ELECTRIC POWER RESEARCH INSTITUTE

Advanced Compressed Air Energy Storage Demonstration

Alabama Electric Cooperative's CAES Plant (110 MW-26 Hr).

CAES can help integrate higher penetration of Wind and other renewable resources and enable increased grid stability.

CAES plants can help reduce minimum loading issues of base load coal and nuclear plants. The major expected benefits from CAES plants will accrue from the following applications:

- Load Leveling
- Ramping
- Frequency Regulation

Achieving significant CO_2 emission reductions will require, among other things, significant grid integration of large scale renewable resources. This includes wind and solar photo voltaic generators whose output fluctuates over time. In the case of wind generators, power may be produced during unwanted off-peak time periods. Large penetration of renewable resources will require utilities to resolve the reliability challenge associated with rapid power fluctuations. Also, as new base load generation such as nuclear is brought online, it will be required to turn low value off-peak power into high value on-peak power. Energy storage systems can help resolve these issues and a storage technology ready for near term demonstration is the compressed air energy storage (CAES) technology.

The proposed project involves the phased planning, design, construction, and performance monitoring of two CAES plants. One will use below ground air storage for bulk storage (at about 300MWs with 10 hour storage) and one will use an above ground air vessel/piping system for short term storage (at about 15MWs with two hour storage).

Although a few CAES plants have been in operation, it is necessary to design, test and demonstrate an advanced CAES plant and an above-ground storage system.

Strategic Value

The proposed demonstration plants address three utility challenges:

- Converting large scale wind and other intermittent resources to firm, dispatchable resources.
- Enabling the conversion of low value off-peak energy to high value on-peak energy.
- Mitigating the minimum loading issues during off-peak time periods for base loaded coal and nuclear plants.

Technical Description

CAES plants use electricity to compress air into a storage system. When electricity is needed, the high-pressure air is withdrawn, heated via combustion and run through an expansion turbine to drive an electric generator. Compared to a combustion turbine, such plants burn about one-third the premium fuel and produce about one-third the pollutants per kWh of plant output.

CAES may utilize an underground air storage reservoir or an above ground air storage system. The turbomachinery for both types of plants use the same type of compressor and expansion turbine equipment and differ only in the utility requirements for plant size, in terms of MW capacity and in the number of storage discharge hours needed.

The goal for underground air storage systems is to verify the proper air flow rate and integrity metrics for the geologic formation used to store the high pressure air. Underground air storage systems are particularly cost-effective for bulk energy storage when the discharge time interval is three to 12 hours.

For above ground air storage systems, the project intends to determine the thermal and cyclic fatigue characteristics of the vessels or pipeline air storage system. This is a critical issue because as the air expands during the generation cycle, it cools and water deposits inside the air store, potentially causing corrosion. For this utility application, the durability characteristics of corrosion resistant materials and protective coatings used for vessels and pipes will be evaluated over time.

CAES plants using above ground air storage are easier to site but are more expensive to build than CAES plants using underground air storage.

Roles

Using a collaborative approach, EPRI and the project participants will create the framework for managing the RD&D work. The host utility, together with EPRI, will perform economic and thermodynamic trade-off analyses to size and design the plant. The host utility for each CAES plant will be responsible for plant siting, construction, operations and ownership. Also, EPRI will perform independent plant performance tests and evaluations. EPRI will develop a guidebook for CAES technology and document the lessons learned.

Project Management

This project will be completed in three phases. Phase 1 will establish the collaborative and perform CAES technical and economic analyses for each participant. During this phase participants may consider becoming a host for either CAES plant, based, in part, on the findings of Phase 1. Candidate designs and cost estimates for the advanced CAES plants will be finalized during Phase 1.

Phase 2 begins once a utility participant becomes a host for either CAES plant, construction contracts are signed by the host utility and construction begins. Phase 2 will document plant construction and lessons learned. Phase 3 will monitor performance for up to three years after plant commissioning. All project results will be included in the CAES Guidebook.

Benefits

The results of the demonstration project may provide critical information and data to make decisions when confronted with the need for energy storage solutions. Also, higher penetration rates of intermittent renewable resources could lead many utilities to evaluate the advanced CAES technology.

Technical feasibility and economic assessment of the above-ground CAES plant using vessel or pipe type storage systems may provide the industry with decision support information. It could also generate data to evaluate the advanced CAES storage options to deal with the effects of renewable generators, which produces new, stringent requirements for ramp-rate, spinning reserve and power regulation support.

Although there are many types of energy storage technologies that utilities can deploy today, advanced CAES has the potential to be a better technology solution than advanced battery or pumped hydro solutions, for storage capacities from 10 MWs to 100s of MWs, with two to 10 hours of storage. This is the range required to deal effectively with intermittent power variability, minimum loading of base units, energy management and load management/leveling issues.

CAES, using a below ground air storage system, is about a factor of 10 to 20 times less expensive than battery energy storage systems for a 300 MW capacity plant with a discharge time of 10 hours. CAES with an above ground air storage system is about 20% to 40% less costly than battery systems when the plant capacity is 15 MW with a discharge time of two hours. Also, the CAES plant has a 30 year life; whereas, after 10 to 15 years, battery plants will need to replace all their cells, increasing the cost for such plants substantially.

Pricing

For further information about the pricing of this demonstration project, please consult with an EPRI account executive.

Contact Information

For more information, contact the EPRI Customer Assistance Center at 800.313.3774 (askepri@epri.com).

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