

Exhibit A SCOPE OF WORK

TECHNICAL TASK LIST

Task #	CPR	Task Name
1.0	N/A	Administration
2.0		Transmission Grid Infrastructure Research
2.1		Demonstration of SmartWires™ Transmission Line Impedance Control Technology
2.2		Improved Seismic Performance of Transformer Bushings
2.3		Improved Seismic Performance of Substation Insulators
2.4		Underground Transmission Technologies
3.0		Transmission System Operation Research
3.1		Developing Tools for Wide-Area Storage Management for Wind and Solar Generation
3.2		Oscillation Detection and Analysis
3.3		Application of Mode Analysis for Grid Operation (MANGO) on the Western Inter-connection
4.0		Transmission Planning and Environmental Research
4.1		Adaptive Relaying Technology Development
4.2		Developing Tools for Online Analysis and Visualization of Operational Impacts of Wind and Solar Generation
5.0		Technology Transfer Activities

KEY NAME LIST

Task #	Key Personnel	Key Subcontractor(s)	Key Partner(s)
1	None	None	None
2	Lloyd Cibulka	Georgia Tech University of California Berkeley SUNY-Buffalo	
3		Pacific Northwest National Laboratory	
4		Virginia Tech Pacific Northwest National Laboratory	
5	None	None	

GLOSSARY

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

Acronym	Definition
BPA	Bonneville Power Administration
CAISO	California Independent System Operator
CCM	Commission Contract Manager
CERTS	Consortium for Electric Reliability Technology Solutions
CIEE	California Institute for Energy and Environment (University of California)
CPR	Critical Project Review
DOE	U.S. Department of Energy
DOMO	Dynamic Operating Margin Optimization
EMS	Energy Management System
EPRI	Electric Power Research Institute
FACTS	Flexible AC Transmission System
FCC	Fault Current Controller
GHG	Greenhouse Gas
IEEE	Institute of Electrical and Electronics Engineers
kV	Kilovolt
LBNL	Lawrence Berkeley National Laboratory
MANGO	Mode Analysis for Grid Operation
MCEER	Multidisciplinary Center for Earthquake Engineering Research
NASPI	North American Synchro Phasor Initiative
NREL	National Renewable Energy Laboratory
ORNL	Oak Ridge National Laboratory
PAC	Policy Advisory Committee
PAG	Project Advisory Group
PAM	Program Administration Manual
PARS	Power Applications and Research Systems, Inc
PEER	Pacific Earthquake Engineering Research (Center at UC Berkeley)
PG&E	Pacific Gas and Electric
PIER	Public Interest Energy Research
PMU	Phasor Measurement Unit
PNNL	Pacific Northwest National Laboratory
PSERC	Power Systems Engineering Research Center
RD&D	Research, Development and Demonstration
RFP	Request for Proposal
RON	Research Opportunity Notice
RPS	Renewable Portfolio Standard
RTR	Real Time Rating
SCADA	Supervisory Control and Data Acquisition
SCE	Southern California Edison
SCIT	Southern California Import Transmission
SPS	Special Protection System
SUNY	State University New York
TAC	Technical Advisory Committee
TRP	Transmission Research Program (Part of Energy Commission PIER Program)
UC	University of California
UCC.1	Uniform Commercial Code (Financing Statement)

Acronym	Definition
WACS	Wide Area Control System
WECC	Western Electricity Coordinating Council

Problem Statement

California has adopted energy policies that require substantial increases in the generation of electricity from renewable resources. Extensive improvements are needed to California's electric transmission infrastructure to get the electricity generated by new renewable power facilities to consumers.

California must take immediate action to develop and maintain a cost effective, reliable transmission system capable of responding to important policy challenges, including global climate change. While the achievement of state greenhouse gas policy objectives by the electricity sector will depend to a large degree on the interconnection and operational integration of renewable resource generation with the transmission grid, resolving these important issues will ease California's transition to a more carbon constrained generation base. California utilities must also ensure that projects meeting traditional reliability and congestion management objectives are developed in a timely manner. Actions already underway at the state and federal levels to address planning, permitting, financing, and integration barriers to renewable generation interconnection need to be assessed to ensure that state policy objectives are met. California must continue to address important transmission project and transmission corridor planning and permitting barriers to help achieve the state's renewable generation and environmental policy goals.

