The KNU 5 and 6 experience-
A review by the Architect Engineer

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Korea Electric Power Corporation(KEPCO) entered into an agreement with Overseas Bechtel, Incorporated(OBI) and Bechtel International, Inc.(BII) on May 1, 1978 to provide engineering, procurement and construction management services for Korea Nuclear Units 5 and 6(KNU5 and 6).

KEPCO performed overall project management. OBI provided engineering and procurement services as agent for KEPCO offshore. BII assisted KEPCO in construction management onshore at the KORI jobsite in Korea. Korea Power Engineering Company, Inc. provided designs on various areas of the plant. The nuclear steam supply systems were provided by the Westinghouse Electric Corporation(U. S.) and the turbine generators were supplied by the General Electric Company(U. K.). Construction was performed by the Hyundai Engineering and Construction Company.

Korea Nuclear Unit 5 started generating power commercially on September 30, 1985 and Unit 6 on April 30, 1986. The plants are located at the KORI Nuclear Power Site, at the southeastern coast of the Korean peninsula about 30 kilometers northeast of Pusan. KEPCO's earlier Nuclear Units 1 and 2 are also located at the KORI site.

The KNU 5 and 6 power plant project achieved an excellent record for low overall cost, high quality and short construction schedule. In addition, significant progress was achieved in the transfer of technology and self-sufficiency by greatly increasing the direct participation of Korean engineers, technicians, and suppliers in the total engineering, manufacturing, and construction process.

A) DESIGN APPROACH

The key KEPCO decision during the early planning of the project was to base the KNU 5 and 6 design on a replication of

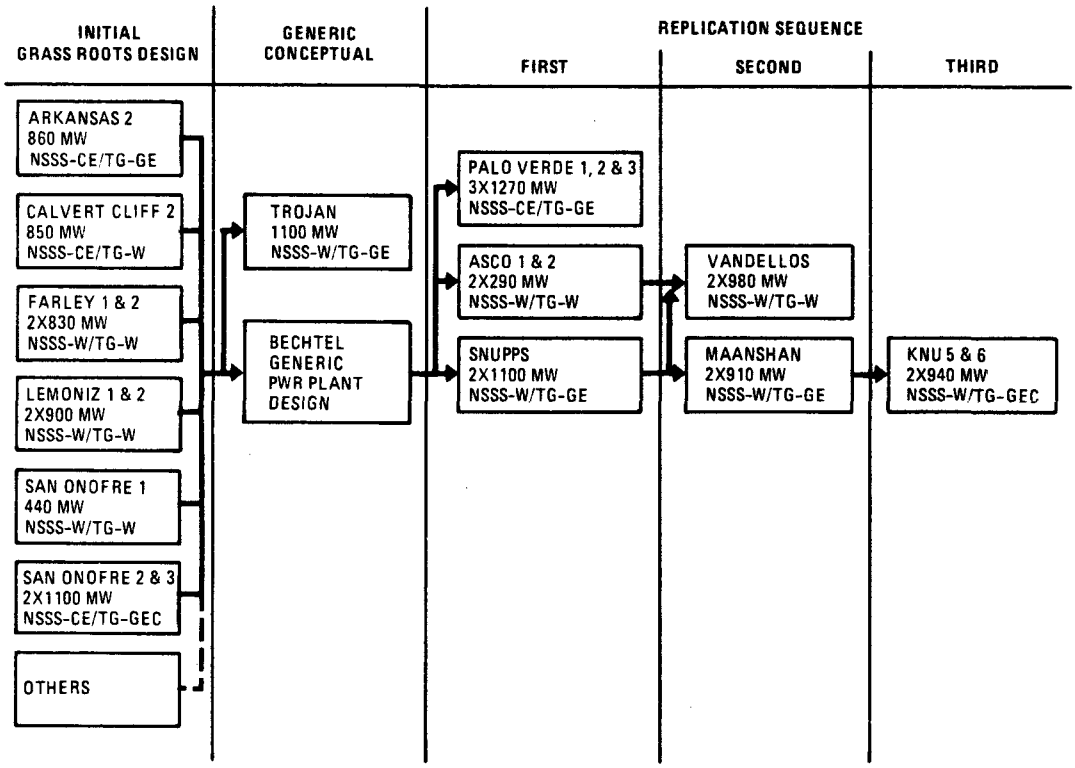
the latest derivative of the Bechtel generic PWR plant design which was termed the reference plant. The pedigree of the Bechtel generic nuclear plant and the sequence leading to the basis for the KNU 5 and 6 design is shown below in **Figure 1.**

