CENTRAL COOLING PLANT PROJECTS

As a part of ERA's regular consulting activities, the firm has made a special focus of central cooling plant projects, including chillers and chilled water distribution projects. A sampling of these assignments includes:

- **John Muir Medical Center - Central Cooling Plant Modernization and Expansion.**

  John Muir Medical Center faced a multi-part problem in 1994. The original building chillers were aging and used CFC refrigerants. Operating cost for these chillers was excessive, the total cooling capacity for the 3-phase building was fully employed on a design day (no safety factor!) and the old cooling towers represented a potential legionella threat in their original location immediately next to a main outside air intake.

  Working with the Director of Plant Services over a number of years, ERA explored numerous chiller plant modernization and expansion alternatives, including thermal storage, gas and steam-fired absorption, individual chiller retrofit and others. Finally, it was determined that replacing the original 800 ton, 2-chiller plant with modern chillers totaling 1100 tons and integrating it with the newer 400 ton plant was the most practical and cost-effective alternative available to the Medical Center. Interestingly, this project was one of ERA's early applicaitons of its ***Virtual Central Plant***™ technology!

  Given the task of designing the new plant, ERA worked closely with the Medical Center's favored mechanical contractor and developed a project combining many attractive features, including:
  - two new, R-22 (convertible to R-134a) centrifugal chillers with very high efficiency (approximately .5 kw/ton)
  - removal of existing cooling towers and creation of a new cooling tower platform (allowing the old towers to stay in service right to the cut-over point and the new platform constructed in such a way as to eliminate structural reinforcing of the roof structure, thereby completely avoiding disruption to hospital operations)
  - two new, variable-speed, oversized cooling towers to provide very cold condenser water, even on design days
  - modifications to the chilled water distribution system to allow either chiller plant to serve the entire facility independently (by means of an inter-plant, variable flow, chilled water transfer pumping system)
  - configuration of the new plant's chilled water piping to provide for a dual-loop system (separate building and chiller flow loops) and automatic switchover to a single-loop system for even greater efficiency (once the plant was completely commissioned)
  - automation of the entire chilled water operation (consisting of 4 chillers in two plants) - ERA performed the detailed final design of the control system and performed all commissioning and programming of the control system and prepared custom operator-terminal graphics to display the new plant in operation - no controls contractor was employed on this project

- temporary interconnection of the two main plants during construction so as to allow chilled water to be delivered to the entire complex during the construction period

Based on ERA's mechanical, electrical, structural and control systems design (and control panel fabrication and commissioning), the project was completed without a single during-construction change order and the plant was brought on line during the early summer of 1995 and performed in such a superior fashion that the remaining plant was able to be left off-line for the entire summer, increasing the original annual savings of approximately $50,000 by another $30,000. The project was featured in an article published in the Winter 1996 edition of *Energy and Environmental Management* (a Penton publication).

- **Marin County Civic Center - Replace Administration Building Chilled Water Plant.**

The Marin County Civic Center is a somewhat famous building, due to its unique architecture and the fact that it was Frank Lloyd Wright's last project. Facing an aging chilled water plant and the prospect of CFC abatement, the County hired ERA to perform a feasibility study for modernizing the plant. This study identified a 2-phase approach which would replace the oldest chiller plant in the complex immediately, followed, when funding became available, with the replacement of the newer plant.

Hired to implement the first phase of the project, ERA designed a plant replacement project which included:

- a new, R-134a centrifugal chiller with very high efficiency (approximately .5 kw/ton)
- a new, variable-speed, oversized cooling tower to provide very cold condenser water, even on design days
- configuration of the condenser water system so as to eliminate a small tower dedicated to a light-load chiller (the new tower will serve either or both chillers)
- conversion of the chilled water distribution throughout the complex to variable flow
- interconnection of the new and remaining existing chiller plants so as to allow either plant to support the entire complex (this was not previously possible without operation of additional chilled water pumps)
- automation of the entire chilled water operation (consisting of 5 chillers in three different locations)
- temporary interconnection of the two main plants during construction so as to allow chilled water to be delivered to the entire complex during the construction period

While following public bid procurement regulations, ERA crafted a contractor qualifications criteria which ensured that only well-qualified contractors would be permitted to submit bids on the project. The result was a trouble-free construction period, with completion of the project without any change orders in May, 1996.

