SYNOPSIS

This case describes the process of selecting and designing the heating technology for the Midfield Terminal Energy Facility at the Pittsburgh International Airport. It also discusses the importance and impact of project management in carrying out this endeavor. The case compares the widely used steam heating system with a hot water system. The author highlights the importance of realistic scheduling, budgeting, equipment selection, quality adherence, and minimization of long-term cost.

LEARNING OBJECTIVES -"PITTSBURGH INTERNATIONAL AIRPORT MIDFIELD TERMINAL ENERGY FACILITY"

In discussing this case, participants should gain a better understanding of:

- negotiation
- the relationship between quality, costing/budgeting, and scheduling
- selection from a set of options
- project schedule management

Discussion Point

- The author mentions that “many owners try to save money by minimizing engineering costs and that this often results in poor construction documents and excessive contingencies in the form of additional construction change orders to a project.

Form TWO Groups and

- <u>Debate importance of planning vs. monitoring ongoing procsses</u>

ittsburgh International Airport
idfield Terminal Energy Facility

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RNING OBJECTIVES

After studying this case, the students will further understand the impact of the following issues of project management:

- negotiation
- the relationship between quality, costing/budgeting, and scheduling
- selection from a set of options
- project schedule management.

SCUSSION QUESTIONS AND POSSIBLE ANSWERS

1. The design team was concerned with developing "real" quotations and selecting the best energy system. Which of the nine project management body of knowledge areas was used most? Describe this process.
   a. Project cost management.
   b. This process is defined in *PMBOK Guide*, section 7, as "the processes required to ensure that the project is completed within the approved budget. It consists of resource planning, cost estimating, cost budgeting, and cost control." The approach used by the design team resembles a "life-cycle costing."
2. The authors state that project cost is directly proportional to the level of quality required. Comment on this statement.
   a. There is a relationship between cost and quality, but that relationship rarely is directly proportional. With proper scheduling and planning, as well as with proper control of the project, quality in the process is assured. This

is an important point, for the best equipment and materials purchased will not provide the best quality end product when the process used is faulty.

3. Something which was not mentioned by the authors of this case was that the airport was created using public funds and thus faced the problems associated with dealing with the government and consequently the public as stakeholders. How did the owner/engineers of this project deal with this challenge?
   a. Although not clearly discussed, the owner/engineers must have included the government in their development plans through meeting and other communications. By keeping the stakeholders informed and including them in the process when appropriate, the ownership the stakeholders grow to feel for the project ensures their support and cooperation.
4. The author states that if realistic budget and quality are established, the project is properly controlled by controlling the schedule. They later state that the schedule is the key controlling mechanism. What are the key assumptions of this statement?
   a. One of the assumptions is that the scope management process was properly carried out and that identified activities are clearly stated.
   b. The project will not face non-controllable factors that will create unplanned challenges (Risk evaluation).
   c. All the activities will have been scheduled for and their impact recognized.
5. The author mentions the importance of negotiating the quality, budgeting, and scheduling with the project's owner. Elements of every project and even every activity of life involve negotiation. Project managers always have to conduct negotiations in a project. What are some strategies for negotiating as a project manager?
   a. In the book, *Project Management: Strategic Design and Implementation*, 2nd ed., by Cleland, Chapter 15, A Project Manager's Guide To Contracting, describes the negotiating process. This method is presented in the book, *Getting to Yes: Negotiating Agreement Without Giving In*, by Roger Fisher and William Ury. This straightforward, creative strategy for firmly pursuing your interests and dealing with interests conflicting with yours, has four main principles:
      - Separate people from the problems.
      - Focus on the common interests in the process rather than the opposing positions of the parties.
      - Generate a number of creative options prior to beginning negotiation.
      - Insist that results be based on some objective criteria.

Additional Discussion Points:

The author mentions that "many owners try to save money by minimizing engineering costs and that this often results in poor construction documents and excessive contingencies in the form of additional construction change orders to a project." Have the students divide into two groups and have one of the groups defend the importance of planning and the other group defend the importance of monitoring ongoing processes.

Pittsburgh International Airport Midfield Terminal Energy Facility

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Project Abstract

The purpose of this paper is to present the conceptual thought process and the project management methodology that facilitated in producing the Pittsburgh International Airport Midfield Terminal Energy Facility (see Figure 1). The primary objectives were to design a facility that was of first-class quality, on schedule, within budget parameters, and in compliance with all environmental regulations. The energy facility was subcontracted by Allegheny County to a third-party developer. This developer would provide the conceptual engineering, detailed design, construction management, operations, and maintenance to produce thermal (heating/cooling) energy and electric power for the new Midfield Terminal.

