

EPRI Solar Thermal Hybrid Demonstration Project at a Pulverized Coal Plant

Overview, Value, and Deliverables



OVERVIEW

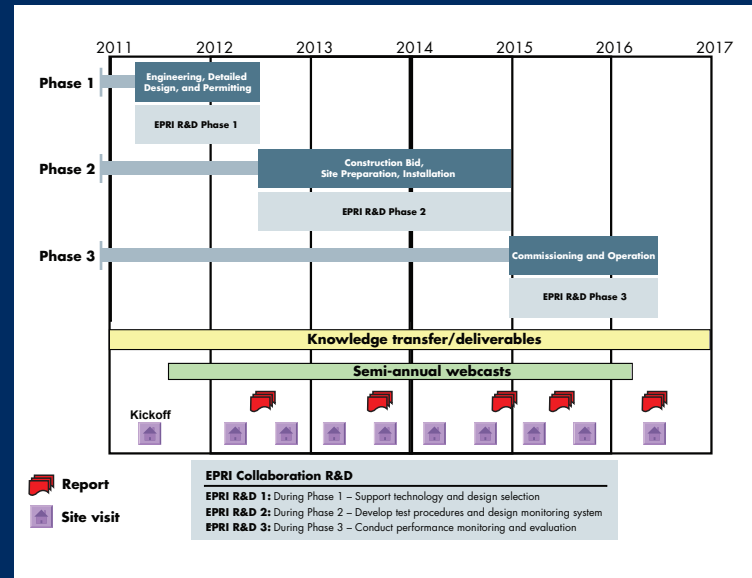
The impetus to reduce CO₂ emissions and meet renewable portfolio standards has led power project developers to consider solar thermal hybrids, wherein steam generated from solar collectors is fed into the steam cycle of a fossil-fueled generating unit. Combining the two types of generation within a single power cycle capitalizes on the strengths of both:

- The combination of fossil and solar generation ensures dispatchable power is available to the grid at all times.
- Solar thermal hybrid technologies potentially can help meet renewable portfolio standards and CO₂ emissions reduction goals at a lower capital cost than stand-alone solar plants because the existing power block and other generation infrastructure can be used.
- Siting solar technology at an existing fossil plant site can shorten project development timelines and reduce transmission and interconnection costs.
- Solar thermal augmentation reduces fossil plant emissions and fuel costs per MWh generated and may help increase plant output during times of peak demand.

These advantages have led the Electric Power Research Institute (EPRI) to form a collaborative to support a solar thermal hybrid demonstration project at a pulverized coal plant.

EPRI plans to work with Tri-State Generation and Transmission Association as the host of the project, which entails integration of a nominal 36-megawatt (MW) solar concentrator field into the existing 245-MW Escalante Generating Station in Prewitt, New Mexico. The detailed engineering phase of the project is scheduled to start in 2011 and it is anticipated that a parabolic trough, central receiver, or linear Fresnel solar collector system will be used. Once completed, it will be the first large-scale application of solar integration with a coal plant. The Escalante Station application also is unique in that it currently supplies low-temperature steam to a nearby paper mill. In addition to providing steam for the power cycle, the solar field may supply the paper mill load, thus restoring plant generation capacity.

The project is a follow-on to an earlier EPRI study in 2009-2010, which assessed the feasibility of integrating solar thermal steam into existing coal-fired plants. The earlier study determined that several solar integration options—ranging from saturated steam for feedwater heating to high-pressure superheated steam for main steam augmentation—are



Proposed Project Timeline

The table above shows the planned project R&D timeline and scheduled deliverables.

available to the Escalante Station. Main steam augmentation was selected for additional analysis that included modeling of the expected performance, estimation of the incremental system costs, and a cost-benefit evaluation of the investment under various financing structures, incentives, and market conditions.

“Tri-State is investing in leading research in a number of innovative renewable energy technologies that bring value to our member cooperatives,” said Ken Anderson, Executive Vice President and General Manager at Tri-State. “We are intrigued with the positive results of EPRI’s solar augmentation study that was conducted at our Escalante Generating Station and we are extremely interested in further exploring the practical application of this breakthrough technology that could further advance the efficiencies at one of our existing facilities.”

