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ACTIVITIES REPORT

BENEFICIAL USES OF WASTE HEAT
COVERING ORNL ACTIVITIES
THROUGH DECEMBER 31, 1972,
IN THE JOINT AEC(ORNL)—TVA PROGRAM

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MASTER

OAK RIDGE NATIONAL LABORATORY

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ABSTRACT

Under a cooperative program established between the Atomic Energy Commission and the Tennessee Valley Authority, the Oak Ridge National Laboratory is participating with the TVA on a project to demonstrate the use of waste heat from a steam-electric power plant. The demonstration will require the construction of a large (approximately one acre) greenhouse which will be heated and cooled by reject heat from the Brown's Ferry Nuclear Plant. In order to procure engineering and agricultural information necessary to the design of the Brown's Ferry facility, a 2500 square foot pilot research greenhouse has been designed and erected at the TVA Muscle Shoals Facility. Initial operation of the pilot research facility will be in the spring of 1973.

INTRODUCTION

A recognized component of the widely discussed "Energy Crisis" is the need to examine ways of improving the use of energy presently being generated. In the generation of electrical power, significant quantities of energy are rejected as waste heat to the environment. Preliminary studies at the Oak Ridge National Laboratory and elsewhere indicate that some of the low temperature energy now rejected as waste heat directly to the environment might be used productively in a variety of ways. One way which appears attractive would be the heating and cooling of enclosed structures devoted to agricultural or aquacultural activities.

In preliminary work carried out at ORNL under the Housing and Urban Development Program, we examined the use of waste heat for heating and cooling a greenhouse.¹ The results of these early analytical studies indicated that waste heat (100°F or below) from a steam-electric power plant might be successfully used in such an application. A feasibility experiment was conducted at ORNL using a small existing greenhouse as a test facility. A bank of evaporative pads was installed along with a fin-tubed coil downstream of the pads, and the system was connected to the adjacent Ecology Building's air conditioning system cooling tower, so that warm water normally fed to the tower could be diverted to the greenhouse. The system was operated for approximately a one-year period during which time the warm (70 to 110°F) water was used to successfully heat and cool the facility as required.

Although this early work qualitatively determined the sense of the concept, the quantitative data obtained in the program was limited and we recognized the need for a more comprehensive experimental test program. One of the first needs identified was for the development of better engineering information including information on the performance of the evaporative cooling pads.

Interest in waste heat utilization also existed within the Tennessee Valley Authority organization since their power plants are large sources of waste heat. Results from our preliminary analytical studies and from the feasibility experiment were sufficiently encouraging, that discussions were begun with the TVA on a possible collaborative effort. In the spring

of 1971, a joint program in cooperation with the Agricultural Development Division of the Tennessee Valley Authority was initiated to investigate, design, and develop a demonstration greenhouse for utilization of waste heat from the Brown's Ferry Nuclear Power Plant presently under construction by the TVA.

In the joint program it was agreed that ORNL would be responsible for providing the conceptual design and engineering requirements for the facilities considered within the program. Specifically, particular attention would be given to heat loss and heat gain from the greenhouse and the requirements for heating and cooling the structure. ORNL agreed to help prepare the necessary specification for bid proposals and to aid TVA in reviewing the technical proposals.

The scheduled startup time for the Brown's Ferry Power Plant, together with unresolved engineering and agricultural questions regarding the performance of a demonstration size greenhouse, led to the decision to design and build as a pilot plant a smaller experimental research greenhouse at the Muscle Shoals Facility of the Agricultural Development Division before committing the larger Brown's Ferry facility. In support of this effort, the Laboratory prepared specifications for all major components and reviewed all vendor drawings supplied for the pilot greenhouse and other equipment. ORNL developed the conceptual design of an evaporative pad and fin-tube system for this installation and prepared a process water flow sheet including a hot water heater and feed pump system to supply waste temperature water to the greenhouse. The Laboratory prepared requirements for instrumentation for the control system and reviewed vendor proposals on the system. ORNL also prepared a tabulation of data that will be required in the engineering performance tests of the pilot facility and will cooperate in conducting the tests.

