COMBINED CYCLE COGENERATION WITH THERMAL STORAGE

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Generating Peaking Power With Ice

In Fayetteville, North Carolina there is a unique application of thermal energy storage (TES) that has peaked the interest of many in the electric utility industry. As it gets increasingly harder for summer peaking electric utilities to plan and add new generating capacity, this approach offers the potential of providing needed additional generating capacity, without many of the headaches normally associated with the construction of new facilities.

This approach integrates a combined cycle cogeneration system with TES to provide approximately 68 megawatts (MW) of additional generating capacity during the critical weeks of summer. This approach is not unique in the respect that it is the only one of its kind. In fact it is the second such project, but four times larger than its only predecessor, making it the largest ice thermal storage system in the world.

Planning For The Future

Between the period from 1976 to 1980 the Public Works Commission of the City of Fayetteville installed eight simple cycle natural gas (or oil) fired internal combustion (IC) turbines, in what was to become known as the Butler-Warner Generating Plant. The purpose of the IC turbines was to reduce expenditures for summer peaking power supplied by their local investor owned utility. At that time summer peak demand charges were approximately $28.00 per kW.

During the mid 1980’s the city’s peak demand grew at an annual rate of 4%, significantly higher than other municipalities. With future peak growth projections of 2.5% to 3%, it became obvious that some additional capacity was going to be required to meet the anticipated load projections.

In 1984 a study conducted for the commission concluded that the conversion of the IC turbines from simple cycle to combined cycle cogeneration would be cost effective. The conversion of six of the simple cycle units, incorporating three heat recovery steam generators, was completed in 1988. However, during the very high summer peaking periods the turbines were only able to produce approximately 192 MW. This was a direct result of the lower density of the air during the hot summer days.

Lacking capital for the construction of new generating facilities, the commission again was faced with the requirement for additional capacity. It was at this time that the concept of installing the ice storage system was proposed to increase the output of the turbines. The new design was to increase the plant’s peaking generating capacity by 68 MW, from 192 MW to 260 MW.

The concept was simple. By cooling the intake air of the IC turbines, the air density would be increased. The greater air density would then increase the output of the generators. To do this it was projected to require 2,560 tons of off-peak ice production per day, making it the largest ice TES project in the world.

Site Specifics

There are two basic modes of system operation, ice building (refrigeration) and air cooling (chilled water circulation). The system is designed for remote/automatic operation from a 10,000 square foot central control building.

The most notable visual feature of this $17 million project is the two 2.3 million gallon ice storage tanks. Each pre-stressed concrete tank is forty feet in diameter and 100 feet tall. Each tanks have four 655 ton ice makers located on top capable of producing 26,750 pounds of ice per hour, for a total output of 214,000 pounds per hour. The ice is made only during off-peak hours, i.e., nights and weekends. Once produced, the ice is then used to make chilled water.

Utilizing five 500 HP chilled water pumps, 36,000 gpm of chilled water is circulated to ninety-six (96) air coils located in front of the turbine inlets. Each coil has the capability of lowering the inlet air from the summer peak ambient temperature (100°F at 98% RH) to 35°F - 40°F. This decreased inlet air temperature during peak periods has the net impact of increasing generating capacity by approximately 68 MW, or 35%. Waste heat is rejected to four (4) cooling towers.

System Benefits/Economics

As a result of the construction and operation of this system, the City of Fayetteville is saving more than $3 million per year, bringing the payback for the project to less than five years. The life of the TES system is projected to be greater than 25 years.

Project benefits, in addition to the increased capacity, include:

- Improved efficiency (net heat rate of 1,572 Btu/kWh for the additional power)
- Extended life of the IC turbines
- More effective use of base capacity

Despite the enormity of the plant and system, construction was completed within fifteen months after design release. The capital cost of the thermal energy storage system was shown to be only one-half that of a simple cycle combustion turbine design of similar capacity, thereby making it very cost effective for the city and its customers.