Bechtel developed its unique generic design concept in the early 1970's in response to the nuclear industry need for standardization. A key feature of the generic design is that it is based on optimized basic mechanical and electrical systems designs and a modular plant arrangement, and yet provides the flexibiliey for accommodating alternative major equipment components (NSSS, T/G and BOP) and adaptation to various site conditions.

The Bechtel generic design features the same-hand, slide-along arrangement of the identical units for a multi-unit plant. This concept produces the proven advantages of significantly reducing the number of design documents and engineering manhours required and also results in overall shorter schedule and cost savings.

The adoption of the replication philosophy and utilization of the reference plant design permitted the engineering design and construction activities to be performed concurrently on KNU 5 and 6. This design approach supported a short overall project schedule and contributed to the efficient overall management of the project by KEPCO to achieve low overall plant cost.

〈Figure 1〉

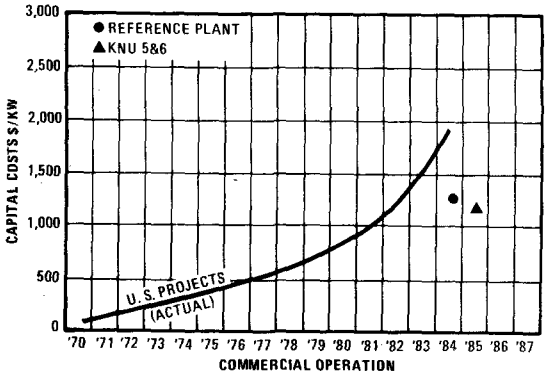


Figures 2 and 3 below show the cost and schedule performance of KNU5 and 6 in comparison to U. S. plants and the reference plant.

The ready availability of the reference plant data provided a fully developed basic plant design and safety criteria, bulding layouts, equipment arrangements, and process, electrical and control system concepts. The availability of such reference documents for replication substantially reduced the engineering manhour requirements to perform the design and assured a better optimized design with minimum design iterations. The replicated design was updated to include the project specific codes and standards. The review of the TMI action items and incorporation of related items into the design required an additional effort by the OBI design team. The concept of replication is shown in a simplified form in Figure 4.