“This new project will seek to demonstrate a near-term and cost-effective way to use solar energy at commercial scale,” said Carolyn Shockley, Vice President of Generation at EPRI. “This is a key step along the road toward taking full advantage of technologies to lower the industry’s carbon footprint.”

The demonstration project is organized in three phases. Specific tasks and activities during each phase are designed to make maximum use of EPRI's capabilities and offer the greatest benefits to funders:

Phase 1, the Design Phase, includes design, siting, and permitting, and is expected to take approximately one year. EPRI will review the proposed design (including the solar field, control system, and integration into the steam cycle) to help ensure the solar thermal system will meet intended cost and performance targets without negatively impacting the plant's operating performance and reliability, availability, and maintainability (RAM). EPRI also will provide support for permitting activities.

Phase 2, the Construction Phase, is expected to take two to three years. Along with site construction activities, Phase 2 includes development of test plans for performance evaluation. The EPRI team will participate in test selection; development of commissioning, operating, and testing procedures; establishment of performance metrics; and design of the monitoring systems for the solar field and the integrated hybrid plant.

Phase 3, the Operations Phase, will encompass EPRI's testing and monitoring activities for one to two years, as needed, to capture performance and RAM data. EPRI will conduct performance evaluations and component tests. EPRI also will conduct independent economic and operating experience assessments. Results will help funders design performance test and monitoring plans for their own solar thermal hybrid plants, and should identify opportunities for improving the cost-effectiveness of integrated solar thermal hybrid systems.

PROJECT VALUE

Participants in the EPRI collaborative project can gain insight into the state of solar thermal technology development and hybrid project design knowledge, which can be applied to their own generation resource studies or future project developments. The real-world setting for the project (i.e., a plant operating in a commercial dispatch environment) provides a significant opportunity for learning and for verifying performance model predictions.

The demonstration project will provide:

- Detailed insights into solar thermal technologies and their integration with pulverized coal plants

- Independent assessments of plant technology and economic performance
- Access to project reports, best practices, plant data, and other materials
- Timely knowledge of the project through site visits, webcasts, and access to project experts
- Identification of opportunities for future performance and cost improvements, as well as risk reduction
- Procedures for solar plant performance monitoring and evaluation

DELIVERABLES

Table 1 presents the deliverables anticipated from the project, while Table 2 presents examples of the types of information which will be developed by the project.

Kickoff Meeting

A kickoff meeting will be held in 2011 to introduce collaborative funders to project personnel (Tri-State, solar technology supplier, and EPRI team), confirm project objectives, and review the plan of action. The kickoff meeting may be coupled with a visit to a solar technology supplier's facilities or the project site.

Webcasts

EPRI and its partners (Tri-State and solar technology supplier) will hold two webcasts annually to provide funders with information on project accomplishments and technical findings on (a) system integration and performance, (b) challenges encountered and their resolution, and (c) operational issues (following startup).

Site Visits

Site visits will occur twice a year beginning in the second year of the project, nominally spaced in even intervals with the webcasts (i.e., a webcast or site visit will occur roughly every quarter). The site visits afford the opportunity for more detailed technical updates and firsthand observations of the integrated solar-coal plant systems in operation. Engineers from EPRI, Tri-State, the solar technology supplier, and possibly A&E contractors will be on hand to answer questions. Both process design/construction and operations/test groups will be represented. During the site visits, the project host and solar equipment supplier will share their experiences and lessons learned as well as performance and RAM results.

Project Reports

Each participant will receive the reports listed in Table 1 (based on non-proprietary information) covering the full spectrum of the project’s phases.

Project Schedule

The anticipated project schedule (above) shows the relationship between project development activities and the related EPRI R&D. The final schedule will depend on the pace of development by the project host.