The TVA was responsible for final approval of the proposed design, procurement of the greenhouse, for construction, preliminary agricultural information, and crop marketing studies required to determine the best methods for utilizing the pilot facility. TVA will operate the facility to obtain information on both engineering performance and crop production. The information will be used in the design of the larger Brown's Ferry greenhouse.

Few demonstration programs or experiments have been conducted using either waste or low-temperature heat for greenhouse applications. The University of Arizona, together with the University of Sonora, has, for a number of years, been operating an experiment using sea water at approximately 80°F for heating and cooling greenhouses in experiment stations at Puerto Penasco in Sonora, Mexico, and at Tuscon, Arizona. Heat utilization is only one component of that particular program and one of their major objectives is to demonstrate the rational use of water in desert areas through enclosed environment agriculture. Supplemental heat can be provided to their greenhouses from the blowdown of a desalting facility at the station.

A small greenhouse experiment conducted under the sponsorship of the Niagara Mohawk Power Company investigated the use of heater water for soil heating, evaporative heating, and "dry heating" for greenhouse application. Although several small vegetable crops were raised in this experiment, no agricultural research work was carried on.

No demonstration projects using waste heat from steam-electric power plants for heating or cooling an operating greenhouse have been conducted, although such applications are under study at a few locations. The current ORNL-AEC-TVA program is directed towards such a demonstration.

EVAPORATIVE PAD TEST FACILITY

One of the early ORNL concepts proposed for heating and cooling a greenhouse envisioned the use of a bank of evaporative pads through which the heated discharge water from the power plant would be circulated. Literature searches carried out for experimental data on which to base early analytical models of pad performance,¹ and subsequent discussions with the evaporative pad manufacturers, revealed a dearth of experimental data, particularly for the liquid-film heat and mass transfer coefficients. Instrumentation available in the small ecology greenhouse feasibility experiment and limitations on the use of that facility precluded the gathering of accurate data on the performance of the evaporative pads. In addition to heat and mass transfer characteristics, there was a need

for air pressure drop data (since fan size and operating cost are functions of Δp) and a need to determine when water flooding of the pads occurs. Further, we recognized the need to compare the aspen pads proposed in the ORNL concept with alternate pad materials to see if materials with better performance features could be found. For the above reasons, a simple evaporative pad test facility was designed and constructed at ORNL.

Facility Description

A test facility for determining the thermal and hydraulic characteristics of evaporative pad materials and configurations was designed and fabricated to accommodate pad configurations up to 35 in. by 96 in. The facility is shown schematically in plan in Fig. 1.

The system functions as follows: Air drawn from two possible inlets, flows through a bank of electric heaters and a baffle screen that serves as a flow straightener as the air approaches the evaporative pad. A fan, located downstream of the pad, discharges the air into a 24-in.-diam duct containing an air flow measuring station. The duct discharges into an outlet plenum which in turn discharges outside the building.

Because the pads within a greenhouse will operate at times with inlet air under nearly saturated conditions, pad characteristics had to be tested under these conditions. To provide for inlet air humidification, a short section of 30-in.-diam ducting containing disc and doughnut baffles and a header for injecting steam to control the moisture content of the inlet air was installed. Inlet air could be admitted through this ducting or through an adjustable 24 in. by 96 in. door which admitted building ambient air to the test section. Air flow through the facility was controlled by throttling at these inlets.

To control the inlet air temperature to the pads, a bank of six finned, tubular electric heaters with a rated capacity of 48 kW was installed. Power input to the heaters was controlled by Variac auto-transformers. An air flow measuring station was installed in accordance with the ASME Power Test Code for Fans. The station was installed in a straight section of the 24-in.-diam galvanized steel ducting located immediately downstream

Fig. 1. Schematic Plan of Evaporative Pad Testing Facility.

of the fan. Horizontal and vertical velocity traverses were made across the duct using a calibrated hot-wire anemometer and the resultant profile was integrated over the area of the duct to determine the air flow rate.

