provide the native Microsoft file format.
- Project management documents will be in Microsoft Project file format, version 2007 or later.

- **Software Application Development**
  Use the following standard Application Architecture components in compatible versions for any software application development required by this Agreement (e.g., databases, models, modeling tools), unless the CAM approves other software applications such as open source programs:
  - Microsoft ASP.NET framework (version 3.5 and up). Recommend 4.0.
  - Microsoft Internet Information Services (IIS), (version 6 and up) Recommend 7.5.
  - Visual Studio.NET (version 2008 and up). Recommend 2010.
  - C# Programming Language with Presentation (UI), Business Object and Data Layers.
  - SQL (Structured Query Language).
  - Microsoft SQL Server 2008, Stored Procedures. Recommend 2008 R2.
  - Microsoft SQL Reporting Services. Recommend 2008 R2.
  - XML (external interfaces).

  Any exceptions to the Electronic File Format requirements above must be approved in writing by the CAM. The CAM will consult with the Energy Commission'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 Contractor shall:

- Attend a "*Kick*-off" meeting with the CAM, the Commission Agreement Officer (CAO), and any other Energy Commission staff relevant to the Agreement. The Contractor 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;
- Deliverables (subtask 1.1);
- CPR meetings (subtask 1.3);
- 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;
- Deliverables (subtask 1.1);
- Progress reports and invoices (subtask 1.5);
- Final Report (subtask 1.6);
- Technical Advisory Committee meetings (subtasks 1.10 and 1.11); and
- Any other relevant topics.

- Provide an *Updated Schedule of Deliverables, List of Match Funds,* and *List of Permits*, as needed to reflect any changes in the documents.

The CAM shall:
- Designate the date and location of the meeting.
- Send the Contractor a *Kick-off Meeting Agenda*.

Contractor Deliverables:
- Updated Schedule of Deliverables *(if applicable)*
- Updated List of Match Funds *(if applicable)*
- Updated List of Permits *(if applicable)*

CAM Deliverable:
- 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 Energy Commission funding, and if so whether any modifications must be made to the tasks, deliverables, schedule, or budget. CPR meetings provide the opportunity for frank discussions between the Energy Commission and the Contractor. 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 Contractor, and may include the CAISO and any other individuals selected by the CAM to provide support to the Energy Commission.

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 Contractor, but the overall Agreement amount will not increase. CPR meetings generally take place at the Energy Commission, but they may take

place at another location, or may be conducted via electronic conferencing (e.g., WebEx) as determined by the CAM.

The Contractor shall:

- Prepare 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.
- Submit the CPR Report along with any other *Task Deliverables* that correspond to the technical task for which the CPR meeting is required (i.e., if a CPR meeting is required for Task 2, submit the Task 2 deliverables along with the CPR Report).
- 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 Contractor's input.
- Send the Contractor a *CPR Agenda* and 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 Contractor 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, deliverables, 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 Contractor with a *Progress Determination* on continuation of the project, in accordance with the schedule. The Progress Determination may include a requirement that the Contractor revise one or more deliverables.

Contractor Deliverables:

- CPR Report(s)
- Task Deliverables (draft and/or final as specified in the task)

CAM Deliverables:

- CPR Agenda
- List of Expected CPR Participants
- Schedule for Providing a Progress Determination
- Progress Determination

Subtask 1.4 Final Meeting

The goal of this subtask is to complete the closeout of this Agreement.

The Contractor shall:

- Meet with Energy Commission 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 Contractor 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 state-owned equipment.
  - Need to file a Uniform Commercial Code Financing Statement (Form UCC-1) regarding the Energy Commission's interest in patented technology.
  - The Energy Commission's request for specific "generated" data (not already provided in Agreement deliverables).
  - Need to document the Contractor's disclosure of "subject inventions" developed under the Agreement.
  - "Surviving" Agreement provisions such as repayment provisions and confidential deliverables.
  - Final invoicing and release of retention.
  - Prepare a *Final Meeting Agreement Summary* that documents any agreement made between the Contractor and Commission staff during the meeting.
  - Prepare a *Schedule for Completing Agreement Closeout Activities*.
  - Provide *All Draft and Final Written Deliverables* on a CD-ROM or USB memory stick, organized by the tasks in the Agreement.

Deliverables:

- Final Meeting Agreement Summary *(if applicable)*
- Schedule for Completing Agreement Closeout Activities
- All Draft and Final Written Deliverables

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 Contractor 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 Fund and in-state expenditures.