The conceptual engineering analyses that precedes full-scale preparation of engineering design drawings and specifications are fundamental to the long-term financial objectives of any new facility project, particularly those that involve energy-intensive processes. This basis of design phase planning often requires close scrutiny of fuel options and long-term fuel availability, major equipment, alternate selections, environmental concerns, and operations/maintenance requirements over the expected life of the facility.

When the basis of design is complete, the owner/engineer project management strategies play a major role in the success of the project. Key elements of the project management program include proper budgeting/scheduling of the engineering design, construction, and start-up phases; proper communication between all parties interfacing with the facility; availability of certified information during the design phase; and the engineer's degree of detail in the contract documents to minimize cost contingencies from the contractor.

Introduction

The Midfield Terminal Energy Facility was designed to meet the 9,100 tons of ultimate cooling load and 113×10^6 Btuh ultimate heating load of the new Midfield Terminal Complex (see Figure 2). All thermal energy loads are weather dependent type, space heating/cooling for the terminals and aircraft. No process type (i.e., deicing, base load domestic hot water, etc.) thermal energy loads are tied to the energy facility. The energy facility also provides electric power to the Midfield Terminal from the new substation located between the energy facility and the field-erected concrete cooling tower. The substation will

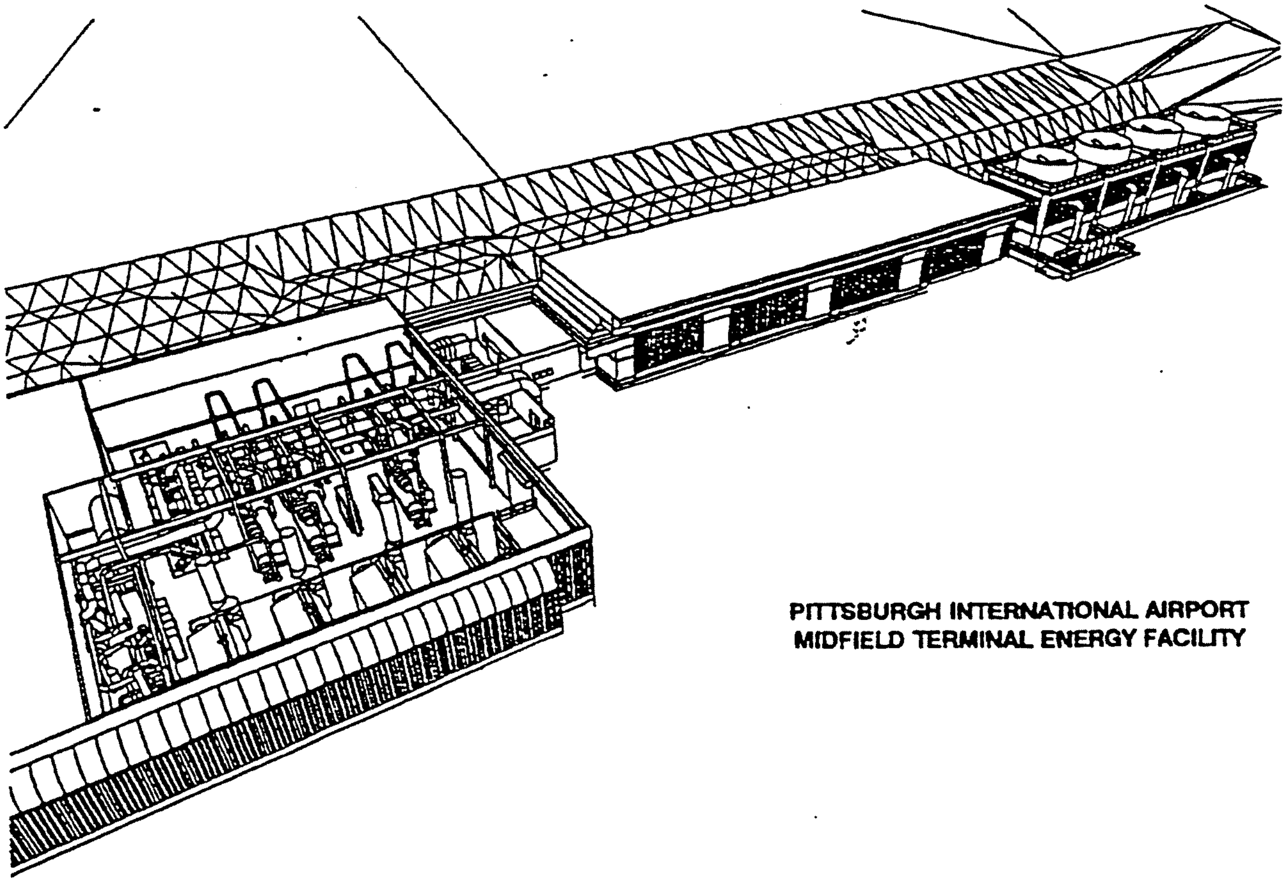

FIGURE 1

initially have three 22.9 kV/4.16 kV, 10,000 kVA (12,500 kVA FA) delta-wye transformers rated at a 55° F temperature rise. Each substation vault also contains a 4,160 V, 1,800 kVAR capacitor bank to optimize power factor. Space is reserved for a future fourth transformer. The ultimate projected peak electric demand on the substation is 24 MW. The Pittsburgh International Airport is owned and operated by the Allegheny County Department of Aviation. The new Midfield Terminal includes a 500,000 square-foot landside/central services building and a 1,200,000 square-foot airside building having a present seventy-five aircraft gate capacity with provisions to expand to an ultimate 100-gate terminal. These two terminal buildings are situated nearly 0.5 miles apart, and are connected by an underground people mover to shuttle passengers between the two buildings, and a utility tunnel with several miles of piping, cable, and conduit. Due to the nature and proximity of the buildings at the Midfield Terminal, a formidable engineering challenge was presented for designing a central energy facility (see Figure 2).