A schematic of the water system feeding the evaporative pad is shown in Fig. 2. The system could be operated as either an open or closed system or as a combination of the two. As an open system, the building hot and cold water were mixed in a thermostatically-controlled mixing valve to obtain the desired feed water temperature to the pad. Total water flow was manually controlled by a throttling valve in series with two flowmeters to provide flow measurement ranges of 0.4 to 4.3 gpm and 1.8 to 17.6 gpm. The water was fed to a distribution header at the top of the evaporative pad from where it was sprayed on to a baffle to insure a more uniform flow across the top of the pad. The water was collected at the bottom of the pad in a return gutter and returned by gravity to a drain pan that emptied to the building drain.

When operating as a closed system, the valve to the building drain was closed, the valves in the inlet hot and cold water lines were also closed, and water was recirculated from the drain pan back to the mixing valve by a canned-rotor centrifugal pump. A combination of the closed and open systems was possible when supply water was mixed with the recirculated water at the mixing valve and the excess makeup water passed out the overflow line in the drain pan.

Instrumentation was provided in the facility for measuring temperatures (air and water), flows (air and water), and differential pressures (air) across the pad. Twelve chromel-alumel thermocouples were connected to a 12-point recorder and used for control information only and not for data purposes. An additional 12 calibrated chromel-alumel thermocouples, in conjunction with a precision potentiometer, were used for data purposes. Several calibrated thermometers were fitted with wetted wicks and used for measuring wet bulb temperatures. (Two recording hygrometers were installed for humidity measurement, but their accuracy was insufficient to provide useable data.) As previously mentioned, air flow was measured with a hot wire anemometer and water flow with Rotameter type flowmeters. A micro-manometer was used to measure the air pressure drop across the evaporative pad and a mercury barometer measured atmospheric pressure.

Fig. 2. Schematic of Water System of Evaporative Pad Testing Facility.

Since some temperature data were taken downstream of the fan where the air is well mixed, power input to the fan was measured with a watt-meter to provide data for the necessary temperature corrections. Protection of the test loop was provided by a number of emergency sensing circuits and shut-off systems.

The facility was operated principally by three successive groups of graduate students from the MIT Chemical Engineering Practice School at ORNL during the period of November 1971 through April 1972.

Test Results

Two pad types were studied: (1) a standard aspen fiber unit 2 in. (thick) by 33 in. (wide) by 7 ft (high) and (2) a polyurethane (ten pores per in.) unit 1 in. (thick) by 33 in. (wide) by ~7 ft (high). Data were taken to evaluate air-film heat and mass transfer coefficients, liquid-film heat transfer coefficient, and air pressure drop. Certain other quantitative and qualitative observations were made. A cross-flow computer simulation was written to model the pad performance and to analyze the data from adiabatic cooling tests to obtain the liquid-film heat transfer coefficient. A listing of this program is found in ORNL-MIT-148. Three reports,²⁻⁴ one of which is still in press, present the detailed information on the tests conducted. A summary of results and conclusions is given below.

Aspen Pads

1. The air-film heat and mass transfer coefficients increase in direct proportion to the air flow rate (per unit face area), are essentially independent of water flow rate, and are weakly temperature dependent. A typical example of the heat transfer data taken for adiabatic cooling runs on the aspen pads is shown in Fig. 3. The correlations obtained are:

$$h_g a_H \text{ (Btu/min-ft}^2\text{-}^\circ\text{F)} = 1.05 G^{0.99} L^{-0.025} \exp(0.01 T_{GF})$$

and

ORNL DWG. 73-3830

Fig. 3. Heat Transfer Coefficients as a Function of Superficial Air Mass Velocity.

