STATE OF CALIFORNIA

CONTRACT REQUESTS FORM (CRF)

CEC-94 (Revised 5/11) CALIFORNIA ENERGY COMMISSION

☐ New Contract _____ ☒ Amendment to Existing Contract: 500-09-040 Amendment Number: 1

Division	Contract Manager:	MS-	Phone	CM Training Date
ERDD - Environmental Area	Marla Mueller	43	916-327-1716	8/19/2002

Contractor's Legal Name	Federal ID Number
The Regents of the University of California, Advanced Power and Energy Program, UC	95-2226406

Title of Project
Air Quality Implications of Electrification and Renewable Energy Options

Term	Start Date	End Date	Amount
New/Original Contract	6/7/2010	3/31/2014	$ 499,980

Line up the Amendment information as best as possible within the following table.

Amendment #	End Date *(mm/dd/yy)*	Amount
Amendment 1	3/31/2015	$335,731

Business Meeting Information			
Proposed Business Meeting Date	4/10/2013	☐ Consent	☒ Discussion
Business Meeting Presenter	Marla Mueller	Time Needed:	5 minutes

Agenda Item Subject and Description

Possible approval of Amendment 1 to Agreement 500-09-040 with The Regents of the University of California, Irvine (UCI) to add $335,731 to the existing agreement amount, extend the agreement by 12 months, and expand the scope of the project to explore reducing emissions of criteria pollutants and greenhouse gases (GHGs) to meet future health-based federal air quality standards and GHG targets in California through increased electrification. The Terms and Conditions are being modified.

Business Meeting approval is not required for the following types of contracts: *Executive Director's signature is required in all cases.*

☐ Contracts less than $10k *(Policy Committee's signature is also required)*

☐ Amendment for a no-cost time extension. Must be first extension, less than one year and original contract less than $100k.

☐ Contracts less than $25k for Expert Witness in Energy Facility licensing cases and amendments.

Purpose of Contract or Purpose of Amendment, if applicable

The purpose of this amendment is to explore reducing emissions of criteria pollutants and greenhouse gases (GHGs) to meet future health-based federal air quality standards and GHG targets in California through increased electrification. As directed by the Department of General Services, Office of Legal Services, the Exhibit D, Special Terms and Conditions, Disputes Provision is being amended to remove the Binding Arbitration language. In addition, other edits are being made to the remaining language.

California Environmental Quality Act (CEQA) Compliance

1. Is Contract considered a "Project" under CEQA?
   ☐ Yes: skip to question 2 ☒ No: complete the following (PRC 21065 and 14 CCR 15378):
   Explain why contract is not considered a "Project":
   Contract will not cause direct physical change in the environment or a reasonably foreseeable indirect physical change in the environment because the contract involves modeling activities.
2. If contract is considered a "Project" under CEQA:
   ☐ a) Contract **IS** exempt. (Draft NOE required)
   ☐ Statutory Exemption. List PRC and/or CCR section number: _____
   ☐ Categorical Exemption. List CCR section number: _____
   ☐ Common Sense Exemption. 14 CCR 15061 (b) (3)
   Explain reason why contract is exempt under the above section:
   ☐ b) Contract **IS NOT** exempt. The Contract Manager needs to consult with the Energy Commission attorney assigned to their division and the Siting Office regarding a possible Initial Study.

Budgets Information								
Contract Amount Funded		Breakdown by FY			Funding Sources			
Funding Source	Amount	FY	Amount	Approved?	Funding Source	FY	Budget List No.	Amount
ARFVTF	$	12-13	$335,731	Yes	PIER-E	10-11	501.027I	$335,731
ECAA	$		$					$
State- ERPA	$		$					$
Federal	$		$					$
PIER - E	$335,731		$					$
PIER - NG	$		$					$
Reimbursement	$		$					$
Other	$		$					$
TOTAL:	$335,731	TOTAL:	$335,731				TOTAL:	$335,731
Reimbursement Contract #:					Federal Agreement			

Contractor's Administrator/ Officer		Contractor's Project Manager	
Name:	Gillian Fischer	Name:	Scott Samuelsen
Address:	300 University Tower University of California	Address:	UC, Irvine 221 Engineering Lab Facility
City, State, Zip:	Irvine, CA 92697-7600	City, State, Zip:	Irvine, CA 92697-3550
Phone/ Fax:	949-824-2644 / 949-824-2094	Phone/ Fax:	949-824-5468 / 949-824-7423
E-Mail:	gfischer@uci.edu	E-Mail:	gss@uci.edu

Contractor Is

- ☐ 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)*

Selection Process Used

- ☐ Solicitation _____ Solicitation #: _____ # of Bids: _____ Low Bid? ☐ No ☐ Yes
- ☐ Non Competitive Bid *(Attach CEC 96)*
- ☒ Exempt Interagency

Civil Service Considerations

- ☐ Not Applicable (Contract 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:
Public Resources Code 25620, et seq., authorizes the Commission to contract for the subject work. (PIER)

Payment Method

☒ A. Reimbursement in arrears based on:
☐ Itemized Monthly ☒ Itemized Quarterly ☐ Flat Rate ☐ One-time
☐ B. Advanced Payment
☐ C. Other, explain:

Retention

1. Is contract subject to retention?	☒ No	☐ Yes
If Yes, Do you plan to release retention prior to contract termination?	☒ No	☐ Yes

Justification of Rates

Standard UC rates are being charged on this project. The overhead rates are the negotiated rates between the UC and the Department of General Services.