PROJECT OBJECTIVES

The Midfield Terminal and Central Facility is projected to be a long-term operation and major consumer of electric power and natural gas. The facility must be capable of providing energy deliverables 365 days per year and requires staffing twenty-four hours a day. An airport application is especially sensitive to issues concerning reliability of equipment safety, combustion and

Ultimate Cooling Load:	9100 Tons
Chilled Water Supply/Return Temp:	42° F/58° F
Chilled Water Flow Rate:	13,650 gpm
Chilled Water Distribution Pressure Loss:	200 feet TDH
Ultimate Heating Load:	113×10^6 Btuh
HTW Supply/Return Temperature:	350° F/250° F
HTW Flow Rate:	2,425 gpm
HTW Distribution Pressure Loss:	190 feet TDH
Ultimate Electric Demand:	24 MW
Substation Electrical:	23 kV/4.16 kV
Substation Transformers:	3 each @ 10.0 MVA (12.5 MVA FA)
Substation Capacitors:	3-4160 V banks each @ 1800 kVAR

FIGURE 2 FACILITY ULTIMATE DESIGN CRITERIA

cooling tower emissions, and other environmental-related concerns. The key objective of the energy facility equipment systems review was to maintain focus on reliability criteria. The Pittsburgh International Airport has an excellent record of minimizing the number of days that the airport has been forced to shut down aircraft operations due to equipment malfunctions or weather conditions. The basis objectives incorporated in the conceptual study process were ultimately to specify an energy facility that met the following owner/engineer primary criteria:

- long-term availability of energy/fuels
- reliable equipment system selections
- state-of-the art centralized control
- optimum equipment systems efficiencies
- environmentally safe emissions
- low maintenance operations.

PROJECT MANAGEMENT

The key to successful project management on any major facility is to have a well-defined plan that is realistic, obtainable, and properly monitored throughout the project. Project management is able to balance successfully the following:

- quality
- costs/budget
- schedule.

It is relatively easy to balance two of those three factors, but the project will not be successful without meeting the objectives of all three. The first objective—quality—was stressed not only by Allegheny County but also by the owner of the energy facility. This energy facility was to be a first class facility with the best equipment available to produce reliable energy over a long-term contract. The quality in a project is controlled by staffing the project with the proper technical personnel and ensuring that they have the information and tools needed to study and analyze the technical requirements and make recommendations to the project manager for equipment and systems.