The California Energy Commission (Energy Commission) formed the Public Interest Energy Research (PIER) Transmission Research Program in 2003 in response to SB 1038, legislation that revised PIER's mandate to include projects that have the potential to enhance transmission and distribution capabilities. More recently, SB 1250 (2005-2006, Reg.Sess.), with an emphasis on renewable energy delivery, greenhouse gas (GHG) reductions, and energy efficiency, provides additional research direction.

Goals of the Agreement

The goal of this Agreement is to conduct public interest RD&D to advance science and technologies that:

- Enhance transmission integration of renewables
- Make the transmission system operate with a higher efficiency and reduce the GHG emissions from the transmission system
- Accelerate new transmission through new planning tools & technologies:
- Expand the capacity of transmission corridors
- Enhance ability to operate transmission under uncertain & complex conditions

Objectives of the Agreement

The objectives of this Agreement are to advance transmission science and technology to

- Facilitate new transmission investment.
- Increase power flows in a given corridor.
- Manage increased power flows & associated reliability risks.
- Reduce response times for wide-area network protection to less than minutes for operators and less than seconds for automation.
- Enhance the integration of renewable power with the grid

- Reduce greenhouse gas impacts and increase energy efficiency of the electric grid in California.

This effort will contribute to these objectives by:

- Developing methods for congestion planning, and uncertainty forecasting.
- Developing a more deterministic cost/benefit allocation process
- Developing technologies and systems for increased power flows.
- Developing technologies and systems for controlling power flow
- Developing operational decision support tools to improve operational response times
- Developing more robust system components
- Developing technical solutions to the special problems of wind integration into the transmission system.
- Identify the greenhouse gas emissions and energy inefficiencies of the electric transmission systems for improvements and technology gaps.
- Address the “path to market” for these new technologies

TASK 1.0 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 and TACs (Task 1.10)
- PAC and TAC 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 any additional costs will be borne by the Contractor.

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 satisfactory progress is not being made, this conclusion will be referred to the Energy 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 Quarterly 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:

- Quarterly Progress Reports

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:

- 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 to the PIER Technology Transfer Group for final editing. Once final editing is completed, 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

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 not reimbursable under this Agreement. While the PIER budget for this task will be zero dollars, the Contractor shall show match funds for this task. Permits must be identified in writing and obtained before the Contractor can incur any costs related to the use of the permits 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)

PAC and TACs

Task 1.10 Establish the PAC and TACs

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

The PAC and TACs 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 and TACs. The exact composition of the PAC and TACs may change as the need warrants. PAC and TACs members serve at the discretion of the Commission Contract Manager.

The PAC and TACs 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 and TACs 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 and TACs 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.
- Recruit PAC and TACs 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 and TACs members.
- Submit letters of acceptance or other comparable documentation of commitment for each PAC and TACs member

Deliverables:

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

Task 1.11 Conduct PAC and TAC Meetings

The goal of this task is for the PAC and TACs to provide strategic or technical guidance to this project by participating in regular meetings or teleconferences.

The Contractor shall:

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

- Prepare PAC and TACs meeting summaries, including recommended resolution of major PAC or TACs issues.

Deliverables:

- Draft PAC and TACs Meeting Schedule
- Final PAC and TACs Meeting Schedule
- PAC and TACs Meeting Agenda(s) with Back-up Materials for Agenda Items
- Written PAC and TACs meeting summaries, including recommended resolution of major PAC or TACs issues

TECHNICAL TASKS

Unless otherwise provided in the individual Task, the Contractor shall prepare all deliverables in accordance with the requirements in Task 1.5.

Task 2.0 Future Transmission Grid Infrastructure Research

The goal of this task is to identify new or expanded transmission infrastructure research activities that

1. Improve the transmission infrastructure to increase the transmission of electricity from renewable resources.
2. Improve the efficiency of the transmission infrastructure.
3. Reduce the emissions of GHG that are associated with the transmission infrastructure.

The Contractor shall:

- Prepare the Future Transmission Grid Infrastructure Research Report. The Report shall include but not be limited to a description of what future transmission infrastructure research activities could be conducted relative to the following areas:
 - Equipment and devices to provide direct improvements to the transmission infrastructure for the integration of renewable energy resources.
 - SmartGrid technologies for their application to improve the transmission infrastructure to increase the transmission of electricity from renewable resources.
 - Equipment and devices that increase the efficiency of the transmission infrastructure and reduce emission of GHG that are directly associated with the transmission infrastructure.
- The Report will incorporate all the research identified in Task 2 and identify all other areas that need to be addressed in this research area.