Disabled Veteran Business Enterprise Program (DVBE)

1. ☒ Not Applicable
2. ☐ Meets DVBE Requirements DVBE Amount:$ _____ DVBE %: _____
   ☐ Contractor is Certified DVBE
   ☐ Contractor is Subcontracting with a DVBE: _____
3. ☐ Requesting DVBE Exemption (attach CEC 95)

Is Contractor a certified Small Business (SB), Micro Business (MB) or DVBE?	☒ No	☐ Yes	
If yes, check appropriate box:	☐ SB	☐ MB	☐ DVBE

Is Contractor subcontracting any services?	☒ No	☐ Yes		
If yes, give company name and identify if they are a Small Business (SB), Micro Business (MB) and/or DVBE:				
	☐ No	☐ SB	☐ MB	☐ DVBE
	☐ No	☐ SB	☐ MB	☐ DVBE
	☐ No	☐ SB	☐ MB	☐ DVBE
	☐ No	☐ SB	☐ MB	☐ DVBE
	☐ No	☐ SB	☐ MB	☐ DVBE
	☐ No	☐ SB	☐ MB	☐ DVBE
	☐ No	☐ SB	☐ MB	☐ DVBE
	☐ No	☐ SB	☐ MB	☐ DVBE
	☐ No	☐ SB	☐ MB	☐ DVBE
	☐ No	☐ SB	☐ MB	☐ DVBE

Miscellaneous Contract 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 ☐ _____		
5. Will a final report be required?	☐ No	☒ Yes
6. Is the contract, with amendments, longer than a year? 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.

The following items should be attached to this CRF		
1. Scope of Work, Attach as Exhibit A.	☐ N/A	☒ Attached
2. Budget Detail, Attach as Exhibit B.	☐ N/A	☒ Attached
3. CEC 96, NCB Request	☒ N/A	☐ Attached
4. CEC 30, Survey of Prior Work	☒ N/A	☐ Attached
5. CEC 95, DVBE Exemption Request	☒ N/A	☐ Attached
6. Draft CEQA Notice of Exemption (NOE)	☒ N/A	☐ Attached
7. Resumes	☒ N/A	☐ Attached
8. CEC 105, Questionnaire for Identifying Conflicts		☒ Attached

Contract Manager	Date	Office Manager	Date	Deputy Director	Date

The following signatures are only required when contract approval is delegated to the Executive Office and not approved at a Business Meeting. See Business Meeting Information Section.

Presiding Policy Committee	Date	Associate Policy Committee	Date	Executive Director	Date

WORK STATEMENT

TECHNICAL TASK LIST

Task	CPR	Task Name
1		Administration
2		Literature Review and Previous Studies
3		Project Advisory Committee (PAC) and Workshop
4		Renewable Power Implementation Scenarios and Modeling
5		Spatial and Temporal Emissions Characterization
6		Air Quality Modeling
7		Greenhouse Gas Impacts
8		**Electrification Implementation Scenario Development**

KEY NAME LIST

Task	Key Personnel	Key Subcontractor	Key Partner
1	Scott Samuelsen		
2	Donald Dabdub; Jacob Brouwer		
3	Scott Samuelsen; Jacob Brouwer		
4	Scott Samuelsen; Jacob Brouwer		
5	Jacob Brouwer; Donald Dabdub		
6	Donald Dabdub		
7	Scott Samuelsen; Jacob Brouwer		
8	**Scott Samuelsen; Jacob Brouwer**		

GLOSSARY

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

Term/ Acronym	Definition
AB	**Assembly Bill**
APEP	Advanced Power and Energy Program, UC Irvine
BAAQMD	Bay Area Air Quality Management District
CAISO	California Independent System Operator
CARB	California Air Resources Board
CESL	Computational Environmental Sciences Laboratory
CMAQ	Community Multiscale Air Quality model
CPR	Critical Project Review
CPUC	California Public Utilities Commission
DG	Distributed Generation
DOE	United States Department of Energy
Energy	California Energy Commission

Term/ Acronym	Definition
Commission	
EPA	**Environmental Protection Agency**
EPRI	Electric Power Research Institute
GHG	Greenhouse Gas(es)
GIS	Geographic Information Systems
GREET	Greenhouse gases, regulated emissions and energy in transportation
GWh	**Gigawatt hour**
IAP	Independent Advisory Panel
LCA	Life cycle assessment
NASA	National Aeronautics and Space Administration
NREL	National Renewable Energy Laboratory
PAC	Project Advisory Committee
PCA	Preferred Combination Assessment
PHEV	Plug-in Hybrid Electric Vehicle
PI	Principal Investigator
PIER	Public Interest Energy Research
$PM_{2.5}$	Particulate matter less than 2.5 micrometers in aerodynamic diameter
RD&D	Research, Development and Demonstration
RETI	Renewable Energy Transmission Initiative
RPS	Renewable Portfolio Standard
SDAPCD	San Diego Air Pollution Control District
SCAQMD	South Coast Air Quality Management District
SCE	Southern California Edison
SoCAB	South Coast Air Basin
SJV	San Joaquin Valley
SJVAB	San Joaquin Valley Air Basin
SJVAPCD	San Joaquin Valley Air Pollution Control District
SMAQMD	Sacramento Metropolitan Air Quality Management District
UCI	University of California, Irvine
WECC	Western Electric ~~Company Cooperative~~**Coordinating Council**
WWSIS	Western Wind and Solar Integration Study

Problem Statement:
The air quality and greenhouse gas (GHG) emissions impacts of meeting Renewable Portfolio Standard (RPS) goals in California are uncertain. Given the constraints of system stability and viability of the wholesale power market, which require consideration of transmission constraints and installation of complementary energy storage, demand response, dispatchable generation, smart grid, and other technologies, there is a broad spectrum of possible future generation scenarios. Determining air quality and GHG impacts requires development of realistic implementation scenarios for renewable

power that meets RPS goals with the required complementary technologies. One must develop and apply a means of determining the spatial and temporal distribution of emissions produced by such scenarios. Finally, one must simulate the atmospheric chemistry and transport associated with such scenarios in a detailed air quality model in air basins of interest. To-date no in-depth study that includes these considerations has been conducted to assess air quality and GHG impacts of meeting RPS goals in California.