Project cost is equally important but is directly proportional to the level of quality required. Many owners try to "save money" by minimizing engineering costs, and this often results in poor construction documents and excessive contingencies in the form of additional construction change orders to a project. Good quality engineering can be cost effective. If the owner/engineer team understands the objectives and the long-term benefit that can result from value engineering. The third objective, project schedule, must be realistic so that all tasks, purchasing, interface with other entities, and other contingencies are properly factored into the schedule.

The owner/engineer negotiated a realistic engineering and construction budget that would ensure the level of quality required and sufficient monies to implement the project once the conceptual design was completed. A complete project schedule was prepared covering three years that included performing various studies to select the best equipment, prepare major equipment coordination with other engineers and contractors, pre-purchase major equipment, detail design with required review phases, prepare construction bidding, award contract, develop facility construction, start up end testing, and conduct demonstration phase testing. These major tasks covered a period of three years and were carefully monitored to ensure that the project did not get off schedule. If realistic budget and quality are established, the project is properly controlled by controlling the schedule, not the budget. This appears to be contrary to many project managers who are always concerned about budget, budget, budget. If the plan is correct and the budget sufficient, the schedule is the key element in controlling all project costs and achieving project success.

The energy facility met all of the quality, budgets, and schedule objectives as defined earlier in this paper. Major equipment was pre-purchased, design documents were developed, and the project was bid on time in September of 1990. The construction contract was awarded in mid-November of 1990 (one-year schedule), and in the first week of December major equipment started to be delivered to the energy facility as planned. All major equipment was in the facility by March 1991 and facilitated the contractor in finalizing the fabrication piping drawings. The construction for the project continued and was completed on time; however, start-up and testing were delayed due to some minor problems beyond the control of the owner/engineer. The start-up and testing, as well as the demonstration phase testing, began later than scheduled. However, because of contingencies built into the schedule, we were able to complete the project six weeks ahead of schedule.

Heating Equipment Alternatives

During the proposal phase, the County RFP required the energy developer to provide a high-pressure steam heating system that would provide sufficient high pressure steam and spare capacity to meet the heating load of the Midfield Terminal complex. Since there was no opportunity during this phase to recommend alternative heating systems, the project was bid-based on a steam heating system. As the conceptual design developed, SE Technologies, Inc. (SET) began to put together a very strong case for a high-temperature water (HTW) system in lieu of a high-pressure steam (HPS) heating system. The high-temperature water system would provide 350° F water to the Midfield Terminal

- Total of Four High Temperature Water Generators (HTWG)—(Three) Operating and (One) Standby
- HTWG Key Design Features (typical of each unit @ 100 percent firing)

Manufacturer:	Cleaver Brooks
Model Number:	DLW-60; Packaged Water Tube 400 Psig Design
Heat Input Rating:	49,534,000 Btuh
Heat Output Rating:	39,300,000 Btuh
HTW Water Flow Rate:	808 gpm
Water Inlet/Outlet Temperatures:	250° F–350° F
Primary Fuel:	Natural Gas
Emergency Fuel:	No. 2 Fuel Oil

FIGURE 3 HEATING PLANT DESIGN CRITERIA

complex, with a 250° F minimum return temperature (see Figure 3). It has always been SET's opinion that hot water heating is a more economical and lower maintenance system for heating buildings versus steam; however, to convince Allegheny County, a formal study and presentation had to be prepared. The heavy commercial, institutional, and industrial sectors seem to have overlooked many of the benefits of high-temperature water systems for space heating since steam heating systems have been used for so many years in many facilities. Steam heating systems have been the work horse for many years and many engineering and design consultants who are used to designing steam systems continue to design them since it is basically what they have done in the past. Obviously there are economies of scale for the engineering firm that is familiar with a certain type of system and comfortable with the concept. The consultant can draw on previous designs and thus minimize the efforts in preparing a package for another client. The end-user, or owner, may also be used to a steam system and, therefore, feels comfortable with this type of design. The owner for the Midfield Terminal Energy Facility was open to investigating other types of heating systems in an effort not only to reduce his operation and maintenance costs but also to provide a safe and more reliable system and product to Allegheny County. SET then proceeded to do an in-depth study and analysis of HTW heating systems versus HPS heating systems.