The project has been so successful and trouble-free to date, that the County decided to proceed immediately with the second phase design, the Courthouse Building chiller plant, which was completed in late 1997. This project, while somewhat simpler overall, included the re-arrangement of the two series-piped chillers to parallel flow and the arrangement of

the existing 2-cell (400 tons each) cooling tower so that regardless of which new chiller is operating (300 and 500 ton machines to replace the existing twin 400 ton units) the chiller that is on line will be served by an oversized tower. This will be done by installing two large, variable speed condenser water pumps (a primary and backup, with pre-set incremental speeds to match the chillers & towers on line) and automatic valves so that a single 400 ton cell will serve the 300 ton unit, and both 400 ton cells will serve the 500 ton unit. Since the Administration Building chiller plant was oversized, only under "emergency" conditions (the inadvertent loss of the new Administration Building plant) will the new 300 and 500 ton chillers need to operate with only 800 tons of cooling tower serving them - meaning that the new chillers will be served with oversized heat rejection equipment under any mode of operation, even thought the existing (non-oversized) cooling towers will be used for the project! This feature is possible due to the innovative approach to the design and the deft employment of the existing, very capable, building automation system already in the building.

- **Sierra Nevada Memorial Hospital - Central Cooling Plant Expansion and Modernization.**

In 1992, ERA was engaged to perform a conceptual design study for the expansion and modernization of the building's central cooling equipment. Typical of most hospitals, building expansion design teams had bypassed the integration of utility systems as being beyond the scope of their purview and designed new, stand-alone, central cooling plants for each wing. With the new wing under design, the Hospital would have had a total of three plants. As suggested to the Hospital, ERA undertook to investigate how the existing plants could be restored and simultaneously expanded, both to renew the failing old equipment and provide additional capacity for the new wing. The resulting study identified a plant that could be built within the confines of the existing building, would integrate all cooling operations, provide chiller redundancy for greater reliability and would convert the entire plant to variable flow operation for improved energy efficiency. In addition, the study identified a serious system deficiency wherein small, critical HVAC systems had been added to the chilled water system without the incorporation of outside air economizers - resulting in the central plant having to run 24 hours per day, 365 days per year. A dedicated, compact chilled water system (with its own water-side economizer) was incorporated into the project to take this burden off the central plant.

ERA was subsequently engaged to perform final design on this project in a phased fashion, the first phase of which (the dedicated critical-HVAC chilled water system) was completed during early 1993 and interestingly included pre-purchasing of the chiller and it's temporary installation to support surgery (which was in desperate need of cooling due to the deterioration of the existing main plant) during the summer of 1992. ERA provided critical commissioning services for this small system, which had to be brought on line smoothly so as to prevent disruption of Cat Scan operations.

The main chilled water plant expansion and modernization phase (the bulk of the work) has was completed over the winter of 1993/94. This project included interconnection to the new building automation system and incorporated oversized heat rejection equipment to

maximize available PG&E rebates. In addition, the key equipment (chillers and cooling towers) were pre-purchased by the Owner, primarily to optimize their selection under the complete control of the Owner, separate from the construction bidding process.

As a "side-effect" of the energy retrofit and chilled water plant projects completed by ERA, ERA was also asked to evaluate digital zone controls as an option for the new wing HVAC systems. While this was determined to be attractive (since the marginal cost was small for new construction), in the process of the analysis, it was discovered that the out-of-state HVAC design engineers had configured the new wing air handling systems without outside air economizers, which would have put the central cooling plant back into 24 hour, 365 day operation! This oversight was brought to the attention of the Director of Plant Operations and immediately corrected through directed re-design of the systems.

Additional work at this facility has included design of an extension of the critical HVAC chiller system to the new outpatient wing, conceptual design of a new clinical laboratory, design of the Second Floor Nursing Consolidation project, investigation and planning of isolation room upgrade work, and investigation of indoor air quality concerns.

- **Golden Pacific Brewing - Brewery Refrigeration and Thermal Storage System.**

A major part of the new brewery that Golden Pacific Brewing built in 1997 was the low temperature refrigeration system. This glycol and water, low temperature system, designed to operate at 25°F, needed to have the flexibility to serve the cooling needs of the various process phases in the brewery, from the ice water tank, to fermenters, to bright beer tanks, to yeast propogators, to finished product storage tanks to the packaged product wharehouse. All of these process activities have varying cooling loads over time, and, at times, the total load on the plant is very small - meaning that a very flexible system was needed.