Electricity generation capacity growth will need to occur concurrently with the cleaner generation of electricity. A recent study[1] projects that by 2050, California electrical grid generation will be twice as large as today's total grid generation (approximately 600,000 GWh versus 290,000 GWh) and will meet the statewide GHG target with large amounts of electrification in transportation and other sectors. The study modeled many sectors in addition to transportation, and relied more heavily on electricity compared to hydrogen for mobile applications. The study proposes about 10 renewable electricity installations each year between now and 2050, capable of producing 500 megawatts each.

Similar studies include two funded by the Energy Commission's Public Interest Energy Research (PIER) program.[2,3] The problem is that the air quality impacts of such high electricity use scenarios are not well understood, mainly because of the intermittency and non-coincidence of renewable power with demand that must be complemented by other generation resources that may have emissions.

Goal of the Agreement:
Identify and analyze renewable power implementation scenarios with enabling technologies and demand response strategies that can maintain system reliability and optimize the impact on air quality and GHG emissions in California. **Identify and analyze electrification scenarios that: (1) reduce emissions of GHG to meet AB 32 requirements and (2) result in criteria pollutant levels in the SCAQMD and SJVAPCD that meet EPA standards by 2023 and 2032.**

Objectives of the Agreement:
The objectives required to meet this goal are as follows:

Objective 1: Review existing relevant literature and previous studies

Objective 2: Organize and conduct stakeholder interviews and a workshop focused on coordination with current and previous efforts including at the

[1] James H. Williams, Andrew DeBenedictis, Rebecca Ghanadan, Amber Mahone, Jack Moore, William R. Morrow, Snuller Price, and Margaret S. Torn "The Technology Path to Deep Greenhouse Gas Emissions Cuts by 2050: The Pivotal Role of Electricity," Science; Vol. 335 Issue 6064, p53-59, 7p, January 6, 2012.
[2] California Carbon Challenge (http://eaei.lbl.gov/california%E2%80%99s-carbon-challenge-scenarios-achieving-80-emissions-reduction-2050).
[3] California Air Resources Board, "Vision for Clean Air: A Framework for Air Quality and Climate Planning," Public Review Draft, June 27, 2012.CA Council on Science and Technology study (http://www.ccst.us/news/2012/0921ghg.php).

California Energy Commission (Energy Commission) and National Renewable Energy Laboratory (NREL)

Objective 3: Develop future more renewable grid implementation scenarios (detailed electric sector modeling)

Objective 4: Develop electrification scenarios

Objective ~~4~~**5**: Spatially and temporally allocate emissions from each scenario

Objective ~~5~~**6**: Simulate air quality impacts of each scenario with a detailed atmospheric chemistry and transport model

Objective ~~6~~**7**: Develop life cycle GHG emissions inventories for each scenario

TASK 1 ADMINISTRATION

MEETINGS

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 Contractor shall:

- Attend a "kick-off" meeting with the Commission Contract Manager, the Contracts Officer, and a representative of the Accounting Office. The Contractor shall bring their Project Manager, Contracts Administrator, Accounting Officer, and others designated by the Commission Contract 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 Contract 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:
  - Terms and conditions of the Agreement
  - CPRs (Task 1.2)
  - Match fund documentation (Task 1.7)
  - Permit documentation (Task 1.8)

  The technical portion of the meeting shall include, but not be limited to, the following:
  - The Commission Contract Manager's expectations for accomplishing tasks described in the Scope of Work;
  - An updated Schedule of Deliverables
  - Progress Reports (Task 1.4)
  - Technical Deliverables (Task 1.5)
  - Final Report (Task 1.6)
  - Establish the PAC (Task 1.10)
  - PAC Meetings (Task 1.11)

The Commission Contract Manager shall designate the date and location of this meeting.

Contractor Deliverables:

- An Updated Schedule of Deliverables
- An Updated List of Match Funds
- An Updated List of Permits
- Schedule for Recruiting PAC Members

Commission Contract Manager Deliverables:

- Final Report Instructions

Task 1.2 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 if it should, are there any modifications that need to be made to the tasks, deliverables, schedule or budget.

CPRs provide the opportunity for frank discussions between the Energy Commission and the Contractor. CPRs generally take place at key, predetermined points in the Agreement, as determined by the Commission Contract Manager and as shown in the Technical Task List above and in the Schedule of Deliverables. However, the Commission Contract Manager may schedule additional CPRs as necessary, and, if necessary, the budget will be reallocated to cover the additional costs borne by the Contractor, but the overall contract amount will not increase.

Participants include the Commission Contract Manager and the Contractor, and may include the Commission Contracts Officer, the PIER Program Team Lead, other Energy Commission staff and Management as well as other individuals selected by the Commission Contract Manager to provide support to the Energy Commission.

The Commission Contract Manager shall:

- Determine the location, date and time of each CPR meeting with the Contractor. These meetings generally take place at the Energy Commission, but they may take place at another location.

- Send the Contractor 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 to modify the tasks, schedule, deliverables and budget for the remainder of the Agreement, including not proceeding with one or more tasks. If the Commission Contract Manager concludes that the project needs a formal amendment or that satisfactory progress is not being made and the project needs to be ended, these conclusions will be referred to the Commission's Research, Development and Demonstration Policy Committee for its concurrence.

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

The Contractor 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 deliverables identified in this Scope of Work. Submit these documents to the Commission Contract 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.

Contractor Deliverables:
- CPR Report(s)
- CPR deliverables identified in the Scope of Work

Commission Contract Manager Deliverables:
- Agenda and a List of Expected Participants
- Schedule for Written Determination
- Written Determination

Task 1.3 Final Meeting
The goal of this task is to closeout this Agreement.

The Contractor shall:

- Meet with the Energy Commission 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 Contractor, the Commission Contracts Officer, and the Commission Contract 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 Contract Manager.