$$k_g a_M (\text{lb}_m/\text{min-ft}^3) = 4.27 G^{1.0} L^{-0.015} \exp(0.009 T_{GF}) ,$$

where

h_g = local air film heat transfer coefficient, Btu/min-ft²-°F

a_H = area of air-water interface per unit volume for heat transfer, ft²/ft³

G = superficial air mass velocity, lb/min-ft²

L = superficial water mass velocity, lb/min-ft²

T_{GF} = air film temperature, °F

k_g = local air film mass transfer coefficient, lb/min-ft²

a_M = area of air-water interface per unit volume for mass transfer, ft²/ft³

2. The liquid-film heat transfer coefficient is a moderate function of air flow rate and a weak function of both temperature and liquid flow rate. The latter suggests that flow is in the laminar mode in a thin film along the fiber and that increasing the flow rate up to the flooding point does not promote mixing or turbulence. Turbulence would cause a substantial decrease in liquid-film resistance. The correlation was:

$$h_L a_H = 2.46 G^{0.4} L^{0.15} \exp(0.01 T_{LF}) ,$$

where

h_L = local liquid film heat transfer coefficient, Btu/min-ft²-°F

T_{LF} = liquid film temperature, °F

3. Flooding occurred at a liquid flow rate of ~3.3 gpm/ft (of pad width). (The test was conducted at a maximum air flow rate of ~227 cfm/ft².) This confirms earlier predictions that a value of 3 gpm/ft is a realistic maximum water flow limit. Flooding was qualitatively determined as the flow at which significant streams of water could be observed running down the face of the pad and not distributing across the pad material.
4. Air pressure drop ranged from about 0.02 to 0.1 in. of water over the range of air flow rates tested. These values will be higher for a dirty pad. The variation with air flow was approximately as $G^{1.6}$. Pressure drop was relatively insensitive to water flow rate. Typical data is shown in Fig. 4.

Fig. 4. Air Pressure Drop Across Evaporative Pads as a Function of Air Flow Rate.

5. For the conditions tested, air was leaving the pads with relative humidities in the range of 78 to 82% and the water temperature drop on a once-through basis was about 60 to 70% of that theoretically possible. It should be noted here that the tests were carried out within a relatively narrow range of ambient air conditions (in the vicinity of 83°F, 40% RH), and the above results may not apply at extremes of high or low temperature or humidity. Limitations on inlet temperature and humidity were determined to a large degree by the use of ambient building air as the source.
6. Generally, the mass transfer coefficients are very high and thus the heat transfer capacity appears to be limited by air-film heat transfer. The latter coefficients are consistently lower than the liquid-film heat transfer coefficients.
7. For seven different test cases the computer model developed for pad performance predicted the air outlet temperature to within 0.4% and the water temperature to within 0.6% of the experimentally measured values. These discrepancies are about two to three times the estimated experimental error in temperature measurement, but are still well within acceptable limits for design purposes. The model used for pad performance prediction is described in more detail in Ref. 2. Because the calculations are based on the enthalpy difference of the air through the pad relative to saturated air conditions, the program model is not applicable for saturated or super-saturated air (fog).

Polyurethane Pads

1. The air-film heat and mass transfer coefficients were very similar in magnitude to those for the aspen pads under the same conditions. The functional dependence on air flow rate was not as strong, however, and the temperature dependence could not be correlated.
2. The liquid-film heat transfer coefficient appears to be less than for the aspen pads. This may be due to uneven water distribution caused by the non-wetting characteristic of this pad material.
3. Flooding occurred at about 4.2 gpm/ft or ~27% higher than for the aspen pad (which is twice as thick). Per unit of water flow area,

flooding occurred at $\sim 430 \text{ lb}_m/\text{min-ft}^2$ versus $\sim 170 \text{ lb}_m/\text{min-ft}^2$ for the aspen pad. It is possible that a redesigned water distribution header would raise the flooding point even above the observed value.