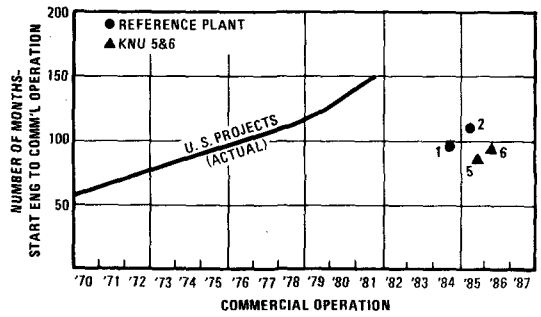
〈Figure 2〉

AVERAGE CAPITAL COSTS/KW BY YEAR OF INITIAL OPERATION



〈Figure 3〉

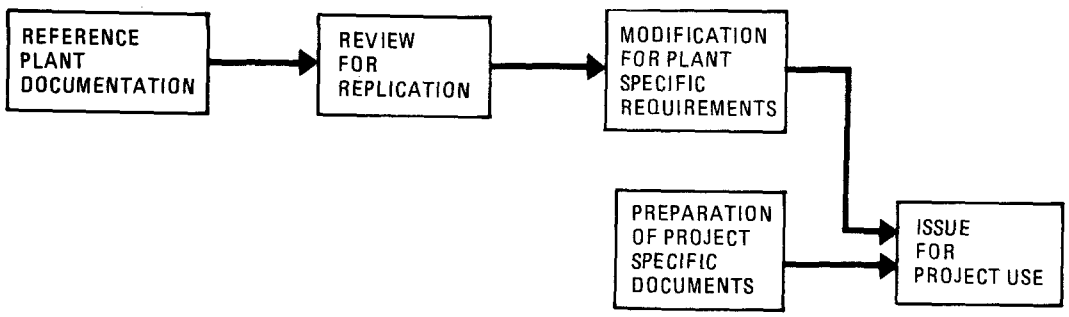
SCHEDULE PERFORMANCE BY YEAR OF INITIAL OPERATION



B) PROJECT APPROACH

The component approach was selected by KEPCO for KNU 5 and 6 rather then the "turnkey" approach which was utilized for the previous Korean nuclear units. The equipment and material including the NSSS and TG was procured based on competitive bidding by qualified international suppliers, and with Korean participation. Through the component approach, it was possible to achieve Korean localization of BOP equipment of up to 30 percent as well as reduc-

〈Figure 4〉



ing costs.

At the site, an Integrated Management Team(IMT), led by KEPCO, was established with direct responsibility for the day-to-day operations and decision making and was able to respond rapidly to meet the construction requirments. The IMT established and maintained the necessary liason with the various participating project groups not located at the jobsite and was responsible for directing and controlling the work at the jobsite.

From the very beginning of engineering and procurement activities, Korean nationals of all disciplines were assigned to the project team for direct on-the-job participation in the project functions. This did provide indepth transfer of design technology to the participants and assured guidance to OBI's design personnel on any special Korean requirements.

The direct involvement of the KEPCO personnel assigned to the Norwalk office to participate in Bechtel's offshore procurement activities contributed greatly to the success of the accelerated procurement program which was instituted to firm up the pricing for BOP equipment during a period of high inflation.

The establishment of the Resident Engineering Organization(REO) and the Integrated Field Procurement Organization(IFPO) was very effective in providing engineering and procurement capabilities to the jobsite. REO was an extension of OBI onshore and responsible for performance of those tasks which could be performed most expeditiously and effectively at the jobsite. IFPO was successful in the procurement and expediting of many items of equipment necessary for plant completion, startup and start of plant operation from onshore and offshore directly from the jobsite.

A Construction Completion Group was instituted at the jobsite to identify and expedite the work-to-go by startup system and contributed significantly to the progress of the project.

KEPCO had direct responsibility for the startup of the plant with technical assistance from experienced BII and supplier personnel.

C) PROJECT ORGANIZATIONS

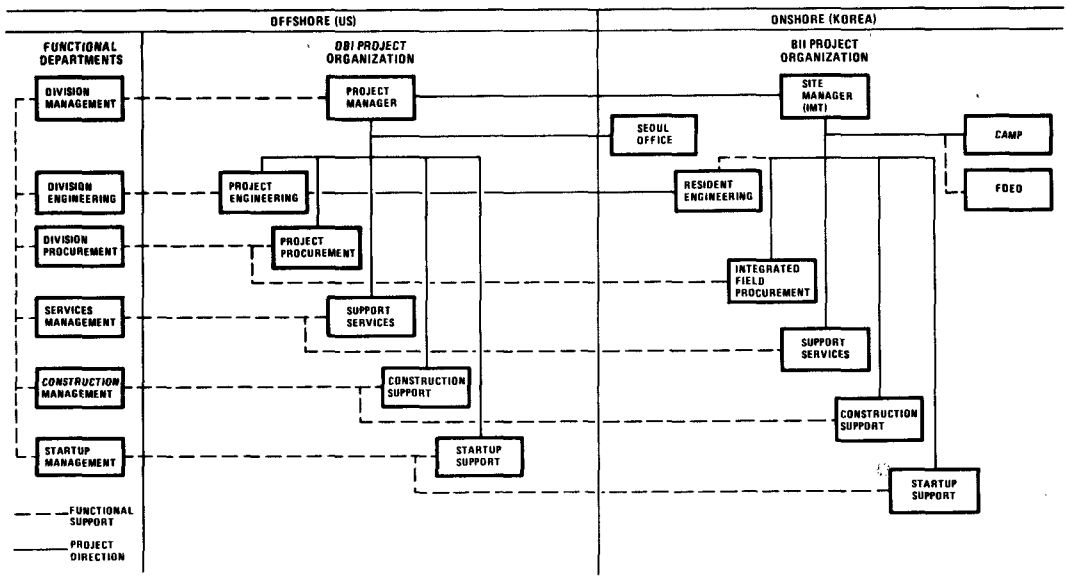
The OBI offshore project services were performed at the Bechtel offices in Norwalk, California, U. S. A. The BII onshore services were performed by BII at the KEPCO-Seoul office and at the KNU 5 and 6 jobsite.

