DISCUSSION

P. Leung[1]

The authors are to be complimented for their excellent paper on a subject which is so vital for the planning and development of power plants in the decades ahead. The authors' proposed dry- and wet-peaking cooling tower systems offer an attractive option, both economically and technically, to the dry-towers-only system.

In the past several years, we have seen an exponential growth rate of technical papers written on various aspects of dry cooling tower systems for power plant applications. Although it has been recognized that a dry cooling tower is, first, a proven technology, second, has considerably less site constraint and environment impact, and third, eliminates evaporative make-up water and blowdown disposal requirements, broad acceptance of dry tower systems for power plants in the U.S. has been very slow in coming. Why? The obvious reason is that a dry tower system may cost three to four times the capital cost compared to a wet tower system, plus the attendant penalty in plant efficiency by five to ten percent. Due to the high capital intensity of power system operation and the current constraint on capital, it becomes more difficult for the power industry to justify a dry towers power plant. Another reason is that make-up water for a wet towers system is still obtainable at a reasonable price which is foreseeable within this decade.

However, questions may arise as to whether we could rely solely on the current technology of wet cooling towers and the continued availability of make-up water to meet our future power plant requirements, in light of our projected 1200–1600 coal-fired and nuclear power plants at an average unit size of 1000 MW to be added by the year 2000. The answer must be negative.

Site constraint, environmental impacts and blowdown disposal are among many factors which will greatly reduce the acceptability of wet cooling towers for future installations even with the availability of make-up water. Options other than dry-towers-only must be sought and planned *NOW*.

The authors offer a promising, practical, and viable option. In their paper, system design, major components, and control operations for several dry and wet-peaking tower systems are thoroughly explored. I wish to add the following observations:

1 The capital cost of the proposed system would be about 45–60 percent of the dry-towers-only system.

2 Little or no design modification is needed to use the commercially available low back pressure turbines.

3 In addition to fossil-fueled power plants, the proposed system is equally applicable for PWR as well as BWR nuclear turbine cycles.

4 For turbine selection, the shorter last-stage low pressure turbine blade length with smaller exhaust annulus area would prevail.

In closing, power engineers should welcome this excellent and timely paper and give special attention to its continued development in the future.

J. P. Rossie[2]

This well-written paper presents an extraordinary amount of useful engineering information on the performance characteristics of combination wet/dry tower systems. The utility industry has been reluctant to move toward dry cooling for generating plants, undoubtedly because of the increased costs and the relative novelty of the concept. The combination wet/dry tower system offers a means of obtaining operating experience with dry cooling without taking the giant step of using a 100 percent dry system, and may be the bridge which the industry requires to accept dry cooling as a common method of rejecting waste heat.

The physical separation of the dry and wet towers is one of the outstanding features of the concept presented in this paper, and should be helpful in overcoming fears that there may be fouling of the air-cooled heat exchanger surfaces from carryover of water vapor as drift from the associated wet tower. Also, the use of surface condensers, which is a departure from the European dry cooling practice of direct-contact condensing, should find acceptance with United States utility operators, since many water-treating problems are eliminated as compared to direct mixing of steam and cooling water.

Now that the necessary technical performance data on dry- and wet-peaking tower systems has been made available, the next logical step would be economic studies to determine the bus-bar production cost of electrical power with this cooling method, as compared to other methods. Of particular interest would be a study to determine whether or not there are economic advantages in using high-back-pressure turbines with the dry- and wet-peaking tower systems.

B. M. Johnson[3]

The authors have made a valuable contribution to the understanding of heat rejection systems in which the conservation of water is a major consideration. The mechanism for determining the water savings available with a combination of dry and wet towers, as a function of the heat load to be assumed by the wet tower at an arbitrary design point, has been developed.

This paper presents a logical first step toward the answer to the understanding of the larger question—what is the most cost-effective way of combining evaporative-cooling, peaking capability with dry cooling? The next step would be a study to optimize the wet tower size and the ambient dry and wet bulb temperature to be used as the design bases under a particular set of site conditions; i.e. meteorological conditions, construction costs, etc.

Such a study should logically also include a comparative cost evaluation of the arrangement proposed by this paper and alternative arrangements, such as hybrid towers, water augmented wet surface dry towers, and adiabatic air cooling.