4. Air pressure drop was greater at all flow rates than for the aspen pad, being on the order of two to three times as great at the higher flow rates of interest (see Fig. 4). Pressure drop also had a stronger functional dependence on air flow being approximately $G^{2.0}$. Unfortunately, no improvement in performance accompanied this higher pressure drop, as would be expected in a more conventional heat transfer apparatus. This would tend to indicate that the cellular structure of the polyurethane, in conjunction with its non-wetting property, combines to make a significantly less effective heat and mass transfer system (per unit of fan work) than the fibrous wettable aspen material.

Future Experimental Pad Research

The heat and mass transfer coefficients can be increased by an increase in the air flow rate per unit of pad face area (i.e., air face velocity), especially since for the aspen pads pressure drop is low (e.g., $\sim 0.06 \text{ in. H}_2\text{O}$ at 150 cfm/ft^2 and maximum water flow rate). Since this is done at the expense of fan size and power, the economic trade-off, which includes initial capital costs and operating costs, must be determined. At higher air flows the water should more nearly approach the air wet bulb temperature. If tests demonstrate that the air is not approaching saturation as rapidly as the water approaches wet bulb, the water flow rate can be increased per unit of air flow area. This could be done, for example, by putting two vertical pads in series to form, effectively, a 4-in.-thick pad.

The results to date indicate that future research should concentrate on wettable material such as aspen. Little or no data on other materials was found in the literature.

Although there is no evidence of such a problem at the air velocities tested, at higher air velocities moisture carryover may occur. This could be a problem if the water source is from cooling towers. (TVA now plans towers for the Brown's Ferry Plant.) Conventional water treatment methods

for cooling towers commonly employ chemical additives such as chromates and algaecides. If extensive droplet carryover were to occur from the pads at high air velocities, the chemicals within the liquid could be detrimental to crops. However, our preliminary experience and experience from operation of the University of Arizona Greenhouse with seawater, indicate that this will not be a problem. An investigation will be required to determine the upper limit on air velocity before carryover becomes significant.

To date, pads have been tested only in the vertical position. Improved pad performance might be possible and more economic use of greenhouse area probable, with other pad orientations. Pad performance should be examined with pads set at an angle (e.g., 45°) or when horizontal. This could have important application in controlled-environment enclosures using the inflated plastic design. These structures normally do not have the necessary room at the perimeter to accommodate an 8-ft vertical pad.

In order to predict the performance of the evaporative pads with saturated or supersaturated air (fog) conditions, a modification of the present program is necessary. Saturated conditions are expected to prevail in a greenhouse during the winter when the interior air is continuously recirculated through the pads. The present simulation depends on a differential enthalpy driving function between air through the pads and the air enthalpy at saturated conditions.

MUSCLE SHOALS GREENHOUSE

ORNL work contributing directly to the design and construction of the pilot greenhouse at Muscle Shoals fell into three principal categories: (1) the preparation of specifications for purchasing of the external structure and internal components, (2) the process flow system design, and (3) recommendations for the control system design.

Greenhouse Structure

ORNL prepared specifications or detailed descriptions for the greenhouse structure, a hot water supply (to simulate the waste heat source), the fin-tube heat exchanger (for humidity reduction), the evaporative pad unit, and several other minor components. The principal components are shown in schematic arrangement in Fig. 5.

The greenhouse structure is a modification of a standard Lord and Burnham design, 25 ft wide by 100 ft in length with an 8-ft high eave. Figure 6 is a photograph of the external structure. The roof is supported by aluminum trusses, the bottom chord of which supports a polyethylene sheet to form an attic plenum for air recirculation as seen in Figs. 5 and 7. All glazing is fixed in place. Inlet louvers at one end of the house allow ambient air to be drawn through the evaporative pads and pass downstream, across the fin-tube heater coil. If the inlet and outlet louvers are closed, air from the attic is recirculated through the greenhouse and returned to the attic. Two fans, located in enclosed cubicles at the far end of the greenhouse from the pads, draw air through the house. Each fan is a two-speed unit capable of delivering 18,000 cfm at 0.125 in. of water gage. Downstream of the fans are plenums with exhaust and recirculation louvers to control the direction of air flow. The hot water supply system and two instrumentation and control cabinets are located inside the greenhouse near the fin-tube heat exchanger.