  The technical portion of the meeting shall present findings, conclusions, and recommended next steps (if any) for the Agreement. The Commission Contract Manager will determine the appropriate meeting participants.

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

  - What to do with any state-owned equipment (Options)
  - Need to file UCC.1 form re: Energy Commission's interest in patented technology
  - Energy Commission's request for specific "generated" data (not already provided in Agreement deliverables)
  - Need to document 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 schedule for completing the closeout activities for this Agreement.

Deliverables:
- Written documentation of meeting agreements and all pertinent information
- Schedule for completing closeout activities

REPORTING

See Exhibit D, Reports/Deliverables/Records.

Task 1.4 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.

The Contractor shall:

- Prepare progress reports which summarize all Agreement activities conducted by the Contractor 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 Contract Manager within 10 working days after the end of the reporting period. Attachment A-2, Progress Report Format, provides the recommended specifications.

Deliverables:
- Progress Reports will be submitted with each invoice

Task 1.5 Test Plans, Technical Reports and Interim Deliverables
The goal of this task is to set forth the general requirements for submitting test plans, technical reports and other interim deliverables, unless described differently in the Technical Tasks. When creating these deliverables, the Contractor shall use and follow, unless otherwise instructed in writing by the Commission Contract Manager, the latest version of the PIER Style Manual published on the Energy Commission's web site:

http://www.energy.ca.gov/contracts/pier/contractors/index.html

The Contractor shall:

- Unless otherwise directed in this Scope of Work, submit a draft of each deliverable listed in the Technical Tasks to the Commission Contract Manager for review and comment in accordance with the approved Schedule of Deliverables. The Commission Contract Manager will provide written comments back to the Contractor on the draft deliverable within 10 working days of receipt. Once agreement has been reached on the draft, the Contractor shall submit the final deliverable to the Commission Contract Manager. The Commission Contract Manager shall provide written approval of the final deliverable within 5 working days of receipt. Key elements from this deliverable shall be included in the Final Report for this project.

Task 1.6 Final Report
The goal of this task is to prepare a comprehensive written Final Report that describes the original purpose, approach, results and conclusions of the work done under this Agreement. The Commission Contract Manager will review and approve the Final Report. The Final Report must be completed on or before the termination date of the Agreement. When creating these deliverables, the Contractor shall use and follow,

unless otherwise instructed in writing by the Commission Contract Manager, the latest version of the PIER Style Manual published on the Energy Commission's web site:

http://www.energy.ca.gov/contracts/pier/contractors/index.html

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

Task 1.6.1 Final Report Outline

The Contractor shall:

- Prepare a draft outline of the Final Report.

- Submit the draft outline of Final Report to the Commission Contract Manager for review and approval. The Commission Contract Manager will provide written comments back to the Contractor on the draft outline within 10 working days of receipt. Once agreement has been reached on the draft, the Contractor shall submit the final outline to the Commission Contract Manager. The Commission Contract Manager shall provide written approval of the final outline within 5 working days of receipt.

Deliverables:

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

Task 1.6.2 Final Report

The Contractor shall:

- Prepare the draft Final Report for this Agreement in accordance with the approved outline.

- Submit the draft Final Report to the Commission Contract Manager for review and comment. The Commission Contract Manager will provide written comments within 10 working days of receipt.

  Once agreement on the draft Final Report has been reached, the Commission Contract Manager shall forward the electronic version of this report for Energy Commission internal approval. Once the approval is given, the Commission Contract Manager shall provide written approval to the Contractor within 5 working days.

- Submit one bound copy of the Final Report with the final invoice.

Deliverables:

- Draft Final Report
- Final Report

MATCH FUNDS, PERMITS, AND ELECTRONIC FILE FORMAT

Task 1.7 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. While the PIER budget for this task will be zero dollars, the Contractor may utilize match funds for this task. Match funds shall be spent concurrently or in advance of PIER funds during the term of this Agreement. Match funds must be identified in writing, and the associated commitments obtained before the Contractor can incur any costs for which the Contractor will request reimbursement.

The Contractor shall:

- Prepare a letter documenting the match funding committed to this Agreement and submit it to the Commission Contract Manager at least 2 working days prior to the kick-off meeting:
  1. 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.
  2. 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 Contractor shall identify its owner and provide a contact name, address and telephone number, and the address where the property is located.
     - 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 significantly 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 Contract Manager if during the course of the Agreement additional match funds are received.

- Notify the Commission Contract Manager within 10 working days if during the course of the Agreement existing match funds are reduced. Reduction in match funds may trigger an additional CPR.

Deliverables:

- A letter regarding Match Funds or stating that no Match Funds are provided
- Letter(s) for New Match Funds
- A copy of each Match Fund commitment letter
- Letter that Match Funds were Reduced (if applicable)

Task 1.8 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 reimbursable under this Agreement. Permits must be identified in writing before the Contractor can incur any costs related to the use of the permit(s) for which the Contractor will request reimbursement.

The Contractor shall:

- Prepare a letter documenting the permits required to conduct this Agreement and submit it to the Commission Contract Manager at least 2 working days prior to the kick-off meeting:
  1. If there are no permits required at the start of this Agreement, then state such in the letter.
  2. 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
     - Schedule the Contractor will follow in applying for and obtaining these permits.

- The list of permits and the schedule for obtaining them will be discussed at the kick-off meeting, and a timetable for submitting the updated list, schedule and the copies

of the permits will be developed. 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, then provide the appropriate information on each permit and an updated schedule to the Commission Contract Manager.

- As permits are obtained, send a copy of each approved permit to the Commission Contract Manager.

- If during the course of the Agreement permits are not obtained on time or are denied, notify the Commission Contract Manager within 5 working days. Either of these events may trigger an additional CPR.