This project was structured in the project /functional matrix type organization as shown in Figure 5. This type of organization is considered to be the most efficient approach in a complex project environment.

In a matrix type of organization, the functional departments provide the personnel to form the dedicated project team. A Senior manager represents the departments on the project. Additional personnel is added or removed from the project on a planned basis in order to achieve the optimum manpower and experience level dictated by the ongoing work. The functional depart-

〈Figure 5〉

PROJECT MATRIX ORGANIZATION



ments also provide the project with guidelines for consistent work methods, experience feedback from other projects and are responsible for the quality of the completed work.

The functional departments provide guidance on how to perform the work. The project team determines project goals such as project objectives, plans, budgets and schedules.

1) Offshore Project Team

For this major project Manager is the project team and the senior Bechtel representative responsible for the execution of the contract. He is the prime interface with the client and Bechtel senior management.

The OBI project team consists of project Management; Project Engineering; Project Procurement; Project Support Services including Quality Assurance, Cost/Schedule, and Finance/Accounting; Construction Support and Startup Support.

For expeditious support of the construction work, engineering data and material control status information were transmitted from OBI office in the United States to the jobsite via a dedicated project satellite communication system.

Another major requirement of OBI was to provide on-job-participation(OJP) of Korean national engineers in accordance, with KEPCO recognition that in addition to providing needed electrical power, the engineering and construction of KNU 5 and 6 would be an excellent means for developing technical capabilities and Korean manufacturing resources and capabilities necessary for the future nuclear power programs. To realize this benefit, it was necessary to greatly increase the role of Korean engineers, technicians, and suppliers in the

total engineering, manufacturing, and construction process, leading to significant gains in transfer of technology.

From the beginning of the project, OBI instituted a major program for the transfer of nuclear technology. The program involved the formation of integrated project teams in the U. S. A. made up of KEPCO, KOPEC, and Bechtel professionals in essentially all project disciplines and consisted of a classroom training(CRT) period and OJP project assignment.

A total of 28 professionals each from KEPCO and KOPEC participated in the technology transfer programs. During their KNU 5 and 6 assignments, KEPCO engineers accumulated approximately 50,000 hours of OJP and 10,000 hours of CRT while KOPEC had in excess of 150,000 hours of OJP and approximately 9,000 hours of CRT.

2) Onshore Project Team

Onshore services were provided by BII in KEPCO-Seoul office and at the KNU 5 and 6 jobsite.

a. KEPCO-Seoul Project Support Team

BII support onshore at the KEPCO-Seoul office was in the area of project management, engineering and procurement to assist KEPCO in the loaclized procurement of materials and equipment.