Deliverables for Task 2.0:

- Future Transmission Grid Infrastructure Research Report

Task 2.1 Demonstration of SmartWires™ Transmission Line Impedance Control Technology

The goal of this task is to develop and demonstrate an emerging technology for the control of the flow of power on transmission lines. Georgia Tech is leading a consortium of electric utilities to develop the SmartWires™ distributed line impedance device, which will sense line current and modify the transmission line impedance to divert excess current to adjacent lines, thereby balancing the power flow among lines to maximize power transfer within the thermal limitations of the lines.

The Contractor shall:

- Identify partner utility and potential commercialization partner/s. Identify line for pilot project and validate impact on line with simulation.
- Redesign Passive Smart Wires module. Design for manufacturing, installation, O&M and data collection requirements. Work with utilities and potential commercialization partner/s.
- Build alpha prototype and validate with testing.
- Build 10 beta prototypes. Validate with installation, testing and data collection.
- Release model for system simulation and manufacturing.
- Integrate Active Smart Wire functionality into existing module.
- Explore suitability for application in distribution level meshed grid.
- Hold a Project Workshop and prepare an Interim Report.
- Build approximately 300 units for pilot program. Test, install and monitor units for a year.
- Prepare a Final Project Report.

Deliverables for Task 2.1:

- Interim Report: Development of Smartwires™ Transmission Line Impedance Control Technology
- Smartwires™ Transmission Line Impedance Control Technology Workshop Report
- Beta-version technology device and demonstration reports
- Technical Report: Smartwires™ Transmission Line Impedance Control Technology Demonstration
- Final Report: Development of Smartwires™ Transmission Line Impedance Control Technology

Task 2.2 Improved Seismic Performances of Transformer Bushings

The goal of this task is to investigate the seismic response of the combined transformer-bushing interaction to enable future analysis and physical seismic qualification of bushing-transformer systems. This will result in more seismically robust bushing designs with better performance during earthquakes, reduced outages of substations, and higher system reliability.

The Contractor Shall:

- Conduct a workshop of manufacturers, utilities and other researchers to identify outstanding technical issues that remain to be addressed by future research on transformer bushings. The Commission Contract Manager must approve the workshop location. The Contractor shall prepare and submit a Workshop Agenda and Presentation in advance of the workshop; it shall include full backup materials for all agenda items. Outreach efforts will seek participation by other California and U.S. utilities.
- Prepare a Workshop Report with recommendations for future research strategies
- Coordinate and supervise the laboratory testing to:
 - Prepare transformer bushing test specimens.
 - Develop a test protocol to simulate the appropriate earthquake conditions.
 - Test transformer bushings for capacity evaluation.
 - Evaluate testing procedures and develop recommendations for a rational protocol for testing.
- Prepare a Draft Report on Transformer Bushing Seismic Testing. Review the testing results and Draft Report with the TAC, the Transformer Advisory Group (TAG), transformer manufacturers, and other stakeholders.
- Prepare a Final Report on Transformer Bushing Seismic Testing.
- Provide a Draft Report on the Seismic Performance of Transformer Bushings; submit to the TAC for comments to be incorporated into the Final Report.
- Provide a Final Report on the Seismic Performance of Transformer Bushings.
- Draft recommended language for inclusion in future revisions of IEEE Standard 693 regarding certification procedures for transformer bushings, and work with the IEEE Standards Committee on inclusion of this language in the Standard.

Task 2.2 Deliverables:

- Proceedings of Industry Workshop on Seismic Performance of Transformer Bushings
- Report on Transformer Bushing Seismic Testing
- Report on Recommended Revisions to IEEE Standard 693, based on the results of Transformer Bushing Seismic Testing
- Report on the Seismic Performance of Transformer Bushings.

Task 2.3 Improved Seismic Performance of Substation Insulators

The goal of this task is to develop the knowledge and data to identify the failure modes of insulators used at substations and constructed of composite and porcelain materials. This information will be used to affect changes in the industry standards (IEEE 693) that specify the performance requirements of these important transmission system components.