Deliverables:

- 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. The CAM will review the Final Report, which will be due at least **two months** before the Agreement end date. When creating the Final Report Outline and the Final Report, the Contractor must use the Style Manual provided by the CAM.

Subtask 1.6.1 Final Report Outline

The Contractor shall:
- Prepare a *Final Report Outline* in accordance with the *Style Manual* provided by the CAM. *(See Task 1.1 for requirements for draft and final deliverables.)*

Contractor Deliverables:
- Final Report Outline (draft and final)

CAM Deliverables:
- Style Manual
- Comments on Draft Final Report Outline
- Acceptance of Final Report Outline

Subtask 1.6.2 Final Report

The Contractor shall:
- Prepare a *Final Report* for this Agreement in accordance with the approved Final Report Outline, 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)
  - Ensure that the document is written in the third person.
  - Ensure that the Executive Summary is understandable to the lay public.
    - Briefly summarize the completed work. Succinctly describe the project results and whether or not the project goals were accomplished.

        - Identify which specific ratepayers can benefit from the project results and how they can achieve the benefits.
        - If it's necessary to use a technical term in the Executive Summary, provide a brief definition or explanation when the technical term is first used.
    - Follow the Style Guide format requirements for headings, figures/tables, citations, and acronyms/abbreviations.
    - Ensure that the document omits subjective comments and opinions. However, recommendations in the conclusion of the report are allowed.
    - Include a brief description of the project results in the Abstract.

- 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.
- Consider incorporating all CAM comments into the Final Report. 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 Final Report 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.
- Submit one bound copy of the *Final Report* to the CAM along with *Written Responses to Comments on the Draft Final Report*.

Deliverables:
- Final Report (draft and final)
- Written Responses to Comments on the Draft Final Report

CAM Deliverable:
- Written Comments on the Draft Final Report

MATCH FUNDS, PERMITS, AND SUBCONTRACTS

Subtasks 1.7-1.8 are not applicable on this Contract.

Subtask 1.9 Subcontracts (to be included *only if needed to comply with the Contract*)
The goals of this subtask are (if needed) 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 Contractor shall:
- Manage and coordinate subcontractor activities in accordance with the requirements of this Agreement.
- Incorporate this Agreement by reference into each subcontract.
- Include any required Energy Commission flow-down provisions in each subcontract, in addition to a statement that the terms of this Agreement will prevail if they conflict with the subcontract terms.
- If required by the CAM, submit a draft of each *Subcontract* required to conduct the work under this Agreement.
- Submit a final copy of the 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).

Deliverables:

- 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 deliverables and provide recommendations for needed deliverable 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 deliverables.

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 (e.g., NYSERDA) relevant to the project.
- Public interest environmental groups;
- Utility representatives;
- Air district staff; and
- Members of relevant technical society committees.

The Contractor 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.

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

Subtask 1.9 Subcontracts (to be included *only if needed to comply with the Contract*)
The goals of this subtask are (if needed) 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 Contractor shall:
- Manage and coordinate subcontractor activities in accordance with the requirements of this Agreement.
- Incorporate this Agreement by reference into each subcontract.
- Include any required Energy Commission flow-down provisions in each subcontract, in addition to a statement that the terms of this Agreement will prevail if they conflict with the subcontract terms.
- If required by the CAM, submit a draft of each *Subcontract* required to conduct the work under this Agreement.
- Submit a final copy of the 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).

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

TECHNICAL ADVISORY COMMITTEE

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 Contractor 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.

Deliverables:

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

IV. TECHNICAL TASKS

TASK 2: DETERMINE TECHNOLOGY OPTIONS AND TRENDS FOR LONG DURATION AND SEASONAL ENERGY STORAGE

The purpose of Task 2 is to assess and develop cost and performance metrics for long duration and seasonal storage technologies across four categories: (1) electrochemical, (2) thermal, (3) mechanical, and (4) gaseous fuels. This Task will include estimates of the installed capacity for each technology, upfront capital as well as operations and maintenance (O&M) costs, benefits and savings, technology readiness level, commercial readiness level, and trends in cost and performance metrics between now and 2045.