Deliverables:

- A letter documenting the Permits or stating that no Permits are required
- Updated list of Permits as they change during the Term of the Agreement
- Updated schedule for acquiring Permits as it changes during the Term of the Agreement
- A copy of each approved Permit

Task 1.9 Electronic File Format

The goal of this task is to unify the formats of electronic data and documents provided to the Energy Commission as contract deliverables. Another goal is to establish the computer platforms, operating systems and software that will be required to review and approve all software deliverables.

The Contractor shall:

- Deliver documents to the Commission Contract Manager in the following formats:
  - Data sets shall be in Microsoft (MS) Access or MS Excel file format.
  - PC-based text documents shall be in MS Word file format.
  - Documents intended for public distribution shall be in PDF file format, with the native file format provided as well.
  - Project management documents shall be in MS Project file format.
- Request exemptions to the electronic file format in writing at least 90 days before the deliverable is submitted.

Deliverables:

- A letter requesting exemption from the Electronic File Format (if applicable)

PROJECT ADVISORY COMMITTEE (PAC)

Task 1.10 Establish the PAC

The goal of this task is to create an advisory committee for this Agreement.

The PAC should be composed of diverse professionals. The number can vary depending on potential interest and time availability. The Contractor's Project Manager and the Commission Contract Manager shall act as co-chairs of the PAC. The exact composition of the PAC may change as the need warrants. PAC members serve at the discretion of the Commission Contract Manager.

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

- Researchers knowledgeable about the project subject matter
- Members of the trades who 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 project subject matter
- U.S. Department of Energy Research Manager
- Public Interest Environmental Groups
- Utility Representatives
- Members of the relevant technical society committees

The purpose of the PAC is to:

- Provide guidance in research direction. The guidance may include scope of research; research methodologies; timing; coordination with other research. The guidance may be based on:
  - -technical area expertise
  - -knowledge of market applications
  - -linkages between the agreement work and other past, present or future research (both public and private sectors) they are aware of in a particular area.
- Review deliverables. Provide specific suggestions and recommendations for needed adjustments, refinements, or enhancement of the deliverables.
- Evaluate tangible benefits to California of this research and provide recommendations, as needed, to enhance tangible benefits.
- Provide recommendations regarding information dissemination, market pathways or commercialization strategies relevant to the research products.

The Contractor shall:

- Prepare a draft list of potential PAC members that includes name, company, physical and electronic address, and phone number and submit it to the Commission Contract Manager at least 2 working days prior to the kick-off meeting. This list will be discussed at the kick-off meeting and a schedule for recruiting members and holding the first PAC meeting will be developed. The contractor shall consider PAC members from, but not limited to:

    - industry (e.g., Southern California Edison, Pacific Gas and Electric, Los Angeles Department of Water and Power, General Electric, GridPoint, Ford, and Toyota),
    - state and local agencies (e.g., Energy Commission, California Independent System Operator (CAISO), California Air Resources Board (CARB), South Coast Air Quality Management District (SCAQMD), San Joaquin Valley Air Pollution Control District (SJVAPCD), Bay Area Air Quality Management District (BAAQMD), Sacramento Metropolitan Air Quality Management District (SMAQMD), San Diego Air Pollution Control District (SDAPCD),
    - environmental groups (e.g., Natural Resources Defense Council) and
    - United State Department of Energy (DOE) national lab researchers.
- Recruit PAC members and ensure that each individual understands the member obligations described above, as well as the meeting schedule outlined in Task 1.11.
- Prepare the final list of PAC members.
- Submit letters of acceptance or other comparable documentation of commitment for each PAC member.

Deliverables:

- Draft List of PAC Members
- Final List of PAC Members
- Letters of acceptance, or other comparable documentation of commitment for each PAC Member

Task 1.11 Conduct PAC Meetings

The goal of this task is for the PAC to provide strategic guidance to this project by participating in regular meetings or teleconferences. No PIER funds can be used for food or drink beyond allowed per diem expenses.

The Contractor shall:

- Discuss the PAC meeting schedule at the kick-off meeting. The number of face-to-face meetings and teleconferences and the location of PAC meetings shall be determined in consultation with the Commission Contract Manager. This draft schedule shall be presented to the PAC members during recruiting and finalized at the first PAC meeting.
- Organize and lead PAC meetings in accordance with the schedule. Changes to the schedule must be pre-approved in writing by the Commission Contract Manager.
- Prepare PAC meeting agenda(s) with back-up materials for agenda items.
- Prepare PAC meeting summaries, including recommended resolution of major PAC issues.

Deliverables:

- Draft PAC Meeting Schedule
- Final PAC Meeting Schedule
- PAC Meeting Agenda(s) with Back-up Materials for Agenda Items

- Written PAC meeting summaries, including recommended resolution of major PAC issues

TECHNICAL TASKS

The Contractor shall prepare all deliverables in accordance with the requirements in Task 1.5. Deliverables not requiring a draft version are indicated by marking "(no draft)" after the deliverable name.

Task 2 Literature Review and Previous Studies

The main goal of this task is to review relevant literature and previous studies to evaluate previous research related to the proposed effort. Relevant topics for the literature review include, but are not limited to~~,~~**:** current grid infrastructure and technologies, future grid infrastructure and technologies, renewable energy technology deployment, complementary energy storage, distributed generation (DG), and other power plant deployment, electric vehicle deployment, **electrification,** and smart grid technologies.