Heating and Cooling Flow Systems

Air passing across the aspen pads will be heated or cooled depending on the entering air wet and dry bulb temperature relative to the supply water temperature to the pads. The water passing down the pads is evaporatively cooled in a bank of eight vertical pads approximately 7 ft high, 23 ft wide, by 2 in. thick. The pads are located approximately 5 ft from the inlet louvers of the greenhouse.

Fig. 5. Schematic of TVA Waste Heat Research Greenhouse.

Fig. 6. External View — TVA Waste Heat Research Greenhouse at Muscle Shoals
Showing Inlet Louvers.

Fig. 7. Interior View — TVA Waste Heat Research Greenhouse Showing Attic Plenum and Fans.

To provide dehumidification* and supplementary sensible heat transfer to the air in cold weather, a bank of fin-tube heater coils is installed about 5 ft downstream of the evaporative pads. The coil consists of 40 1-in.-OD x 18 BWG copper tubes with 5/8-in.-high aluminum fins (nine per inch). Each tube is about 20 ft long, headered at each end to form two circuits of four passes each to provide for even temperature distribution. The tube bank is about 7 ft high.

The fin-tube coil was sized by the vendor on the basis of a specified air flow of 36,000 cfm of 60°F saturated air entering the coil. It was assumed that 40 gpm of 95°F water would be available to the coil and a heat load on the coil of 70 kW was calculated as necessary to reduce the relative humidity of the air leaving the coil to 80%.

The greenhouse flow system was designed by ORNL and a process flow sheet (a schematic of which is shown in Fig. 8) was prepared for use by TVA for making installation drawings. The flow system permits accurate control of water temperature to the evaporative pads through the use of a mixing valve, shown as TCV 101 in the figure.

Water at waste heat temperature for the pads and coil is provided by a 180-kW hot water heater unit with 36 heating elements of 5 kW each connected to a ten-step controller. The mixing valve, located in a bypass line, is used for fine temperature control. System circulation is supplied by a 100-gpm centrifugal pump.

The fin-tube heater can be operated in either series or parallel with the evaporative pads depending on the dehumidification required by the system. There is also a provision for an external water supply for makeup

*The primary reason for providing the fin-tube coil in the system is to permit the addition of sensible heat to the greenhouse and thus limit the maximum relative humidity within the house. Discussions with greenhouse operators revealed the prevalent view that greenhouse operation at high humidities (90 to 100%) would increase the likelihood of propagation of disease. Though this view is not universally held, and experience with high humidity operation has been successful at the University of Arizona and TVA, the research character of this facility dictated the use of the fin coil. If subsequent high humidity experience indicates the coil to be unnecessary, it will be eliminated with a consequent simplification and reduction in the facility cost.

Fig. 8. Schematic of Process Flow Sheet for TVA Waste Heat Research Greenhouse.

(of that evaporated) plus additional water to replace any blowdown required to reduce the concentration of dissolved solids. The system has extensive provisions for equipment maintenance and for the measurement and recording of all operating data of interest.

Control System

The objective of the control system is to maintain temperature and humidity levels within the greenhouse as near the set point as possible under variable external ambient conditions and variable inlet waste heat temperatures. To accomplish this, numerous sensors are located within the growing area.

Within limits, the air temperature is controlled to the set point by automatic adjustment of the fan speed and louver position. An average of five signals from thermistors located in the growing space will activate relays to take appropriate action. An ambient temperature signal can be used to change the set point on the controller.