The first criteria that SET evaluated in comparing the two types of systems was the capital cost for the two plants. SET laid out the equipment and piping arrangement that would be required for both the HTW and HPS system and did a construction cost estimate for both systems. Initial estimates indicated that the construction cost for the HPS system may be slightly less than the cost for a HTW system. However, the cost difference would be so minor (less than 5 percent) that during a competitive bidding environment this cost advantage for high-pressure steam may disappear. Aside from the minor first cost advantage, SET was unable to find any other major advantages for HPS systems relative to the Midfield Terminal's weather-dependent heating loads. Therefore, the following are the advantages that were discovered for the HTW system versus the HPS system.

Better Reliability

One of the key issues in designing any part of a new airport is the reliability of the facility. The county made it very clear to all the engineers, designers, and contractors involved with the Midfield project that reliability was of utmost importance in the design of our system to ensure the continued operation of the airport under all possible environmental conditions. The HTW system is a much less complex system compared to a steam heating system. There is less equipment and equipment of a simpler design in the HTW heating system, and also since it is a closed system, ancillary equipment for deaeration and complex chemical treatment is not required. Although distribution pumping is required for HTW systems, all the pumping systems to the energy facility have standby pumps to ensure reliability of pumping systems.

Improved Safety

Another concern in the construction of the new Midfield Terminal was the safety of the systems, since this will be a public facility used by virtually anyone in Allegheny County as well as throughout the nation and the world. There is a perception among some engineering consultants and owners that a HTW system is more dangerous than steam. A practical test was performed by a United States military agency with a high-temperature water system operating at 370° F in a 2,800-cubic-foot closed area. A blind flange was knocked off the end of a 1-inch pipe. At first a slug of water escaped followed by a fog that spread across the ceilings. In all, it took four and a half minutes before the heat became overwhelming and enough oxygen had been displaced to cause evacuation of all personnel from the space. An identical test was conducted with 150 psi steam system. The evacuation time for this test was only one minute. When a high-temperature water system is relieved to atmosphere, only about 25 percent of the relieved quantity of water will flash to steam. The balance remains in its liquid state.

Greater System Efficiency

In general, the HTW system does not have the parasitic steam and heat losses that are common with standard high-pressure steam systems and no consequent waste of energy and efficiency. Also, the minimal requirement for chemical treatment on a HTW system greatly improves the overall operating cost for high temperature water.

Lower O & M Costs

SET calculated that the net energy savings of steam losses versus pumping energy was significant. Also, the elimination of distribution system trap maintenance as well as minimal chemical treatment costs greatly contributed to overall lower O & M costs.

System Start-Up Simplification

The HTW system maintained in a liquid state by anti-flash pressure protection as compared to the liquid/vapor/liquid cycle inherent with HPS. Therefore, the initial start-up and cyclic control requirements that exist for spring/fall transition weather are easier with HTW. The longer start-up requirements and potential for water hammer associated with the steam system are eliminated.

Since the high-temperature water system is a closed system, makeup water requirements become minimal. The closed system also provides a relatively corrosion-free environment once the initial chemical treatment has been made.

Smaller Piping

The design for the energy facility, using high-temperature water, reduced the size of the distribution supply and return piping compared to the steam supply and condensate return system. Since there are many miles of piping in an airport facility, this was a great economic benefit in favor of high-temperature water. The smaller diameter piping required for high-temperature water systems also attributed to lower pipe heat loss throughout the system.

Pipe Installation Simplified

Since the high-temperature water system is a forced-circulation or pumped system the piping is not required to be installed with critical slopes toward drip legs or traps as required for a steam system.

Closer Temperature Control

The large volume of water in the high-temperature water system provides a tremendous amount of heat storage. Heating loads in airports can change suddenly due to many planes landing at a peak period of time. Because of this heat storage capability, or "flywheel effect," high-temperature water can meet a sudden increase in load without measurable drop in supply temperature. If there is a sudden load increase, the supply temperature is held constant, and the return temperature will diminish without affecting other heating systems. A sudden load increase on a steam system causes the drum pressure to drop with a corresponding slight decay of supply temperature.

There are obvious disadvantages for a HTW system, such as, if steam is required for a process, or to move a turbine for power generation. However, these were not required for the Midfield Energy Facility and, therefore, could not help support a case for the HPS system.

Heating Equipment Evaluation Results

The capital cost for the high-temperature water systems estimated and bid for the Midfield Terminal Energy Facility was within project budget and competitive with the high-pressure steam system. Reviewing the annual operating costs for each system type, a high-pressure steam plant would incur higher fuel costs despite having a slightly higher thermal efficiency. The high pressure steam plant lower system efficiency (i.e., fuel to useful thermal output) is due to:

- parasitic steam to preheat/deaerate boiler feedwater
- continuous blowdown
- flash steam (heat) and mass losses from condensate holding tank and deaerator, respectively
- steam and trap losses in the system.