The Contractor shall:

- Conduct a thorough and systematic literature review including, but not limited to, the following resources and studies:
    - Intermittency Analysis Project: Characterizing New Wind Resources in California, by AWS TrueWind LLC, under CEC contract 500-2007-014 [AWS TrueWind LLC [2007]
    - Review of International Experience Integrating Variable Renewable Energy Generation, under CEC contract 500-2007-029 [Exeter Associates Inc. 2007]
    - Western Wind and Solar Integration Study Update, National Renewable Energy Laboratory, Presentation at the WestConnect Planning Meeting [Lew, 2008]
    - Western Wind and Solar Integration Study, National Renewable Energy Laboratory, Presentation at the SWAT/CCPG Meeting [Lew, 2007]
    - Effect of variable speed wind turbine generator on stability of a weak grid in IEEE Transactions on Energy Conversion, [Muljadi et al. 2007]
    - Western Wind Resources Dataset, National Renewable Energy Laboratory. Available on-line at: http://www.nrel.gov/wind/westernwind/ [NREL, 2009]
    - Model~~l~~ing grid losses and the geographic distribution of electricity generation in Renewable Energy [Ostergaard, 2005]
    - Intermittency Analysis Project: Summary of Final Results, under CEC contract 500-2007-081 [Porter et al. 2007]
    - Creating the Dataset for the Western Wind and Solar Integration Study (U.S.A.). 7th International Workshop on Large Scale Integration of Wind Power and on Transmission Networks for Offshore Wind Farms [Potter et al., 2008]

    - Renewable Energy Transmissions Initiative, Phase 1B, Final Report, RETI 1000-2008-003-F [RETI, 2008]
- Collect information on the current grid and potential future additions to the grid, which would include large-scale deployment of renewable generation projects, small renewable generation, and intermittency issues and non-renewable generation needed to support grid stability will be compiled.
- Collect information on current grid emissions and expected future emissions.
- **Review the literature associated with electrification as a strategy for GHG and criteria pollutant emissions reductions.**
- Collect information on full life cycle analysis for power generation to include GHG emissions from dismantling of aged power plants and construction of new generation stations and transmission lines..
- Prepare chapter on literature review and findings.

Deliverables:

- Chapter of final report on literature review and findings (no draft)

Task 3 Project Advisory Committee (PAC) and Workshop

The goal of this task is to involve the PAC established in Task 1 in the oversight and review of work conducted in the project and to conduct a separate stakeholder workshop. No PIER funds can be used for food or drink beyond allowed per diem expenses.

The Contractor shall:

- Plan for and conduct biannual PAC meetings, presenting recent findings of the project, accepting critique and addressing concerns and recommendations of PAC members.
- Work with the Energy Commission to plan for, organize and host a one-day workshop at University of California, Irvine (UCI) that involves participation of a greater cross-section of stakeholders than those committed to participation in the PAC;
    - Document contributions of stakeholders during the workshop.
    - Address suggestions brought up by stakeholders in the workshop.
    - Use feedback from stakeholders to refine the project approach.
    - Pay special attention to and extensively seek guidance and input from organizations involved in the Renewable Energy Transmission Initiative and the Intermittency Analysis Project.
- Prepare summary highlighting findings and recommendations from the workshop.

Deliverables:

- Meeting minutes from biannual PAC meetings
- Summary from the stakeholder workshop (no draft)

Task 4 Renewable Power Implementation Scenarios and Modeling

The main goal of Task 4 will be to develop detailed understanding and physical representations of future grid infrastructure and related/required complementary technologies that include more renewable power sufficient to meet RPS goals and policies. In addition, detailed modeling of power flow in the Western Electric ~~*Company Cooperative*~~**Coordinating Council** (WECC) region using Ventyx or similar software will be accomplished to understand requirements and implications of more renewable power on California power flow in the years 2020 through 2040.

The Contractor shall:

- Develop renewable power implementation scenarios based upon the rigorous methodology previously developed by UCI for fully characterizing emissions of future implementation scenarios [Medrano et al. 2008].
- Account for all of the following features and specifications in each scenario:
    - Fraction of energy needs met by renewable technologies.
    - Allocation of renewable technology types.
    - Required complementary technology types, capacities, and capabilities.
    - Emissions specifications for all technologies used.
    - Spatial distribution of all renewable and complementary technologies in basin of interest.
    - Operating duty cycle (intermittency) of all technologies.
    - Emissions displaced.
    - Other required estimates.
- Develop realistic and market-based renewable power implementation scenarios that consider, but are not limited to, the following:
    - Geographic information systems (GIS) land-use categories related to specific activity sectors.
    - Factors that define preferential category-specific energy conversion. technologies, duty cycles and differing rates of energy technology. adoption based upon market and technology studies and stakeholder insights.
    - Market forces (e.g., lower cost technologies that meet emissions standards will be preferentially adopted).
    - Regulatory requirements.
    - EPRI electric sector modeling results.
    - Power plant aging and retirement.
    - Environmental restrictions on power plants.
    - Distributed generation.
    - Likely implementation of plug-in hybrid electric vehicles (PHEV).
    - Smart grid technology.
    - Peaking and load-following base-load generators.
    - Out-of-state renewable generation.
    - Transmission limitations.
    - Interactions with the western power grid.
    - Grid stability/spinning reserves requirements.
- Develop each renewable power implementation scenario with sufficient definition to fully characterize each instance of renewable power plus all required

complementary technologies to meet RPS goals while maintaining grid stability and a viable wholesale power market Including:

- Future representative state load demand profiles of interest (e.g., representative winter and summer days of 2020, 2030 and 2040).
- Selected sets of renewable technologies to be used to meet RPS goals (multiple scenarios will allow consideration of a wide array of technology combinations and market considerations).
- Renewable power production dynamics accounting for meteorological conditions, solar intermittency (diurnal solar irradiance, cloud stochastic model), wind intermittency (statistically representative intermittency), and biomass-based power generation.
- Dispatch of non-renewable generation that minimizes cost and remains within capacity and rate limits (market-based dispatch) to obtain hourly dispatch profiles.
    - Use previously developed real market-based correlations of capacity factor for each resource (nuclear, coal, etc.) to determine availability of current dispatchable resources [Jansen, 2009].
- Determine the requirements to maintain grid stability such as complementary spinning reserve, new energy storage, demand response and dispatchable resources.
    - Subtract sum of all renewable power and dispatched power from demand on an hourly basis.
    - Account for dispatchable loads in a manner similar to that used to determine smart grid technology effects on battery electric vehicle charging.
    - Set ramp rate limits, installation capacity, and cost for generators (e.g., biogas, natural gas, coal and nuclear) and energy storage.
- Determine emissions associated with the hourly generation intensity of renewable, dispatched traditional generation and new complementary spinning reserve, energy storage and dispatchable power technologies to evaluate emission changes relative to the base case.