The Contractor shall:

- Perform literature reviews and up to 30 interviews with subject matter experts to assess and characterize the performance of long duration and seasonal storage technologies and document case studies of large or high-profile projects. The contractor will consider categories and technologies including but not limited to the following.
    - Electrochemical
        - Li-ion batteries as a baseline for comparison
        - Flow
        - Iron air
        - Zinc
        - Magnesium
        - Sodium
    - Thermal
        - Solid medium
        - Liquid medium
    - Mechanical
        - Gravity-based
        - Pumped storage hydropower (PSH)
        - Compressed air energy storage (including Adiabatic CAES)
    - Gaseous fuels
        - Electrolytic hydrogen stored in geologic formations
        - Electrolytic hydrogen stored in above-ground tanks
        - Hydrogen carriers (e.g., metal hydrides, ammonia)
- Report on the installed base for each of the identified technologies in terms of projects and total capacities. Develop estimates for key performance metrics for storage technologies from literature, whitepapers, and/or other resources and in consultation with the CAM and TAC, including but not limited to the following.
    - Round-trip efficiency
    - System efficiency that includes auxiliary power and other standby losses

  - Installed costs in $/MWh and $/MW for a range of system sizes
  - Fixed O&M costs in $/MW
  - Variable O&M costs in $/MWh
  - Usable energy (MWh) on a gravimetric, volumetric, and areal basis
  - Cycle life
  - Calendar life
  - Degradation per cycle on a capacity and energy basis
  - Charge/discharge rate
  - Availability (to serve desired reliability function given value stacking)
  - Capacity factor
  - Safety metrics and considerations
  - Charge and discharge characteristics (e.g., continuous, Stages, transition)
  - Charge and discharge ramping control
  - Manufacturability and the ability to rapidly ramp up production to demonstrate the ability to deliver future systems in the size of 100MW to 500MWs for durations of 8 hours to 100 hours or more.
- Note any lifecycle carbon footprint concerns, to the extent they can be discerned.
- Characterize expected technology and commercialization readiness for utility-scale deployments in the 2025, 2030, 2035, 2040, and 2045 timeframes and identify conditions that may accelerate readiness or present risks for significant delays.
- Gather feedback from the CAM and TAC on the identified technologies, costs, and performance metrics, and develop a final characterization dataset for consideration in later Tasks including information being learned from CEC EPIC and LDES research and demonstration projects in California.
- Provide a *Long Duration and Seasonal Storage Technology Characterization and Trends Report Outline.*
- Document Task 2 findings in a *Long Duration and Seasonal Storage Technology Characterization and Trends Report.*

Deliverable:

- Long Duration and Seasonal Storage Technology Characterization and Trends Report Outline
- Long Duration and Seasonal Storage Technology Characterization and Trends Report (Draft and Final)

TASK 3: ASSESS EXISTING MARKET AND CONTRACTING STRUCTURES

The purpose of Task 3 is to assess the ability of current market and financial contracting practices to provide adequate return on investment for development and operation of long duration and seasonal storage resources to meet identified needs. The Task will evaluate the extent to which variable energy prices alone are sufficient to compensate long duration and seasonal storage resources or whether other market mechanisms analogous to resource adequacy programs will be necessary for recovery of costs.

The Contractor shall:

- Develop specific performance requirements, in consultation with the TAC and CAM, that describe operational requirements for seasonal storage of 7 days or longer (hypothetical examples could include: “reservoir must be full on June 1 of every year” or “facility will only charge with otherwise curtailed renewables from March 1 through June 1 every year”)

- Characterize the existing revenue models and compensation structures for utility scale energy storage in California (e.g., energy arbitrage, frequency regulation, capacity reserves, resource adequacy contracts) and the degree to which they are successful in supporting scaling of storage resources
- Characterize the financial challenges (for example, revenue and bankability) long duration and seasonal storage technologies face in securing project financing through existing market mechanisms and recommend future actions for the CEC (and stakeholders such as the DOE and others) to address these identified challenges.
- Evaluate the extent to which the existing wholesale energy markets are sufficient for providing seasonal storage incentives. Identify strong points and shortcomings and recommend future alternatives that will maximize the value and cost benefit of long duration and seasonal energy storage a part of the overall energy storage mixture needed by California to meet or exceed all SB-100 goals.
- Provide an *Existing Market and Contracting Structure Report Outline.*
- Document Task 3 findings in an Existing *Market and Contracting Structure Report.*

Deliverable:

- Existing Market and Contracting Structure Report Outline
- Existing Market and Contracting Structure Report (Draft and Final)