ERA responded by designing a variable flow, thermal storage system. This system included a packaged reciprocating, evaporatively-cooled chiller, a custom-fabricated storage tank (with specially designed and fabricated internal distribution headers), a custom expansion tank/make-up system, and pumped circulation loops between the chiller and the tank and the tank and the plant, with differential-pressure-based control of the plant circulation pumps.

Constructed and started up without a hitch, this portion of the process was the one part of the new brewery that performed its function flawlessly from day one.

- **U.C. Davis Medical Center - Chilled Water Distribution System Study and Remediation.**

Practically since it was first built, this 500,000+ square foot acute care hospital suffered from inadequate cooling in the summer months, with patient room (including surgery recovery rooms!) temperatures exceeding 80°F in the summer months (and frequently approaching 90°F for days at a time)! In the early 1990's, a large project was

commissioned to correct this problem, but resulted in making the situation worse, rather than better.

In 1996 ERA was engaged to perform a thorough investigation of the system. This task included preparing floor plans, isometrics and a schematic diagram for the entire chilled water distribution piping system encompassing all of the piping work performed over more than 50 construction projects over the years. These drawings were then verified/corrected in the field with the assistance of the operations and maintenance staff. Next a computer model of the piping system was prepared and this analysis clearly revealed that the use of a constant flow system with booster pumps at each air handling unit was over-pumping the water and actually causing water to flow backwards through significant portions of the piping system. The result, which explained the building's poor cooling performance, was that many air handling units were receiving warm return water instead of cold supply water to their cooling coils. ERA developed a $1,400,000 remediation plan which consisted of conversion of the entire system to variable flow, elimination of all 53 booster pumps and the installation of digital controls for the new variable speed main chilled water pumps.

This project was implemented in early 1997, with the result that the entire building was comfortable for the first time in 25 years! In addition, the few small areas in the hospital that suffered from cooling problems not related to the flow problems (inadequate airflow, undersized controls, etc.) could be focused on and resolved.

· **San Francisco Chronicle and Examiner - Construct New Central Cooling Plant.**

The San Francisco Chronicle and Examiner and their joint publisher, The San Francisco Newspaper Agency, all jointly occupy a 250,000 square foot facility at the corner of 5th and Mission Streets in San Francisco. The building had historically been occupied since the early 1900's by the Chronicle and was joined by the Examiner in the mid-60's, along with a major addition and modernization of the facility at that time. In spite of this major work and because of the mild summer weather in San Francisco, the building had never been equipped with air conditioning. The Newspaper Agency asked ERA to evaluate the facility for the addition of air conditioning, keeping both cost and disruption to operations in mind. ERA's report, delivered in February, identified four separate options for adding air conditioning to the building, ranging in price from approximately one and one-half to two million dollars. These options all included the re-use of major portions of the existing heating and ventilating equipment (air handlers and ductwork primarily) while adding a central chilled water plant in a new penthouse, chilled water distribution piping systems. installation of cooling coils in the majority of air handling units, modification of certain air handling units to variable volume (to comply with the California Energy Code), the replacement of a small number of air handling units and new temperature controls on all air handling systems.

The Owners made up their minds quickly on the 1.6 million dollar option (about 500 tons of cooling capacity) and implementation began immediately. As recommended by ERA, the project was conducted as an "integrated-design-and-construction" project. ERA commenced with final mechanical and electrical design immediately. In addition, ERA

(utilizing the detailed scope of work documents prepared as a part of the study process above) simultaneously assisted the owner in negotiating fixed price contracts with a selected team of contractors. Design was then completed with the advice and assistance of the contractor team, with final equipment selections and immediate ordering of equipment based on the contractors' most attractive price alternatives. Literally, the design was completed in phase and in tune with the contractors' most immediate needs for equipment ordering and installation details.

Technical features of the project included modification of the building electrical service to serve two new chillers with only a 4 hour power outage, a two-chiller central plant consisting of a reciprocating chiller for low load operation and a centrifugal chiller for peak load operation. The chilled water distribution system is configured as a single-loop variable flow system (without separate chiller and building circulation pumps) and all air handling systems were equipped with direct digital control systems interconnected to a central computer for monitoring and control point reset.

Final design commenced at the beginning of March and chiller start-up was conducted approximately mid-August (of the same year), bringing the project on line as projected in the initial study.