The Contractor shall:

- Work with the TAC comprising of TRP stakeholders and others from industry. Manage the activities of TAC to provide technical direction and oversight to the project.
- Identify candidate manufacturer participants for the study, and arrange for manufacturers to loan or donate specimens.
- Identify important standards and characteristics affecting insulator strength, e.g., size, material composition, manufacturing process, type of joint, and type of grout.

- Collect data on breaking strengths, including characteristics identified previously.
- Perform statistical analysis of the data collected, and establish measures of variability.
- Develop acceptance criteria for the case when composite insulators are used in a seismic qualification test, including practical means for measuring the required quantities (e.g., strain, deflection) that establish acceptability.
- Develop appropriate factors of safety for different mechanical loading conditions.
- Develop expressions of strength prediction, and variability.
- Coordinate outcome with manufacturer participants.
- Provide a Draft Report on the testing of Porcelain and Composite Insulators; submit to the TAC for comments to be incorporated into the Final Report.
- Provide a Draft Report on the Seismic Response and Performance of Porcelain and Composite Insulators; submit to the TAC for comments to be incorporated into the Final Report.
- Provide a Final Report on the Testing of Porcelain and Composite Insulators.
- Provide a Final Report on the Seismic Response and Performance of Porcelain and Composite Insulators.
- Draft recommended language for inclusion in future revisions of IEEE Standard 693, and work with the IEEE Standards Committee on inclusion of this language in the Standard.

Task 2.3 Deliverables:

- Report on Testing of Porcelain and Composite Substation Post Insulators
- Report on Recommended Revisions to IEEE Standard 693 Relating to Qualification Procedures for Porcelain and Composite Substation Post Insulators
- Report on the Seismic Response and Performance of Porcelain and Composite Substation Post Insulators

Task 2.4 Underground Transmission Technologies

The goal of this task is to identify existing and emerging technologies suitable for undergrounding distribution and transmission lines associated with renewable generation, and for protecting transmission systems from physical threats such as fires and extreme storms. Further, a comparative assessment and benefits-cost analysis of the various technologies will be performed.

The Contractor Shall:

- Perform an assessment of current state-of-the-art underground transmission technologies, both domestic and international.
- Evaluate the values, costs and benefits of under-grounding transmission lines.
- Prepare a detailed review of promising underground transmission technologies.
- Identify the barriers to implementation and the significant risk factors associated with under-grounding of transmission lines.
- Develop recommendations and estimated project scope for any required research and development that might be needed to achieve the goal of extending the utilization of underground transmission and distribution cable systems.

Task 2.4 Deliverables:

- Underground Transmission Technology Solutions for Renewable Generation Transmission Integration and Protection from Natural Disasters Final Report

Task 3.0 Future Transmission System Operation Research

The goal of this task is to identify new or expanded transmission operational research activities that improve transmission operations to:

1. Increase the transmission of electricity from renewable resources.
2. Increase the efficiency of the transmission system.
3. Reduce the emissions of GHG that are associated with the transmission system.

The Contractor shall:

- Prepare the Future Transmission Operations Research Report. The Report shall include but not be limited to a description of what future transmission system operation research activities could be conducted relative to the following areas:
 - Technologies to provide improvements to the operation of the transmission system to increase the integration of renewables.
 - SmartGrid technologies for their integration into operations to increase the transmission of electricity from renewable resources
 - Grid operation for possible improvements in the efficiency of the operation of transmission system and reductions in the emission of GHG that are associated with transmission operations.
- The Report will incorporate all the research identified on Task 3 and identify all other areas that need to be addressed in this research area.

Task 3 Deliverables:

- Future Transmission Operation Research Report

Task 3.1 Developing Tools for Wide-Area Storage Management for Wind and Solar Generation

The goal of this task is to determine the extent that energy storage technologies can mitigate the impact of "intermittent and fast ramp" nature of renewable generation upon the transmission system managed by CAISO.