TASK 4: CONCEPTUALIZE REVENUE STRUCTURES FOR LONG DURATION AND SEASONAL STORAGE

Leveraging the assessment of existing market and contracting structures from Task 3, the purpose of Task 4 is to research and identify specific performance requirements that need to be integrated into market product and contracting structures to operationalize long duration and seasonal storage in the future, and to provide representative examples. This task will identify and categorize all the existing market products that are used by the California ISO (energy, reserves, regulation, etc.), those that are currently under consideration by the California ISO (day-ahead imbalance reserves, etc.), as well as current products being employed by the State of California (for example, Resource Adequacy), and assess the extent to which these existing and currently planned products are sufficient to support increasing amounts of dispatchable storage being deployed and sustained in a timely manner (e.g., 15 GW of by 2030, 25 GW of by 2035, and 45 GW of storage by 2045). To the extent that energy storage brings value to the grid that is not covered by existing and planned market constructs, Task 4 will coordinate with staff from the California ISO and the CPUC to research and identify specific performance requirements and market constructs that will cover current gaps and provide necessary compensation to energy storage systems to meet California's long-term environmental and reliability goals.

The Contractor shall:

- Identify and categorize all current and currently planned market products and contracting mechanisms available to compensate energy storage projects for the value they bring to California's high-voltage grid.
- Determine whether these products are sufficient to fully compensate each of the viable storage technologies identified in Task 2 by modeling how those technologies would operate in California in production cost co-optimized dispatch simulation.
- Identify gaps in current market and contracting structures where energy storage technologies bring value to the grid that is not currently compensated in some market or contract form.

- Identify storage system functionality stacking that would generate revenues to cover costs while meeting the needs for short duration, long duration, and seasonal energy storage.
- Characterize any existing or planned research, development, and demonstration efforts that may facilitate financial risk reduction and help overcome bankability challenges.
- In consultation with the CAM, engage collaboratively with the CAISO and CPUC to determine near term feasibility of potential approaches and long-term needs that must be met using new bilateral contracting or market mechanisms that could provide compensation for seasonal or long duration storage that results in predictable return on investment.
- As relevant or necessary, the operational requirements associated with the market products and contracting mechanisms developed here will be incorporated into the production cost modeling in Task 8.
- Provide a *New Market Concepts and Compensation Structures Report Outline*.
- Document Task 4 findings in a *New Market Concepts and Compensation Structures Report.*

Deliverable:

- New Market Concepts and Compensation Structures Report Outline
- New Market Concepts and Compensation Structures Report (Draft and Final)

TASK 5: IDENTIFY POTENTIAL LOCATIONS AND REQUIREMENTS FOR SEASONAL ENERGY STORAGE

The purpose of Task 5 to identify specific locations and grid nodes in California where seasonal storage facilities could realistically be sited, which will serve as an input to subsequent production-cost modeling. It is important to note here that even though this task will focus on siting resources within California, the production cost and capacity expansion simulation modeling in Task 8 will be run for the entire WECC region. This Task will also examine how long duration and seasonal storage deployments at specific locations and grid nodes may impact factors including but not limited to transmission congestion, locational marginal price, renewable curtailment and availability of critical resources such as underground storage or large above the ground tank storage of seasonal energy storage fuel and the transportation of necessary element to make seasonal energy storage operate in a cost competitive basis. This task will build from existing analyses completed by the CEC, CAISO, CPUC, or other entities.

The Contractor shall:

- Perform literature reviews and interviews with subject matter experts on siting for seasonal energy storage in California. The Contractor, in coordination with the CAM, will consider and document parameters including but not limited to the following:
    - Size and duration of storage
    - Proximity to transmission facilities
    - Brownfield: existing capacity resource locations and under-resourced communities
    - Space requirements
    - Water and terrain (e.g., reservoirs) for PSH
    - Feasible locations in California for siting projects, and steps involved (e.g., additional transmission, site feasibility for PSH, water availability for PSH or electrolytic hydrogen, conversion of gas systems, etc.)
    - Technical maximum capacity (i.e., how much can be installed)
    - Appropriate geological conditions

  - Siting and permitting from relevant local, state, and federal agencies
- Identify infrastructure requirements and upgrades to the existing gas transport storage system necessary to use electrolytic hydrogen as seasonal energy storage.
- Identify risk factors for each technology that may hinder full maximization of the technologies beyond strictly economic reasons
- Provide a *Seasonal Storage Locations and Requirements Report Outline*.
- Document Task 5 findings in a *Seasonal Storage Locations and Requirements Report.*
- Prepare a *CPR Report* #1 in accordance with Subtask 1.3.
- Participate in a CPR Meeting.