The separate tower arrangement with the wet tower coupled to a divided water box within the condenser and the provision for switching from wet to dry service would not seem to accommodate itself to daily cycles of all-dry operation (at least with full steam temperature capacity). In order to realize the water savings projected by this paper, it would seem necessary to operate with such daily cycles of all-dry operation over a portion of the year.

W. D. Comley[4]

The authors are to be congratulated in studying the wet/dry systems based on proven and readily available designs for the equipment components.

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Separating the dry tower from the wet tower simplifies the selection of materials on the airside in the dry section since this section is not contacted by water or entrained solids.

With an integral wet/dry tower there is less flexibility in air control compared to separate towers. With separate towers the wet and dry air streams are independent of each other, which allows for finer control over wide changes of ambient temperatures.

Furthermore, separate towers permit a wider selection of manufacturers. The integral wet/dry tower is confined to a few suppliers whose installations have limited long term operation. Using components which have had wide usage is an important consideration with respect to the need for proven reliability.

Series operation requires circulating the wet cooling tower water through the dry tower. Whereas this requires more surface in the dry section compared to using clean water, it should be noted that the difference in surface will not be a large percentage. This is due to the fact that the surface in the dry tower is mainly controlled by the air side resistance. Increases in water fouling do not have as large an effect on the finned surface of a dry tower compared to bare tube surfaces where usually the fouling resistance is a much greater percentage of the overall resistance.

Fouling by the wet cooling tower water can be kept to a minimum if high velocities are maintained in the tube circuit.

The paper presents the advantages and disadvantages of each system. However, from an overall standpoint, the series design appears to be the simplest.

Although several types of systems have been presented, it is important to remember that each plant site will require studying various arrangements in order to arrive at an optimum design.

Authors' Closure

The authors wish to thank the four, authoritative, discussors, for their objective critiques and comments which are invaluable contributions to the paper.

Leung's observations are particularly welcome as he speaks with first-hand knowledge of industry's problems. He has studied the economics and performance of many power plant cooling systems and his experienced views and technical abilities are widely respected in the industry.

Rossie's extensive studies and reports for the EPA, AEC, and ERDA in the field of wet and dry cooling tower systems are known by all who deal with power plant heat sinks. His suggestions for the "next logical step" are already underway, although much still remains to be done. The industry challenge is the development of the alternative economic-optimum designs and arrangements of dry and wet-peaking cooling systems. There is no one answer that will fit every situation.

Johnson's work at Battelle as Consultant to ERDA affords him the opportunity to explore many technical aspects of cooling systems. Johnson raised several important points on which we would like to comment. First, the "design point" is not "arbitrary" but a careful, economic, determination. The design point for a summer-peaking utility system is:

1 A maximum average-summer dry-bulb temperature (and a corresponding wet-bulb temperature) that may or may not be exceeded for a very short time period.
2 A maximum turbine exhaust pressure at full load that will not be exceeded (manufacturer's limit) during the design dry-bulb temperature.
3 A heat-load split between the dry and wet cooling towers such that it will allow the wet tower to consume its allotted hourly or annual makeup water quantity. This design heat load split is found by trial and error.

Johnson's second point concerns switching the wet tower condenser section into dry tower service. If the wet tower size is say 50 percent or less, its condenser section could be left undisturbed (Fig. 16) without much penalty. If the wet tower size is much above 50 percent, then the valve switching would be done automatically (without operator attention) twice a day; once in the morning when bringing in the wet tower and once in the late afternoon when removing it from service. The other design alternative would be to use a nondivided water box arrangement as described in the Conclusions section.

Comley's expertise in heat transfer plus a lifetime of experience in this field makes his views most valuable. His comment about "separate towers permit a wider selection of manufactors" is particularly pertinent. Our proposed system with its separate-structured cooling towers allows the dry tower manufacturers and the wet tower manufacturers to individually offer their best, field-proven, designs. It stimulates price and product competition amongst a larger number of manufacturers, thereby benefiting the purchasers and users. Comley's comments about Series operation with a nondivided water box is another arrangement which should be evaluated as we suggested in our Conclusions section. We wholeheartedly agree with Comley's last statement which is that each plant site should be studied and its optimum design and arrangement determined.