- Develop Renewable Power Implementation Scenarios with renewable power sales accounting for various percentages of retail sales in various future years as follows:
    - Consider the Renewable Portfolio Standard goals of “20% of retail sales in 2010” and “33% of retail sales in 2020”.
    - Consider greater and lesser renewable power penetration levels in various future years (e.g., 2030 – 2050).
    - At least six (6) implementation scenarios that address RPS goals shall be developed in accordance with the methods presented above.
    - Develop at least six (6) renewable power implementation scenarios that include different instances of renewable and complementary technologies with differing spatial and temporal emissions.
    - Develop at least two (2) renewable power implementation scenarios that consider future years beyond 2020 to explore unexpected outcomes (e.g., a major technology breakthrough), and to determine whether differing

constraints (e.g., changes in regulation, land-use, transmission constraints) might produce better air quality results and/or greenhouse emissions reductions while meeting a longer-term RPS goal will be developed in this subtask.

- Use Ventyx or similar software to simulate power flow in the western electric utility grid to determine the requirements and impacts of introducing more renewable power.
- Use Ventyx or similar software to model the western electric utility grid for assessing the degree to which load and demand can be balanced for each of the realistic renewable power implementation scenarios.
    - Accomplish steady-state power flow analyses for maximum and minimum renewable power production states.
    - Accomplish steady-state power flow analyses for conditions representative of all four seasons.
    - Investigate the dynamics of realistic renewable power scenarios for summer and winter by simulation of representative daily variations associated with each scenario.
- Prepare chapter for final report describing implementation scenarios.
- Prepare chapter on Power Flow Simulations of Western Electric Utility Grid.

Deliverables:

- Chapter of final report on Renewable Power Implementation Scenarios (no draft)
- Chapter of final report on Power Flow Simulations of Western Electric Utility Grid (no draft)

Task 5 Spatial and Temporal Emissions Characterization

The goal of this task is to create spatially and temporally resolved emissions fields for each renewable power implementation scenario~~s~~ developed in Task 4 **<u>and for the electrification scenario developed in Task 8.</u>**

The Contractor shall:

- Develop baseline emissions inventories
    - The UCI team will work with the CARB, SCAQMD, SJVAPCD, SMAQMD, BAAQMD, and SDAPCD to develop future baseline emissions inventories for the South Coast Air Basin (SoCAB) and the San Joaquin Valley (SJV).
    - Appropriately scale and manipulate emissions fields to address years for which there is no detailed emissions inventory using socio-economic factors, such as population growth, industrial activity growth, and expected improvement in technology and energy use.
- Spatially and temporally allocate emissions for each “20% by 2020” renewable power implementation scenario developed in Task ~~3~~ **<u>4</u>**.
    - Use the UCI software and databases previously developed using GIS data for spatial emissions allocations.

- Spatially and temporally allocate emissions in the modeling domains of interest for each “33% by 2030 or other selected year” renewable power implementation scenario using established tools and methods as described above.
- Spatially and temporally allocate emissions in the modeling domains of interest for each “40% by 2030 or other selected year” renewable power implementation scenario using established tools and methods as described above.
- Include spatially and temporally resolved emissions for each renewable power implementation scenario.
- **Include spatially and temporally resolved emissions for each electrification scenario.**

Deliverables:

- Chapter of final report on spatially and temporally resolved emissions from the renewable implementation scenarios (no draft)

Task 6 Air Quality Modeling

The goal of Task 6 is to determine the relative air quality impacts of each renewable power implementation scenario **and electrification scenario.**~~, which cannot be determined~~ **These determinations require the** ~~without~~ application of a detailed model that can accurately simulate secondary pollutant formation (e.g., ozone, secondary organic and inorganic aerosols) and transport within the atmosphere.

The Contractor shall:

- Use atmospheric models to simulate air quality throughout the entire state of California for each of the renewable power implementation scenarios.
- Use the Community Multiscale Air Quality model (CMAQ) to accomplish each of the required simulations.
    - Include model input from a state-of-the-art meteorological model (e.g., Mesoscale Model (MM5, www.mmm.ucar.edu/mm5) or the Weather Research and Forecast model (WRF, www.wrf-model.org))
        - Include the CMAQ chemical transport model (the version of CMAQ proposed for use in this study is a version that has been modified by CARB in order to obtain better model performance when applied to California)
- Apply air quality modeling to the Baseline Scenarios
- Apply air quality modeling to the Renewable Implementation Scenarios
- **Apply air quality modeling to the Electrification Scenarios**
- Assess the following air quality impacts of each Renewable Implementation Scenario **and Electrification Scenario**:
    - Spatially and temporally distributed emissions and concentrations of criteria pollutants in the computational domains used in the study.
    - 1-hour and 8-hour average ground-level ozone concentrations
    - 1-hour, 24-hour average and annual $PM_{2.5}$ concentrations

- Analyze and assess the air quality impacts of each of the future scenarios and develop a set of summary findings that rigorously establish the potential air quality impacts of a wide variety of renewable power implementation scenarios
- Prepare chapter for the final report on the air quality impacts of all of the Renewable Power Implementation Scenarios including summary findings.
- **Prepare a chapter for the final report on the air quality impacts of each Electrification Implementation Scenario, including summary findings.**

Deliverables:

- Chapter of final report on air quality impacts of renewable implementation scenarios (no draft)
- **Chapter of final report on air quality impacts of electrification scenarios (no draft)**

Task 7 Greenhouse Gas Impacts

The goal of Task 7 is to develop life cycle GHG emissions inventories for each of the Renewable Implementation Scenarios **and Electrification Scenarios**.