Table 1. Deliverables for the Solar Thermal Hybrid Demonstration Project

Item	Key Content	Timing
<i>Meetings and Webcasts</i>		
Kickoff meeting	Provide the schedule and plan and assure that collaborative funders are fully informed on the project	Project start
Webcasts	Project status, issues/resolution (technical and programmatic), performance results (solar steam contribution, plant heat rate improvement, operability, etc.). Primary focus on integration issues, but will include available data or experiences related to the solar field.	A minimum of 2 per year after the kickoff meeting
Site visits (combined with project review meetings)	In-depth technical updates, observations of solar field operation with the plant, and opportunities for in-depth dialogue with demo team	Twice per year starting in the second project year
<i>Reports</i>		
Project design report	Plant design characteristics (including solar technology, integration approach, etc.); considerations in technology selection; permitting issues; etc.	Provided after the design phase
Test planning report	Procedures for testing during commissioning and operations	Provided after test plans are developed
Construction report	Construction activities; major as-built modifications to design; construction lessons learned	Provided after the construction phase
Commissioning report	Results from pre-operational testing, including comparison with expected results	Provided after completion of commissioning
Operations report	Results from plant performance testing/monitoring during first year of operation; technical and economic analysis of plant performance	At the end of the project

Table 2. Examples of Information Types to be Developed

Type	Process Information
Plant Design	<ul style="list-style-type: none"> • Site characteristics and constraints • Technology selection process and criteria • Design approaches considered • Cost-benefit analysis of integration approach • Modifications to steam cycle including turbine and BOP equipment • Site layout and photographs • Process description (including process flow diagrams, P&IDs, etc.) • Process monitoring, control, and instrumentation • Performance targets • Estimated capital investment and O&M costs
Permitting Issues	<ul style="list-style-type: none"> • Permits required • Environmental considerations • Challenges encountered and lessons learned
Construction	<ul style="list-style-type: none"> • Project schedule • Site preparation • Solar field construction plan and timeline • Balance-of-plant construction (solar steam generator, pumps, tanks, etc.) • Construction progress photographs • As-built process diagrams characterizing flow streams at selected partial and full loads with and without varying levels of solar augmentation • As-built budget and schedule (including changes from plans) • Lessons learned from construction
Commissioning	<ul style="list-style-type: none"> • Testing procedures for solar field and integrated plant • Pre-operational test results (direct normal irradiation, solar steam flow rate, temperature and pressure into the steam cycle, plant steam cycle conditions, electricity generation, changes in fuel use and emissions, etc.) • Time for solar field to come online each day • Plant operational characteristics and constraints • Assessment of actual vs. design performance • Lessons learned (including control and integration issues)
Operational Performance & Experience	<ul style="list-style-type: none"> • Comparison of actual O&M requirements and costs with expected values • Plant technical, economic, and environmental performance based on independent testing • Reliability and availability estimates with equipment failure analysis • Performance for different operating modes (including startup, planned and forced shutdowns, cloud transients, and normal operation) • Opportunities for cost reduction and performance improvement through O&M adjustments, design modifications, operational techniques, etc. • Overall lessons learned and best practices

CONCLUDING REMARKS AND CONTACT INFORMATION

EPRI is supporting nine industry technology demonstrations as part of its efforts to help develop a “full portfolio” of technology approaches needed to make substantial CO₂ emissions reductions while minimizing economic impacts. EPRI’s Prism and MERGE analyses (available at www.epri.com) found that deployment of a full portfolio of advanced technologies, including carbon capture and storage, could reduce U.S. electric sector CO₂ emissions by 2030 to a level below 1990 emissions.

Contact Information

For more information on the **Solar Thermal Hybrid Demonstration Project at a Pulverized Coal Plant**, please contact:

Andy Maxson at 650.855.2334 (amaxson@epri.com)

Cara Libby at 650.855.2382 (clibby@epri.com)

Or contact the EPRI Customer Assistance Center at 800.313.3774 (askepri@epri.com).

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3420 Hillview Avenue, Palo Alto, California 94304-1338 • PO Box 10412, Palo Alto, California 94303-0813 USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com

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