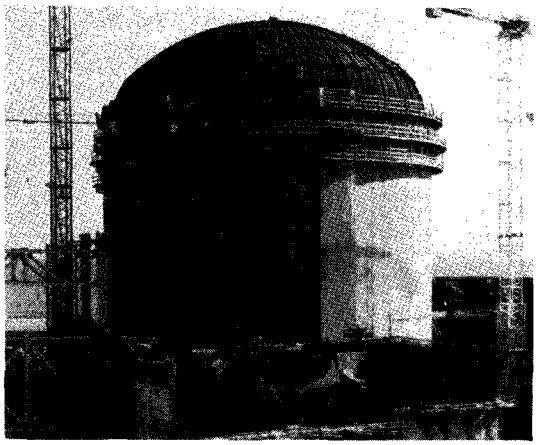
b. Site Management Support Team

BII's main onshore responsibility at the site was to work jointly and cooperatively with KEPCO in accomplishing the construction of KNU 5 and 6 and to support KEPCO in startup, procurement and other selected areas.

Experienced Bechtel personnel worked closely with KEPCO to assist in the development of policies, procedures, and methods to expedite construction activities and resolve project problems. Initially, the overall site organization consisted of several entities, e. g., KEPCO, Hyundai, BII, Westinghouse and GEC, functioning in parallel with each other for their own areas of involvement with the overall direction and coordination by the KEPCO Site Manager. To strenghten the site organization and to obtain more effective control of the site construction efforts, KEPCO directed the implementation of an integrated management team(IMT). In accordance with the directive, the KEPCO and BII site organizations were to function as an integrated, single unit with the KEPCO Site Manager responsible for overall management and direction. The BII Site Manager was to assist the KEPCO Site Manager in magnaing and directing the IMT. Within the IMT, the individual department and and subsection leaders were to operate as a KEPCO/BII counterpart system, sharing responsibilities for their respective departments or subsections activities.

The NSSS/TG suppliers and Hyundai Engineering and Construction Company (HECC) essentially maintained their own independent organizations. Project coordination was accomplisphed through the respective Site Managers.

The IMT concept benefited the overall construction effort by pooling the available



personnel resources and providing direct access to experience at all work levels in direct working relationships.

D) SCHEDULE AND PERFORMANCE

Concurrent design and construction requires careful planning of the design work and adherence to the construction plan and schedule by the construction forces.

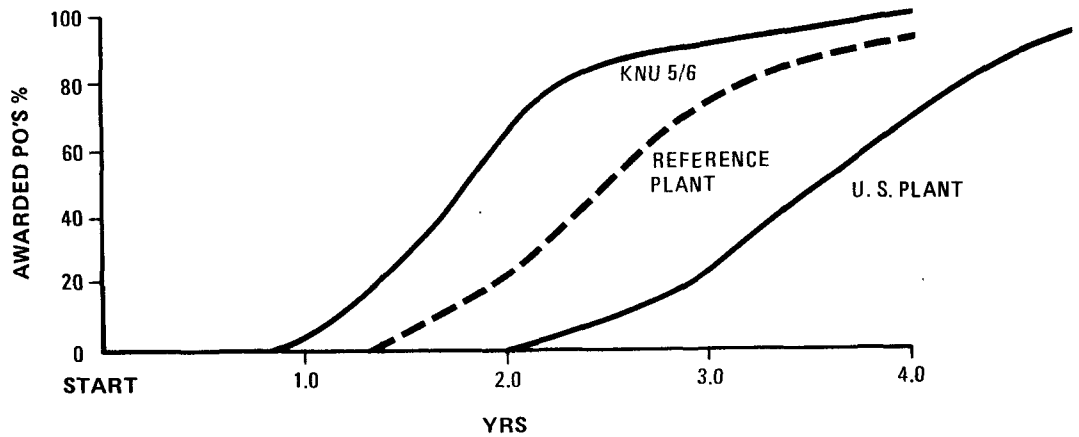
To firm up the largest possible dollar volume during a period of high inflation the accelerated procurement program placed a heavy load on the engineering team to produce specifications, prepare equipment evaluations and assist in procurement negotiations in addition to the commitment for issuance of design documents.