The Contractor Shall:

- Design and conduct field experiments for flywheel energy storage with a dispatchable load and distributed generation.
- Evaluate operational, market, and regulatory opportunities and limitations concerning the use of PG&E Battery Storage Facility and provide a brief report with a summary of findings
- Prepare the sets of simulated control signals for these resources using the actual data provided by BPA and CAISO.
- Calculate and analyze performance characteristics (performance metrics) for each regulation resource for the existing wind generation penetration levels.
- In cooperation with the BPA and CAISO engineers (or with the BPA and CAISO wind generation forecasting service providers), prepare sets of look-ahead data for higher penetration levels of wind energy in these systems (future scenarios).

- Conduct the experiments for the future scenarios and analyze performance characteristics (performance metrics) for each resource in the future scenarios.

Task 3.1 Deliverables:

- Intermediate Report
- Final Report

Task 3.2 Oscillation Detection and Mitigation

The goal of this task is create a method to mitigate the impact of electric transmission system oscillations that occur at the Western Interconnect, using phasor measurement unit (PMU) to monitor and measure the phenomena as it occurs in the field.

The Contractor Shall:

- Simulate the small signal dynamics of the Western Interconnection.
- Develop (and verify the accuracy of) an algorithm to detect and analyze oscillations, based on simulation model to simulate the small signal dynamics of the Western Interconnection.
- Adapt the above algorithm to data obtained from the PMU monitoring the Western Interconnect, and validate the developed algorithm with the field measurement data.
- Develop a simple graphic user interface (GUI) to demonstrate the performance of the developed algorithm.

Task 3.2 Deliverables

- Oscillation Summary Report
- Oscillation Detection Algorithm Summary Report
- Graphic Users Interface
- Final Report: Oscillation Detection and Mitigation

Task 3.3 Application of Mode Analysis for Grid Operation (MANGO) on the Western Inter-connection

The goal of this task is to develop a real-time modal analysis application of phasor measurements for enhancing modal control of the Western Interconnection through operator controllable variables (e.g., transformer taps, dispatch-able loads and generations). The developed procedure (known as MANGO) is expected to enable greater operational stability and reliability in power grid operations.

The Contractor Shall:

- Identify a list of potential controllable variables and their properties in the Western Interconnection.
- Conduct modal analysis to evaluate the influences of the controllable variables on the inter-area modes.
- Expand the MANGO (a model based on neural network techniques) for the Western Interconnection with the inputs and outputs identified.
- Develop and verify the MANGO model with ModeMeter results.
- Establish a procedure for generating and presenting recommendations for operators to mitigate the lightly damped oscillation modes.
- Generate and evaluate sample suggestions based on the procedure.

Task 3.3 Deliverables:

- A summary report on the controllable variables and their influences on the inter-area modes in the Western Interconnection
- MANGO Model and Methodology Summary report
- Recommendations for Damping Improvement Summary Report
- Prototype Computer Program – MANGO
- Report: Application of Mode Analysis for Grid Operation (MANGO) on the Western Interconnection

Task 4.0 Future Transmission Planning and Environmental Research

The goal of this task is to document how to streamline the planning and implementation of transmission upgrades, siting, and installation to improve the transmission of electricity from renewable resources and identify research areas in the transmission planning that can improve efficiency of the transmission infrastructure and reduce the emission of GHG.

The Contractor shall:

- Prepare the Future Transmission Planning and Environmental Research Report. The Report shall include but not be limited to a description of what transmission planning and environmental research activities could be conducted relative to the following areas:
 - Technologies to provide improvements to the upgrading, siting, construction, and installation of transmission equipment to increase the integration of renewables.
 - Methodologies and analytical techniques to provide improvements to the upgrading, siting, construction, and installation of transmission equipment to increase the integration of renewables.
 - SmartGrid technologies for the inclusion into the planning process for transmission to increase the transmission of electricity from renewable resources.
 - Variations of transmission planning methods to improve efficiency and reduce GHG.
- The Report will incorporate all the research identified on Task 4.1 through Task 4.2 and identify all other areas that need to be addressed in this research area.

Task 4 Deliverables:

- Future Transmission Planning and Environmental Research Report

Task 4.1 Adaptive Relaying Technology Development

The goal of this task is develop and demonstrate the role of automation in the protection of the electric transmission grids, necessary for implementation of energy from renewable resources - which are anticipated to be widely distributed geographically and highly variable in their energy production characteristics. This task will specifically focus upon using phasor measurement units implemented as a wide area network to collect and analyze operating data, and then implement certain management strategies that enhance transmission system stability. These operating strategies include adaptive supervision of redundant sources of supply, intelligent load shedding and damping control of low frequency oscillations.