The high-pressure steam higher electric costs result from greater horsepower for forced draft fan and boiler feedwater pumping. For a high-temperature water system, although electric costs are required to pump the water throughout the facility, the savings in steam losses from receiver tanks, traps, and leaks far exceeded the low pumping energy required. The water/sewage charges for high-pressure steam would also be higher due to great system losses, and, in turn, would require more chemical treatment. SET performed a life-cycle cost summary based on the capital and operating costs. The HTW system was determined to have a lower life-cycle (present worth, cost).

The emergence of modern (forced circulation) HTW systems for district space heating applications began early in the 1950s. The most common users of HTW plants have been airports, military bases, universities, and other institutional settings where multiple buildings are spread over long distances. SET recommended to the owner and to Allegheny County that the HTW heating system was the best system with advantages to both the energy facility owner as well as the energy user. From the perspective of a conventional arrangement, when the purchaser is also owner/operator, a HTW system has an operating cost advantage. The owner of the energy facility benefits from reduced maintenance and operating coats. The energy user also benefits with reduced distribution losses versus pumping energy required and also lower maintenance costs of many miles of piping with steam traps and drip legs as well as chemical treatment.

Cooling Equipment Alternatives

A variety of commercially available cooling system prime equipment options were given a conceptual phase evaluation. These included electric-driven, centrifugal, and rotary screw-type chillers; factory packaged chillers versus field-erected chillers; open drive versus hermetic, CFC versus HCFC/HFC refrigerants; and steel packaged PVC fill towers versus field-erected non-PVC fill towers. The initial screening eliminated large capacity (>2,000 ton) field erected chillers due to comparatively large purchase costs, larger space and maintenance clearance requirements that infringed on other major equipment arrangements, and potentially greater ancillary equipment requirements. The county required a low-connected horsepower, field-erected cooling tower with a long-life ceramic-tile fill housed in a special concrete architectural finish. After the initial screening, a cooling plant optimization study was completed by the engineer to define some key design parameters as the basis of the bid specification. The optimization study highlighted an 8,225-ton cooling plant (present design), evaluated cost based on ten-year/fifteen-year terms, 85° F entering condenser water temperature (ECWT) versus 90° F ECWT; cooling tower fan horsepower and 75° F wb versus 78° F wb design; condenser water pump horsepower end variable flow rates; condenser water pipe sizing; end chiller compressor kW/ton. The county requirement for the chilled water supply temperature was fixed at 42° F.

The engineer modeled and furnished to chiller manufacturers an annual cooling load profile datasheet in order to obtain kW/ton performance at the varying tonnage and entering condenser water temperature for different outdoor air wet bulb ranges. The optimization study evaluation considered packaged electric-driven centrifugal and rotary screw, both open drive and hermetic. The chiller pricing included options for 5 kV reduced motor starters, motor surge protection, marine boxes, and sound attenuation. A number of chiller performance selections was obtained by chiller manufacturers based on the above scenarios. The manufacturers were encouraged to model different evaporator and condenser selections (one pass through three pass), compressor options (single or multi-stage), and any worthy unspecified selections within the electric-driven chiller category. The engineer provided the building layout drawings to the bidders to give them the opportunity to provide the optimum chiller arrangement based on number of units and kW/ton efficiency, while ensuring the required maintenance space clearances for their proposed arrangements.

In general, conditions that optimize the economics of the cooling tower/condenser pumps/condenser piping distribution have an adverse impact on chiller kW/ton efficiency and vice versa. For example, the chiller rated kW/ton performance is optimum for conditions of low entering condenser water temperature and low temperature rise across condenser. These chiller processes often result in higher operating costs for the cooling tower fans and condenser water pumps and higher installed costs for this ancillary equipment. The key to evaluating each of the cooling plant scenarios evaluated cost is to compare chiller installed cost and kW/ton performance with the balance of the cooling plant auxiliary equipment installed costs and electric operating costs.