· **County of Sonoma Government Center - Central Mechanical Plant Expansion Study.**

Built in 1988, the Central Mechanical Plant serves the Administration Center, consisting of some 14 buildings encompassing over 720,00 square feet of space. Due to poor cooling performance of the plant and anticipated building expansion and new construction, ERA was engaged to investigate the plant and develop an expansion and modernization master plan.

As determined during the study, the cooling portion of this plant suffers from a number of problems, including:

- ☐ inadequate capacity
- ☐ a number of fundamental design flaws that hamper charging of the chilled water storage tank
- ☐ an unfortunate condenser heat recovery scheme that forces the chillers to operate at elevated condenser water temperatures and prevents proper heating of the buildings
- ☐ an inferior plant control system
- ☐ inadequate heat rejection system, limiting the number of chillers that can be operated simultaneously (only three of the four 250 ton chillers can presently be operated)

ERA developed a multiphase plan totaling some $3,500,000 to modernize and expnad the plant, including:

- ☐ Phase One ($1,600,000):
  - condenser water upgrade (more heat rejection capacity) and removal of the heat recovery system

- repiping of the chilled water system within the plant to greatly simplify the plant and its operation and eliminate the hydronic system flaws which hamper tank charging
- abate CFC by converting all existing chillers to R-134a
- upgrading and expansion of the digital control system and revamping of the control sequence and operating parameters of the plant

☐ Phase Two ($1,900,000):

- expand the plant building
- install a new 500 ton chiller
- install a new 500,000 gallon chilled water storage tank

As part of the study a simulation model of the plant was built using EPRI's "Cool Aid" program, which demonstrated that the the Phase One work will restore comfort while simultaneously reducing operating costs by approximately 20%. The model also demonstrated that the Phase Two work while providing an additional 900 tons of capacity, will still operate at approximately 10% less cost that the present malfunctioning plant.

In an effort to expedite immediate improvements to the plant operations, ERA was engaged immediately upon completion of the study to implement removal of the heat recovery system (complete) and expansion of the heat rejection system (underway in early 1998).

In the process of performing the expansion and modernization study of the plant, ERA determined that a serious need for restoration of air handling systems also existed. Since correction of heating/cooling mixing, defunct economizers and failed control valves had an immediate capacity impact on the now-under-capacity central plant, the County engaged ERA to perform an evaluation of the nearly 100 air handling systems on the 14-building campus. This evaluation included development of a complete inventory of equipment with pertinent technical data, observation (and photographing) of each system, identification of system deficiencies, development of restoration and/or energy retrofit needs/opportunities, budget estimates and presentation of the information in a binder-format final report. ERA is proceeding with contract document preparation for urgent system repairs and improvements pending funding of the full $3,500,000 plant modernization project.

· **Foothill - De Anza Community College District HVAC Master Plan**. The District was planning to engage a performance contractor, and needed to identify the total HVAC infrastructure renewal needs for overall budgeting purposes. For both of these purposes, ERA was hired to prepare an HVAC Master plan, which included inventorying the HVAC systems and equipment, visually inspecting same, and identifying system deficiencies. In addition, the plan included an overall strategy for future HVAC systems, including the consolidation of refrigeration machinery on the De Anza campus by applying ERA's proprietary ***Virtual Central Plant***™ technology (a melding of plant integration, automation and variable flow). In addition, a similar strategy was developed to add air conditioning to the Foothill campus. ERA ultimately identified a total budget need in excess of $10,000,000, and managed the District's engagement of a performance contractor to implement a major portion of the needed work.

- **Santa Clara University Facility Condition Assessment**. Similar to Foothill - De Anza, the University was planning to engage a performance contractor, and needed to identify the total HVAC infrastructure renewal needs as well as begin the process of consolidating HVAC and electrical prime-mover (chillers, boilers and emergency generators) in lieu of stand-alone individual building systems which were exceeding the University's ability to keep up with their maintenance and repair. For these purposes, ERA was hired to prepare a Facility Condition Assessment, which included inventorying the HVAC systems and equipment, visually inspecting same, and identifying system restoration needs. This data was assembled into a comprehensive Microsoft ACCESS database (FCAD). In addition, ERA prepared a conceptual design for the first mini-utility plant. ERA ultimately identified a total budget need in excess of $18,000,000, and managed the University's engagement of a performance contractor to implement a major portion of the needed work.