Humidity control action will be initiated from two gold-grid sensors, one about 5 ft from each end of the growing area along the greenhouse centerline. The controller will operate the three-way valve ($A_H CV$ in Fig. 8) to alter the water flow to the fin-tube heat exchanger.

Although the greenhouse contractor has responsibility for the control system, ORNL provided technical support throughout the evolution of the design. Our particular interest was in assuring that the necessary engineering data could be obtained which would characterize the system performance before and during greenhouse operation. Accuracy and repeatability of data were important considerations.

The Muscle Shoals greenhouse is a pilot research facility with far more sophisticated and complex equipment than is encountered in commercial greenhouses, and hence required proportionately more engineering effort. The specifications reflected the specialized nature of the TVA greenhouse as a research facility. TVA emphasized that flexibility and precision were more important than minimum cost. All specifications were reviewed by cognizant TVA personnel and every effort was made to incorporate their

suggestions and ideas and to explain the rationale behind all major equipment requirements. In the course of preparing specifications, considerable effort was expended in calculating or estimating all major design parameters for equipment to be purchased. For example, heat loss calculations from the facility for Muscle Shoals meteorological conditions were made to permit sizing of equipment such as the hot water heater. During the review of bids and after contracts were awarded, ORNL assisted in the review of vendor drawings, plans, and specifications.

CURRENT STATUS, ENGINEERING TESTS, AND LONG RANGE PLANS

Original plans anticipated completion of the pilot greenhouse in the fall of 1972 but delays have occurred in construction, in procurement of equipment, and in vendor specifications. The external greenhouse structure is complete and all major equipment components are on site. It is expected that the facility should be completed by early April 1973.

Initial operation of the greenhouse will be aimed at determining whether the control system operates acceptably under imposed perturbations. To the extent permitted by external ambient conditions, we will experimentally check the calculations and assumptions made in the design of the facility. Once agricultural studies are started, the extent of engineering tests permissible may be limited so such tests will be conducted first.

Data, principally water temperatures and air humidities and temperatures, will be obtained from the TVA greenhouse throughout the year. This will permit us to characterize pad performance through a much wider spectrum of inlet conditions than was possible in the Evaporative Pad Test Facility at ORNL. In addition, it is desirable to develop a general analytical model of a conventional greenhouse structure like the TVA facility. Temperature and humidity data within the greenhouse, in conjunction with external ambient conditions, should enable us to refine the traditional ASHRAE* greenhouse design methods.

*American Society of Heating, Refrigeration and Air-Conditioning Engineers.

Data provided by the pilot research facility will contribute significant information towards the design of a large demonstration greenhouse for Brown's Ferry. The degree of applicability of the research results from the Muscle Shoals facility to the proposed Brown's Ferry unit depend in part, however, on how significantly the design features change. It is possible that the Brown's Ferry facility may be substantially different in design. Many commercial growers are installing inflated plastic structures as a major means of reducing capital cost. The heat transmission and heat loss characteristics of a plastic structure will be different from those of a glass-glazed structure. However, the design procedures used, the confidence gained from the engineering test data gathered, the operating experience on the pilot facility, and the agricultural results obtained are essential requisites to the design and operation of the larger facility, whether it be glass or plastic.

The Brown's Ferry Demonstration Greenhouse is the first phase of a more comprehensive waste heat utilization complex being planned at the Brown's Ferry Nuclear Plant. As currently envisioned, the heat utilization complex will include, in addition to the greenhouse facility, animal enclosures heated by rejected heat, an aquaculture facility using waste heat to maintain temperatures near those for optimum fish growth, open field experiments with heated water, and waste recycling. Because the program is now only in its initial stages, the rate at which the entire program will proceed is not firm. Present TVA plans call for the development of the heat utilization complex over a period of approximately five years. At that time, they hope to have a fully integrated and operating demonstration system.

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