Deliverables:

- Seasonal Storage Locations and Requirements Report Outline
- Seasonal Storage Locations and Requirements Report (Draft and Final)
- CPR Report #1

TASK 6: IDENTIFY PORTFOLIO EVALUATION CRITERIA AND BENCHMARK/VALIDATE PRODUCTION COST AND CAPACITY EXPANSION MODELS

The purpose of Task 6 is to inform CEC staff about the production cost and capacity expansion models used in this Contract, and to define the performance characteristics and evaluation criteria used to compare portfolios of long duration and seasonal storage technologies. Drawing from State Laws, reliability goals, and other relevant sources, this task will focus on pre-identification of what constitutes a good or successful outcome to help the Contractor judge the performance of different portfolios of long duration and seasonal storage technologies in later Tasks. Finally, this task will also benchmark and validate the production cost and capacity expansion models to be used in Task 8, by back-casting against historical data and recreating historical dispatch and price outcomes to a reasonable extent.

The Contractor shall:

- Document production cost and capacity expansion modeling theory and techniques, as well as the specifics of Enelytix PSO model being used here. This includes modeling methodologies, key assumptions, modeling limitations, as well as inputs, parameters, and configuration options. The Contractor will explain the similarities and differences between PSO and other commonly used models for resource planning in California such as RESOLVE, SWITCH, and others.
- Enhance CEC staff's knowledge of the model's key parameters, key assumptions, limitations, and inputs and outputs to better facilitate discussions and decision processes around portfolio evaluation criteria. The Contractor will conduct presentations to train CEC staff and present validation results from benchmark tests. CAM shall organize the logistics and timing for the presentations.
- Work with CEC staff to set the most appropriate and relevant modeling outputs and portfolio evaluation criteria, which may include but are not limited to:
  - Greenhouse gas emissions
  - Total resource cost
  - Renewable curtailment
  - System resiliency
  - Reliability
  - Risk
  - Long term financial viability of selected energy storage technologies
  - Balanced performance across different scenarios

    - Impacts to under-resourced communities and equity considerations
- Provide a *Portfolio Evaluation Criteria and Production Cost/Capacity Expansion Modeling Report Outline*.
- Document Task 6 findings in a Portfolio Evaluation Criteria and Production Cost Model Report.

Deliverables:

- Portfolio Evaluation Criteria and Production Cost/Capacity Expansion Modeling Report Outline
- Portfolio Evaluation Criteria and Production Cost/Capacity Expansion Modeling Report (Draft and Final)

Task 7: Develop Portfolios and Scenarios

The purpose of Task 7 is to create multiple portfolios with different types and amounts of long duration and seasonal storage technologies as well as multiple exogenously driven scenarios reflecting alternative potential futures for California's grid through 2045. Both the storage resource portfolios and scenarios of future electric system conditions will be developed based on existing information and in consultation with the TAC, CAM, and other stakeholders.

The Contractor shall:

- Develop a minimum of five unique resource portfolios, with input from the CEC and other stakeholders, composed of different types and amounts of long duration and seasonal storage technologies. Portfolio differences may include but are not limited to the following:
    - Technologies included (for example, PSH and electrolytic hydrogen)
    - Mix of storage durations (for example, quantity of 4-hour, 8-hour, 100-hour, and seven day or greater seasonal storage)
    - Locations of storage resources
    - Include a baseline scenario with 4- and 8-hour storage that will be incrementally expanded to include 100-hour and seasonal storage
    - Expansion of transmission system and changes in net imports patterns
    - Other bulk grid or demand-side resources as relevant or necessary
- Develop a minimum of five exogenously driven scenarios, with input from CEC and other stakeholders, reflecting alternative future characteristics of California's electric system through 2045. Scenario differences may include but are not limited to the following:
    - Forecasted electric load (for example, based on different assumptions of vehicle and building electrification) and fuel prices
    - Climate and weather-related trends and extremes, such as extended widespread heat waves or periods of low renewable generation
    - Assumptions regarding cost trajectories for different storage technologies
    - Assumptions regarding retirement of gas generation resources
    - External forces such as:
        - Loss of load from catastrophic events:
            - Examine the impact that catastrophic events, such as wildfires or extended power outages for major metropolitan areas, have on the need for and value of long duration storage – this could include studying the implications of siting projects in major load pockets vs. using transmission lines
        - Climate change impacts

  - Alternative wholesale market structures and storage compensation mechanisms developed in Task 4.
- Document Task 7 findings in a *Portfolio and Scenarios Characterization Report.*
- Provide *Portfolio Composition and Scenario Data Spreadsheets*
  - Portfolio Spreadsheets will include technology type, size, online/offline dates, locations, and other data as relevant/necessary.
  - Scenario spreadsheets will include quantitative data describing the inputs to be modeled. For example: alternate load forecast time series, online/offline dates for resources, and other data as relevant or necessary.