The construction sequence did not always adhere to the preplanned and approved engineering and construction plans and demanded engineering information in advance for areas for which the design had not yet been fully completed or needed additi onal supplier inputs.

Figure 6 shows the accelerated procurement performed offshore for KNU 5 anb 6 compared to the reference plant and a U. S. plant.

This particular problem and others which arose during the course of the project were successfully resolved largely due to the establishment of the IMT and its ability to coordinate all the organizations into a cooperative joint team effort. By all parties working together, an overall schedule of 60 months from first concrete to fuel load was

〈Figure 6〉
EXPEDITED AND OPTIMIZED PROCUREMENT



achieved.

Figure 7 shows a schedule comparison between a comparable U. S. plant, the overseas reference plant and KNU 5 and 6.

E) OBSERVATIONS

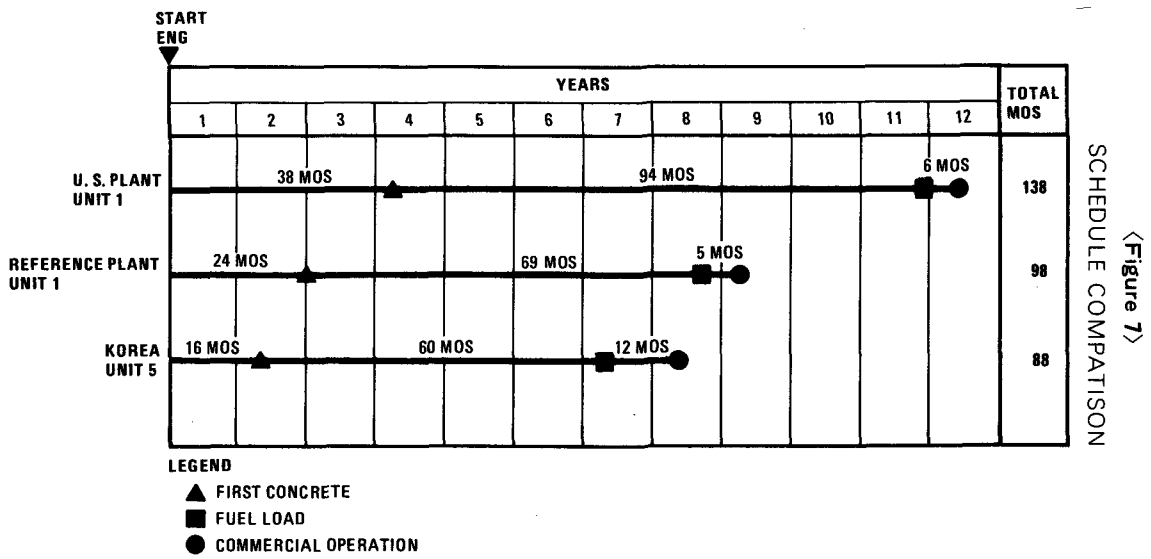
A project of this magnitude required total team effort and objectivity. This project experienced a number of unique challenges in establishing the proper environment to develop and implement this effort. It was important to learn, understand and accept each party's culture, organizational, procedural and contractual restraints and motives for a total cooperative team effort to satisfy the needs of the project.

Development of and agreement to the project schedule by all involved parties will provide total commitment of their organizations to the schedule needs of the project.

The replication concept for KNU 5 and 6 together with the component approach was effective in achieving high quality, low overall plant cost and a short project schedule. The KNU 5 and 6 design also provided the basis for replication of KNU 7 and 8 and has contributed significantly toward the design stabilization for future Korean Nuclear Units.

F) CONCLUSION

The outstanding achievement by KEPCO and its contractors is remarkable when consideration is given to the challenges which occurred and were overcome. The experiences gained in the successful execution of the KNU 5 and 6 project will be very valuable in the future to KEPCO, Bechtel, contractors and suppliers. Undoubtedly, the KNU 5 and 6 experience will benefit KEPCO's next project to make one of the world's most successful nuclear programs even more successful.



〈Figure 7〉 SCHEDULE COMPATISON