The Contractor shall:

- Characterize grid technologies with respect to GHG emissions such that extraction and transportation of the fuel and water consumed for power generation, manufacturing of grid technologies, operation of those technologies, and their recycling/decommissioning emissions are considered.
- Determine carbon dioxide, methane, and nitrous oxide emission factors for each component of the life cycle using a combination of published data, experimental data, and case studies for advanced or next generation technologies.
- Compile and analyze the data to assure a consistent basis and account for error.
- Add grid technologies and established emission factors to the UCI Preferred Combination Assessment (PCA) model, which analyzes the integration of technologies in a given infrastructure scenario on a life cycle basis.
- Use the PCA framework to allow for systematic parametric variation of the technologies affecting GHG emissions resulting in life cycle GHG emissions for each scenario of the study.
- Compare the PCA GHG emissions results to those of the EPRI electric sector model.
- Prepare a chapter for the final report on the GHG impacts of all of the Renewable Power Implementation Scenarios including summary findings.
- **Prepare a chapter for the final report on the GHG impacts of each Electrification Scenario, including summary findings.**

Deliverables:

- Chapter of final report on the GHG impacts of the renewable implementation scenarios (no draft)

- **Chapter of final report on the GHG impacts of the renewable implementation scenarios (no draft)**

Task 8 Electrification Implementation Scenario Development
The goal of Task 8 is to develop a detailed understanding and physical representations of future grid infrastructure and related/required complementary technologies that will address the ability of electrification to: (1) reduce emissions of GHG to meet AB 32; and (2) reduce the emissions of air pollutants to meet the National Ambient Air Quality Standards in the SCAQMD and SJVAPCD that meet EPA standards by 2023 and 2032.

The Contractor will consider the concept of high "electrification" as described and understood by the California interagency working group (CARB, 2012) and the SCAQMD Air Quality-Related Energy Policy adopted by the SCAQMD Board on September 9, 2011. The Contractor will also conduct production simulation modeling in the WECC region using PLEXOS or similar software to understand requirements and implications of the electrification scenarios on California power production in the years 2020 through 2032.

The Contractor shall:

- **Develop each electrification implementation scenario with sufficient definition to account for:**
  - **Various levels of high electricity use in transportation and stationary applications.**
  - **Selected sets of renewable technologies and the high electrification of transportation and other sectors.**
  - **Renewable power production dynamics accounting for meteorological conditions, solar intermittency (diurnal solar irradiance, cloud stochastic model), wind intermittency (statistically representative intermittency), and biomass-based power generation.**
  - **The requirements to maintain grid stability such as complementary spinning reserve, new energy storage, demand response, and dispatchable resources.**
    - **Subtract the sum of all renewable power and dispatched power from demand on an hourly basis**
    - **Account for dispatchable loads in a manner similar to that used to determine smart grid technology effects on battery electric vehicle charging**
    - **Set ramp rate limits, installation capacity, and cost for generators (e.g., biogas, natural gas, coal and nuclear) and energy storage**
  - **Emissions associated with the hourly generation intensity of renewable, dispatched traditional generation and new**

complementary spinning reserve, energy storage, and dispatchable power technologies to evaluate emission changes relative to the base case.

- **Develop Electrification Implementation Scenarios with renewable power sales accounting for various percentages of retail sales in various future years as follows:**
    - **At least six (6) electrification implementation scenarios that address various electrification levels, developed in accordance with the methods presented above for the year 2020 and 2032 to meet AB 32 targeted reductions in GHG emissions.**
    - **At least two (2) spanning electrification implementation scenarios that consider future years beyond 2032 to explore unexpected outcomes (e.g., a major technology breakthrough) and determine whether differing constraints (e.g., changes in regulation, land-use, and transmission constraints) might produce better air quality results and/or greenhouse emissions reductions.**
    - **At least six (6) electrification implementation scenarios that address various electrification, developed in accordance with the methods presented above for the years 2023 and 2032 to meet EPA National Ambient Air Quality Standards for PM and ozone.**
    - **At least two (2) spanning electrification implementation scenarios that consider years beyond 2032 to explore unexpected outcomes (e.g., a major technology breakthrough) and determine whether differing constraints (e.g., changes in regulation, land-use, and transmission constraints) might produce better air quality results and/or greenhouse emissions reductions.**
- **Develop Electrification Implementation Scenarios that will be meaningful to assist in future control strategy development.**
    - **Include at least one electrification scenario that represents the best use of the future electricity supply system while producing the maximum air quality and GHG benefits.**
    - **Incorporate energy storage technology into scenarios starting no later than 2032.**
- **Identify where technology breakthroughs are needed for broad applications and lower costs.**
- **Produce scenarios that are directly comparable, meaning that they meet the same objectives (e.g., meeting the GHG targets and NAAQS).**
    - **When scenarios are not directly comparable, the alternatives must be presented as either: (1) greater or lesser implementation priority; or (2) sooner or later implementation sequence.**
- **Use PLEXOS or similar software to simulate power production in the western electric utility grid to determine the requirements and impacts of introducing more electrification.**
- **Use PLEXOS or similar software to model the western electric utility grid for assessing the degree to which load and demand can be balanced for each of the implementation scenarios.**

- **Accomplish steady-state power production simulation for maximum and minimum renewable power production states.**
- **Accomplish steady-state power production simulation for conditions representative of all four seasons.**

- **Add Task 8 electrification results to the draft chapter for the final report describing the electrification implementation scenarios.**
- **Add Task 8 simulation results to the draft final report chapter on Power Production Simulations of Western Electric Utility Grid.**

Products:

- **Results added to draft chapter on Electrification Implementation Scenarios**
- **Results added to draft chapter on Power Production Simulations of Western Electric Utility Grid**

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