The Contractor shall:

- Develop techniques to automatically adjust the settings of remote protective relays based on real time system measurements, to reduce the likelihood of inappropriate triggering which might increase the effects of a disturbance.

- Develop and demonstrate techniques, based upon real-time data collected from phasor measurement units that will automate the intelligent implementation of load shedding (now implemented manually when the grid is under severe stress prior to a decline in frequency). The contractor will specifically evaluate load shedding under supervisory control when significant loss of generation (as might be experienced in renewable generation) or load takes place to avoid the transmission system breaking into independently operated islands.
- Develop strategies that utilize phasor measurement units to prevent electric generator protection systems from premature tripping, which has been responsible for large-scale cascading failures, in the recent past. This task will specifically focus upon the ability of the PMU to accurately monitor the Thévenin impedance of the system (as seen from the generator terminals) its contribution to shrinking the steady-state stability margins and its impact upon transmission system relays.
- Investigate the application of phasor measurements for damping of low frequency oscillations in the absence of precise knowledge of the oscillations. This task will focus upon the application “collocated control” techniques, used to manage large, short-term disturbances to complex systems (such as instantaneous changes in power produced by renewable generators).

Task 4.1 Deliverables:

- Back-Up Protection Management Summary Report: Using remote phasor measurements in managing back-up protection
- Under-Frequency Load Shedding Summary Report: Algorithms and simulations developed to: prevent the use of islands while taking control actions; recommendations on load shedding and the results of extensive simulations of the chosen strategies
- Generator Protection Summary Report
- Damping Control Summary Report: Methodology to design robust damping controller using remote phasor measurements on a multi mode, multi DC line system for a large system along with suggested limits on the allowed delay
- Adaptive Relaying Technology Development Final Report

Task 4.2 Developing Tools for Online Analysis and Visualization of Operational Impacts of Wind and Solar Generation

The goal of this task is to increase the contribution of electricity generated from renewable resources, in California, by mitigating the impact that an intermittent must-take energy resource have upon the electric transmission system’s operational performance (such as voltage and transient stability), other electric generators and upon energy production costs. Online analysis and visualization tools will be developed that make power system operators aware of current ramping requirements (including load and intermittent generation ramps) compare these against available ramping capability of the online units, project the situation into the future, and suggest measures to address possible related problems. The developed tools will also predict unexpected transmission system impacts of intermittent generation on congested paths and voltage levels and reactive power margins (for following 2 to 3 hrs period).

The Contractor shall:

- Develop a detailed specification for the functions to be implemented in the analysis and visualization tool.

- Develop the methodologies needed for the functions defined in the tool specification, such as, predicting the ramps and ramp duration in real time, and evaluation of the transmission system impacts.
- Test and demonstrate these methods using CAISO system historical data, collecting comments and opinions from power system operators and advisory board members, and making necessary modifications and improvements.
- Install the tools developed around these methods in the designated control rooms within CAISO system and provide necessary training and maintenance during the initial installation and integration with other operational tools, collect feedback from operators in real time operations and make necessary modifications and improvements.

Task 4.2 Deliverables:

- System Specification and Development Plan
- Test Specification
- Beta version of operational tool (software) that will interact continuously with CAISO EMS
- Training manual and operator evaluation methodology
- Developing Tools for Online Analysis and Visualization of Operational Impacts of Wind and Solar Generation
- Final Report

Task 5.0 Technology Transfer Activities

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

The Contractor shall:

- Prepare a Technology Transfer Plan. The plan shall explain how the knowledge gained in this project will be made available to the public. Key elements from this plan shall be included in the Final Report in Task 1.6.
- Conduct technology transfer activities in accordance with the Technology Transfer Plan. These activities shall be reported in the Monthly Progress Reports.
- Fact sheets shall be developed for all projects conducted under this agreement. Prepare fact sheets within 30 days of the start of any project activities on each transmission research project or subjects unless otherwise exempted in writing by the CCM and the Commission Team Lead. All fact sheets will be updated every 6 months and must be approved by the CCM and the Commission Team Lead.

Deliverables:

- Technology Transfer Plan
- Copies of presentations and/or papers presented at appropriate state, national and/or international conferences
- Copies of fact sheets developed on research efforts