Deliverables:
- Portfolio and Scenarios Characterization Report (Draft and Final)
- Portfolio Composition and Scenario Data Spreadsheets

TASK 8: RUN PRODUCTION COST MODEL FOR SCENARIO AND PORTFOLIO COMBINATIONS

The purpose of Task 8 is to evaluate the need for different durations of storage on California's electric grid through 2045, explore how these needs change across exogenously driven scenarios, and compare different portfolios of storage technologies and durations that meet identified needs based on previously identified criteria such as total resource cost and greenhouse gas emissions.

The Contractor shall:
- Simulate the operation and cost of California's electric grid through 2045 using a production cost model, nodally (every substation and power plant above 69 kV) and hourly across the Western Interconnection.
  - Run the production cost model for each combination of previously developed scenario and storage resource portfolio, resulting in a maximum of 36 model runs (i.e., maximum of 6 scenarios and 6 storage resource portfolios)
  - Include the capability for storage resources to providing multiple different services concurrently, as necessary or optimal, such as providing intra-day storage, ancillary services, and system capacity in addition to long duration or seasonal storage.
  - Include multiple sources of uncertainty and variability, such as un-forecasted changes in load, renewable output, and ranges for costs or performance metrics.
- Characterize the need for different long duration energy storage and seasonal storage capabilities on California's grid through 2045 by comparing production-cost model results for different portfolios and under different scenarios.
  - Identify which scenarios and what system conditions result in different requirements for long duration and seasonal storage
- Determine which storage resource portfolios perform best in terms of established evaluation criteria such as total resource cost and system greenhouse gas emissions, as well as what drives those benefits (for example, resource adequacy, less renewable curtailment, less emissions) under a range of scenarios.
- Synthesize the results of different model runs to develop recommendations for electric system planning and storage procurement activities to obtain desired portfolios of storage technologies.
- Document Task 8 findings in a *Modeling Results Report*.
- Provide a *Modeling Results Spreadsheet* that includes the dispatch of storage and other resources modeled as well as calculated results such as total production cost and system emissions.

- Prepare a *CPR Report #2* in accordance with Subtask 1.3.

Deliverables:
- Modeling Results Report (Draft and Final)
- Modeling Results Spreadsheet
- CPR Report #2

TASK 9 TECHNOLOGY/KNOWLEDGE TRANSFER ACTIVITIES

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

The Contractor shall:
- As determined by the CAM, prepare an *Initial Fact Sheet* at start of the project that describes the project. Use the format provided by the CAM.
- As determined by the CAM, prepare a *Final Project Fact Sheet* at the project's conclusion that discusses results. Use the format provided by the CAM.
- Prepare a *Technology/Knowledge Transfer Plan* that includes:
  - An explanation of how the knowledge gained from the project will be made available to the public, including the targeted market sector and potential outreach to end users, utilities, regulatory agencies, and others.
  - A description of the intended use(s) for and users of the project results.
  - Published documents, including date, title, and periodical name.
  - Copies of documents, fact sheets, journal articles, press releases, and other documents prepared for public dissemination. These documents must include the Legal Notice required in the terms and conditions. Indicate where and when the documents were disseminated.
  - A discussion of policy development. State if project has been or will be cited in government policy publications or used to inform regulatory bodies.
  - The number of website downloads or public requests for project results.
  - Additional areas as determined by the CAM.
- Conduct technology transfer activities in accordance with the Technology/Knowledge Transfer Plan. These activities will be reported in the Progress Reports.
- When directed by the CAM, develop *Presentation Materials* for an Energy Commission-sponsored conference/workshop(s) on the project.
- When directed by the CAM, participate in annual EPIC symposium(s) sponsored by the California Energy Commission.
- As determined by the CAM, 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.
- Prepare a *Technology/Knowledge Transfer Report* on technology transfer activities conducted during the project.

Deliverables:
- Initial Fact Sheet (draft and final)
- Final Project Fact Sheet (draft and final)
- Presentation Materials (draft and final)
- High Quality Digital Photographs
- Technology/Knowledge Transfer Plan (draft and final)
- Technology/Knowledge Transfer Report (draft and final)

V. PROJECT SCHEDULE