Cooling Equipment Evaluation Results

The optimization study concluded that a cooling plant utilizing 85° F ECWT, a 10° F rise across the chiller condenser, 75° F wb cooling tower design, and a condenser water flow rate of 3.0 gpm/ton was the most cost effective. The optimization study cost model was driven by the disproportionate chiller compressor kW draw total of 5,100 kW nominal versus only 750 kW nominal for the cooling tower fans/condenser water pumps. Thus, the chiller kW/ton selection weighed heavier than condenser water pump/piping costs and cooling tower price considerations.

This key performance data was written into the chiller specification. All chiller bid proposal data was modeled in spreadsheet form to compare total evaluated cost among the different chiller manufacturers and associated ancillary equipment cost data. The lowest evaluated costs became the "baseline" to compare the cost difference with higher cooling plant evaluated total cost. The differential evaluated cost represented the owner's cash for parity to make all total evaluated costs equivalent. Similar to the optimization study, the final chiller selection evaluation results focused on cooling plant major kW consumption (chiller compressors, cooling tower fans, and condenser water pumps) based on the specification cooling load profile and chiller f.o.b. factory price quotations. In addition, the engineer interjected some balance of plant installation cost adjustments to the evaluation to compare each chiller bid on even terms. For example, a minor HVAC cost penalty was assessed to open drive-type chillers because of their much greater ambient heat rejection compared to hermetic chillers. Adjustments were also made for any separate electric power feeds, auxiliary cooling water requirements, and additional condenser water piping, depending on location of pipe flanges on the condenser bundle.

There were alternate evaluation cost scenarios that considered extended warranty coverage and substitution of HCFC/HFC refrigerants. All shortlisted

- Total of seven Electric-Driven Centrifugal Chillers
- Centrifugal Chiller Key Design Features (present)
- Manufacturer: Trane Company
- Model Number: CVHE113
- Cooling Output: 1,175 tons of refrigeration
- Chilled Water: 1710 gpm; 42° F supply, 58° F Return; three pass
- Condenser Water: 3525 gpm; 85° F entering; 95° F leaving; two pass
- Refrigerent: R-11 (Compatible with R-123)
- Chiller Motor Size: 1100 hp nominal; 4160 V
- Chiller Full Load Performance: 0.62 kW/ton
- ARI Certified Performance: 0.64 kW/ton (APLV)

FIGURE 4 COOLING PLANT DESIGN CRITERIA

chiller proposals were predicated on chillers that would presently utilize an HCFC refrigerant (R-22) or be completely compatible with a future HCFC conversion (R-11 to R-123).

The Trane company proposal, with seven 1,175-ton hermetic R-11 chillers, was the successful bid proposal (see Figure 4).

Several benefits to the owner were identified as a result of the evaluation results and Trane chiller selection:

- lowest five-year and ten-year evaluated cost, based on a total evaluated equipment bid quotation
- simple installation involving a single 4160 V feed to each chiller and less chilled water/condenser water piping requirements (no separate low voltage electric feeds or auxiliary city water cooling piping required for packaged chiller components)
- chiller construction and all components completely compatible with substitute refrigerant R-123 (unit to be equipped with a high efficiency air-cooled purge unit)
- local Trane office has a large factory-trained maintenance service department within ten miles of the project
- Trane can offer an EMS/DDC system to simplify cooling plant centralized control communication with its chiller control panels.

CONCLUSION

The Midfield Terminal Energy Facility project culminates nearly five years of conceptual engineering analyses, design, construction management, and start-up activities. The strategic project management plan developed by the owner/engineer with the proper emphasis given to scheduling, budgeting, and quality resulted in a highly successful project. The project was engineered, designed, constructed, tested, and demonstrated all within schedule (six weeks early) and under budget. The owner's commitment to realistic scheduling, budgeting for comprehensive preliminary engineering studies to select optimum equipment system, and detailed bid documents resulted in very competitive construction bids and minimized construction contingencies.

The project management strategies implemented by owner/engineer will also benefit the owner with long-term operating cost savings.

Study Questions

PITTSBURGH INTERNATIONAL AIRPORT MIDFIELD TERMINAL ENERGY FACILITY

1. The design team was concerned with developing "real" quotations and selecting the best energy system. Which of the nine project management body of knowledge areas was used most? Describe this process.
2. The authors state that project cost is directly proportional to the level of quality required. Comment on this statement.
3. Something which was not mentioned by the authors of this case was that the airport was created using public funds and thus faced the problems associated with dealing with the government and, consequently, the public as stakeholders. How did the owner/engineers of this project deal with this challenge?
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